CHAPTER **EIGHT**

BACKYARD COMPOSTING

Susan Bell
Extension Educator (retired), University of Idaho Extension, Ada County

Anthony Simerlink
Extension Educator, University of Idaho Extension, Power County

Amber Gunstream
Professional Guide, Association of Nature and Forest Therapy, Boise, Idaho

Ann Marie Schram
Idaho Master Gardener, Ada County

Meg Sutton
Master Gardener Assistant, University of Idaho Extension, Ada County

Hatasu Tankersley
Nutrien Ag Solutions, Boise, Idaho

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8 BACKYARD COMPOSTING

Learning Objectives

- Understand what defines composting
- Understand the benefits of compost
- Understand what materials can and cannot be composted
- Understand what organisms play a role in the compost process
- Understand how to make and maintain a simple compost pile
- Understand various other methods for creating compost
- Understand how to troubleshoot if a problem arises
- Understand how to judge when compost is finished
- Understand how to use compost in a garden or landscape

Introduction

Composting is an easy and sustainable method of reducing, reusing, and recycling organic debris from landscapes, gardens and kitchens. It is a way of mimicking what happens continually in nature — the breaking down of organic matter and the recycling of nutrients by microorganisms in the environment. Composting is simply the controlled biological decomposition of organic matter on a smaller scale. Gardeners know that growing robust plants starts with healthy soil. Adding finished compost as an amendment to almost any soil over time improves its characteristics such as structure, workability, and moisture-and nutrient-holding capacity.

MASTER GARDENER TIP

While decomposition occurs on a regular basis in nature, human intervention through composting can speed up the process of plant decay.

The Composting Process

The quality of compost and speed of production depends on several factors that can be manipulated by the gardener. Composting is an aerobic (oxygen-requiring) process. Beneficial microorganisms (microbes) and other larger organisms called macroorganisms are responsible for breaking down (decomposing) organic materials. These decomposers need oxygen and water to live. As they work breaking down organic matter, they generate heat and release water and carbon dioxide (Figure 1).

MASTER GARDENER TIP

Avoid adding weed seeds, diseased plants, or pesticide-treated plants to a compost pile.

WHAT MATERIALS ARE USED IN COMPOSTING

Almost all natural organic materials decompose, but not everything belongs in a backyard compost pile. Generally, compost is made up of garden vegetation, landscape trimmings, food scraps (vegetable or fruit), and livestock manure, but materials like newspaper and wood chips can also be used (Table 1). New items can be added to an existing compost pile as they become available or stockpiled until enough material is gathered to finally construct a compost pile.

Refrain from adding fatty or oily foods, since they can generate odors and attract animals such as rats, racoons, dogs, and skunks. Cat and dog feces should not be added to a compost pile because it may contain pathogens harmful to humans.

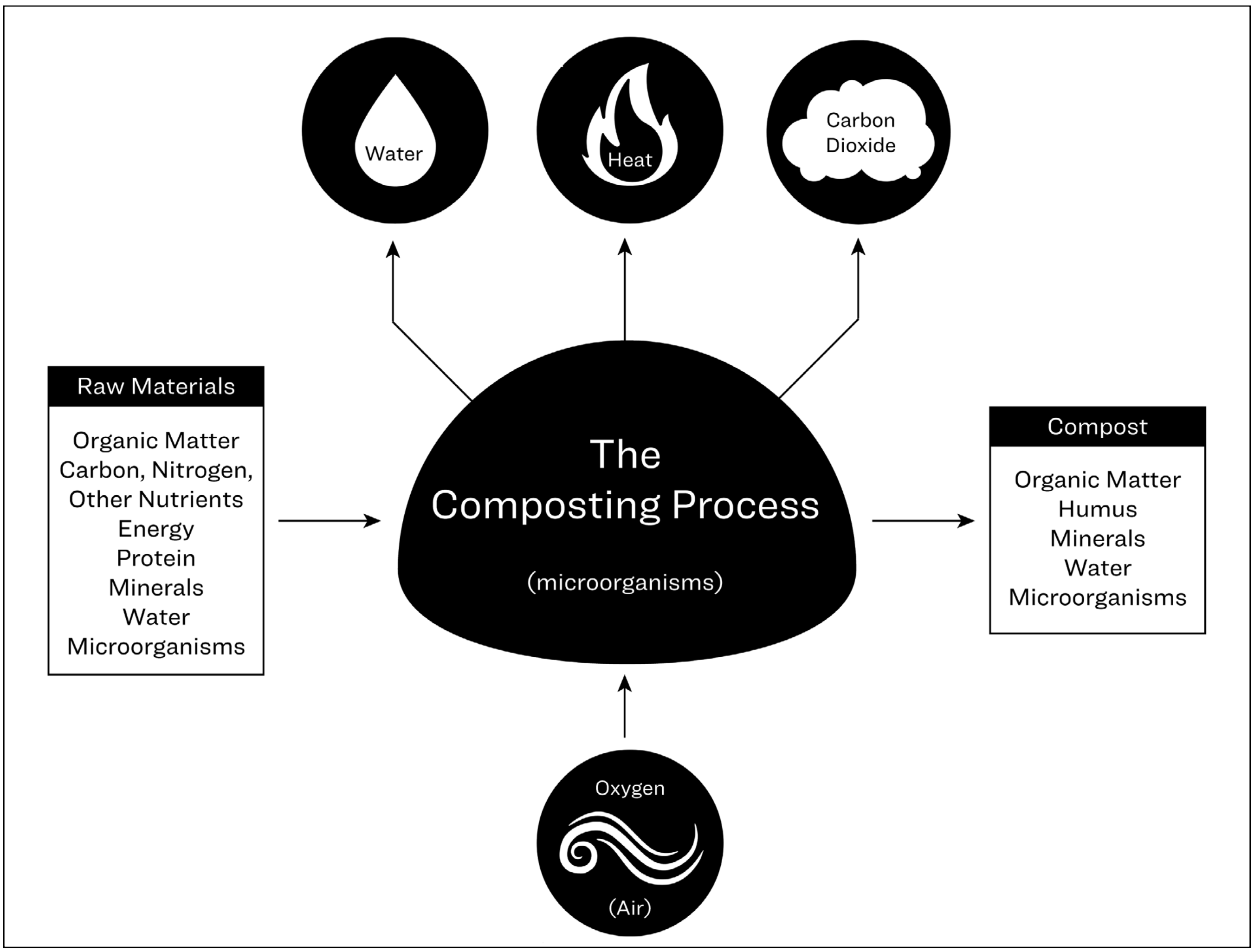

Figure 1. The composting process.

Table 1. Materials that should and should not be composted. Adapted from Dickson et al. 1991.

YES	NO
Aquatic plants	**OILY FOODS** (attract pests)
Bread	Butter
Branches — chipped	Bones
Brush — chipped	Cheese
Coffee grounds	Fish scraps
Corncobs	Lard
Cut flowers	Mayonnaise
Eggshells	Meat and poultry
Evergreen needles	Peanut butter
Fruit	Salad dressing
Fruit peels and rinds	Sour cream
Garden trimmings	Vegetable oil
Grass clippings	
Leaves	**POSSIBLE SOURCES OF DISEASE AND WEEDS**
Manure — cattle, horse, rabbit	Cat manure
Paper	Dog manure
Sawdust	Diseased plants
Straw	Plants with rhizomatous stems
Sod	
Tea leaves and bags	Weeds that have gone to seed
Vegetables	
Vegetable trimmings and tops	**POSSIBLE SOURCES OF TOXINS**
Weeds without seeds	
Wood ash	Cedar chips, bark, branches
Wood chips	Grass treated with persistent herbicides
Wool waste	

Avoid diseased plants, weeds with seeds or rhizomes, and plants recently treated with pesticides. Another group of materials to be cautious about are those containing natural compounds that would be toxic to the microbes in the compost pile or the plants where the compost is later applied. Cedar and black walnut wood are two of these. Cedar deters fungi growth and insects, which are needed in the composting process. All parts of a walnut tree contain an allelopathic substance (juglone) that can inhibit the growth of other plants if juglone accumulates to phytotoxic levels. Although the quantity required to be harmful to your compost pile is not well defined, current studies indicate that composting walnut tree leaves should be fine for compost piles because the composting process breaks down the allelopathic substance juglone.

Some gardeners add lime or wood ash to compost piles, but neither are necessary in the composting process. Lime is added with the intention of neutralizing acidic materials like pine needles or organic acids formed during composting, but the effect of these acids is seldom damaging. In addition, microbes can work at a relatively low pH. The pH of most compost once finished tends to be close to neutral. Lime also encourages ammonia loss, especially when the carbon to nitrogen ratio is too low. Wood ash encourages ammonia loss as well, although it does add some mineral nutrients to compost. Unfortunately, wood ash is highly alkaline, something that might improve low pH soils, but is not needed where soil pH is already high.

HOW MUCH ORGANIC MATTER DO I USE?

Estimating a carbon to nitrogen (C:N) ratio can be simplified by categorizing carbon sources as “browns” and nitrogen sources as “greens.” These categories don’t necessarily represent the color of the materials. For example, livestock manure is considered one of the greens (N), while yellow straw is one of the browns (C). Different materials have different levels of C or N in them and gardeners who are building compost piles need to be aware of these ratios to maximize their composting efforts.

The microorganisms in a compost pile primarily use carbon compounds as an energy source while ingesting N for protein. Because microbes require a nutritional balance of both, the proportion of C to N is important when combining compostable materials. The most ideal mix of C to N is approximately 30:1, but piles slightly outside this range also compost satisfactorily. Sawdust has a high C:N ratio (Table 2), while cattle manure has a low C:N ratio. Because most compostable materials by themselves do not contain C and N in the perfect ratio, mixing materials is necessary to achieve a desired C:N ratio. The materials and proportions used to achieve the best ratio is referred to as a compost “recipe.”

Table 2. Typical C:N ratios of selected home composting materials.*

	Material	C:N ratio
Browns	Dry leaves	60:1
	Cornstalks	60:1
	Straw	80:1
	Shrub trimmings	50:1
	Wastepaper	400:1
	Wood (sawdust, shavings, etc.)	500:1
Greens	Grass clippings	17:1
	Kitchen scraps	15:1
	Vegetable culls	12:1
	Cattle manure	18:1

* These values are only approximations. The C:N ratio of any of these materials varies considerably from one source to the next and as the materials age.

For example, three volumes of browns (dry leaves) to one volume of greens (fresh grass clippings) produces a C:N ratio in a 30:1 to 50:1 range.

Composting is a flexible practice. All organic matter breaks down eventually, but if time is of the essence for a quickly finished product, consider the C:N ratio. When C is too high in a compost pile, the shortage of N will slow decomposition. When the N is in excess, it can be lost to the atmosphere in the form of ammonia gas. Some compost manuals simply say use about three times as much brown materials as green materials. However, for those who prefer accuracy, C:N ratio calculators are available online.

Creating a Simple Compost Pile

When developing a compost pile, some gardeners add organic materials without mixing them, relying on subsequent turnings to blend ingredients, while others combine their ingredients first in a wheelbarrow and then create the pile. Either way is fine. The most important task in constructing a pile is the appropriate C:N balance.

Building a compost pile (sometimes called a “heap”) is the simplest form of composting. The pile needs to be large enough to generate and hold heat, yet small enough to allow air to reach the pile’s center. To generate enough heat to raise a pile’s temperature, the pile should be 3–5 feet wide and at least 3 feet high. A larger pile retains heat better, but as a pile grows in height and width, it can become more difficult to turn. To improve aeration, build the pile on top of pallets, aeration mats, or branches. Another way to ensure better aeration is to insert perforated PVC pipes, bundled cornstalks, or wire mesh tubes vertically into the pile. Pile volume is most important during winter. As cold weather approaches, gradually enlarging the pile helps to maintain an active compost pile.

As you build the pile, add browns and greens in successive layers that are 4–6 inches thick (Figure 2). The first and last layers in the pile should consist of coarse browns like dry cornstalks, straw, or wood chips. The coarse bottom layer improves aeration and insulates the pile from the cold ground. It also absorbs liquids that may leak from above. The coarse top layer prevents materials from blowing out and protects the pile from excessive heat and moisture loss, as well as contains odors. Water is applied as the pile is built by spraying or watering each layer. When the compost has an optimum moisture content, it will feel like a wrung-out sponge — just slightly damp (see Maintaining the Compost Pile: Moisture).

The surrounding outdoor environment contains plenty of microbes to start the composting process, but a pile can easily be inoculated further during construction by sprinkling a shovelful of good garden soil or finished compost (from another pile) between each 4–6-inch layer. This inoculation speeds up the growth of beneficial bacterial populations in the pile.

Although the pile starts in layers, later turnings mix the ingredients throughout the pile. When adding kitchen scraps later to a pile, bury them 12–15 inches beneath the surface to avoid attracting flies or pests. If the pile is not dry or frozen, the scraps will partially decompose within a week or two. The pile can then be turned regularly again. If using an enclosed bin or barrel, there is no need to bury kitchen scraps.

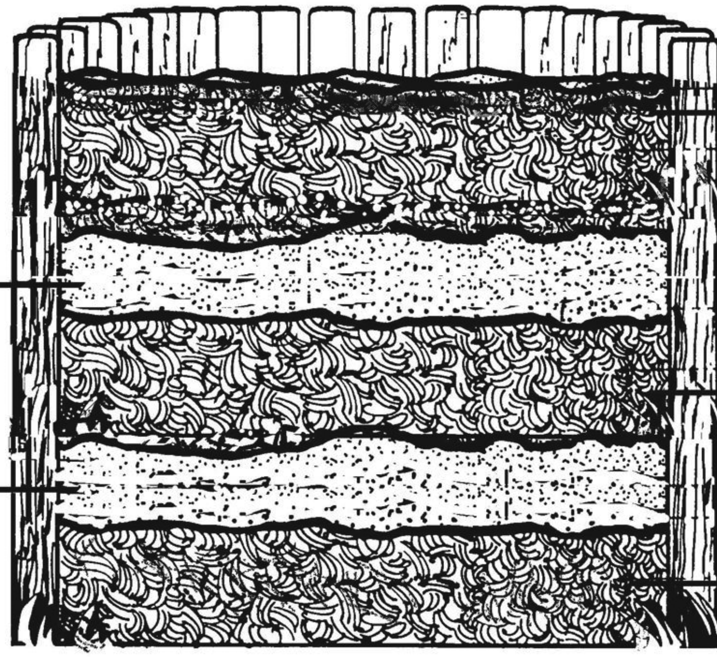

Figure 2. Simple layered compost pile.

MEET THE DECOMPOSERS

The decomposers doing the work in a compost pile make up a diverse and complex system of tiny organisms and animals, both predators and prey. While beneficial microorganisms such as bacteria, fungi, and actinomycetes (a branching type of bacteria) account for much of the decomposition, larger organisms like protozoa and invertebrates (animals lacking a backbone) also play a significant role. In a compost pile you might find nematodes, mites, springtails, flatworms, centipedes, beetles, millipedes, sow bugs, earthworms, snails, slugs, ants, fly larvae, grubs, and other tiny animals and insects.

While many organisms in a compost pile are there just to eat organic matter, others prey on smaller organisms. All the tiny animals and insects found in a compost pile are constantly mixing its materials and transporting nutrients around the compost pile by means of feeding, tunneling, excreting, and dying. The occupants in a compost pile form a complex ecosystem.

Bacteria, considered the workhorses of a compost pile, are the most numerous and active of the resident decomposers. They thrive in moist conditions and attack easily decomposed materials such as green vegetation. Actinomycetes and fungi (mostly yeasts and molds) attack the tougher, more resistant materials like plant stems and wood. They tolerate slightly dryer conditions and become especially important near the end of the composting process when resistant organic compounds, like cellulose and lignin, remain. The hyphae filaments, molds, and spores formed by fungi and actinomycetes are often visible to the naked eye in the later stages of composting.

MASTER GARDENER TIP

Having a watering can or other water source nearby and a 20-inch spike thermometer makes managing a compost pile easier.

MICROBES AND TEMPERATURE

The heat generated in a compost pile arises from the activity of organisms in the pile of decomposing organic matter. Depending on a pile's size, moisture content, and the material being composted, pile temperature can rise temporarily from 100°F to 120°F and may eventually go up to 150°F or higher. However, temperatures between 90°F and 140°F promote the most rapid composting.

Once a new compost pile is constructed, the initial temperature of the pile is usually near ambient air temperature. Psychrophilic bacteria begin the decomposition process. Their activity generates a small amount of heat that increases the pile's temperature. Psychrophilic organisms populate the pile when the temperature range is low with an optimum temperature around 55°F. The temperature change they cause allows another group, the mesophilic organisms, to then populate the pile and dominate. Mesophilic organisms thrive when the temperature is between 70°F and 100°F. Mesophilic bacteria further increase the pile's temperature range and create a perfect environment for heat-loving thermophiles to thrive. Thermophilic organisms live within a temperature range between 115°F and 155°F. Most organisms in the pile die if the temperature exceeds 160°F. If the pile temperature stays high for too long, even thermophilic microorganisms won't be able to work effectively and decomposition slows down.

As compost matures, its temperature decreases naturally, allowing mesophilic bacteria to repopulate and dominate again. With continued cooling of the pile, psychrophiles and invertebrates return. Invertebrates cannot tolerate temperatures that rise above 90°F — they die, go dormant, or escape to cooler sections of the pile. They return when the temperature drops to a more tolerable level.

Because microbial activity generates the heat in a compost pile, temperature is a useful guide to understand how well the compost is progressing. Rising temperatures reflect increased microbial activity. Warm, steady temperatures indicate steady activity. Falling temperatures suggest the microbial activity is decreasing, either because the compost is nearing maturity or because of a problem, such as a lack of oxygen, moisture, or N (See "Troubleshooting" subsection in Maintaining the Compost Pile). Pile temperature can easily be measured with a dial thermometer attached to a 20-inch stem or spike. Such gauges are found online and in nurseries or garden catalogs. Table 3 indicates some simple ways to judge a compost pile's temperature level.

HOT COMPOSTING

Home compost piles tend to be small and frequently lack N. A pile may heat up quickly after adding a large load of greens, such as grass clippings, and then gradually cool down again as the N source is utilized. To keep a pile working at a high temperature like 120°F (sometimes called "hot composting"), add N periodically in the form of greens or N fertilizers (organic or nonorganic). If more raw greens are not readily available, use commercial fertilizers to raise the N level in a compost pile. An organic N fertilizer source might be blood meal, alfalfa pellets, or livestock manure. A nonorganic N fertilizer source might be ammonium sulfate (21-0-0) or another high-N type. When employing a soluble granular fertilizer, first dissolve it in water for more uniform distribution in the pile. Approximating the amount of fertilizer to use takes practice and often the heat reaction in a pile becomes a guide. For example, a bushel (about 4 cubic feet) of dry leaves requires roughly 2.4 ounces of N fertilizer. Table 4 lists a few types of fertilizer and amounts used in composting. If adding more fresh greens to the pile, use less commercial fertilizer.

Table 3. Determining approximate compost pile temperature levels. This is a rough guideline; conditions depend on several factors such as pile size, materials used, and composting stage.

Clue	Temperature Level
Material is frozen beneath the surface	Frozen — little activity
Pile feels cold, colder than the surrounding air	Low — slow rate of composting
Pile feels warm, not hot	Moderate — rapid composting
Pile is steaming and hot to the touch	High — rapid composting
Pile is hot to the touch and the material inside the pile looks or smells charred	Too high — undesirable

Table 4. Amount of various N sources needed to supply 2.4 ounces of N. Adapted from Dickson et al. 1991.

Nitrogen Source	Percent Nitrogen	Ounces of Fertilizer
Ammonium nitrate	33	7.0
Calcium nitrate	15	16.0
Urea	46	5.2
Dried blood	12	20.0
Fish meal	10	24.0

Keeping a compost pile in the range of 130°F–135°F for three consecutive days is said to destroy weed seeds and plant pathogens. In a home compost pile, it is often difficult to sustain even a temperature of 120°F, let alone a higher one. Even if a pile's core reaches 130°F, its edges will not reach the same temperature. This is one reason why turning the pile is important — the outside edges eventually need to make it into the center for the heat treatment. Adding a source of N raises the pile temperature quickly, but it also requires more turning afterwards to regulate the pile's temperature to avoid overly high temperatures.

ACTIVATORS

Any substance that speeds up biological decomposition in a compost pile is considered a compost activator. Commercial activators are available that supply N or microorganisms or both together. Sometimes called "compost starters," these activators influence the compost pile by 1) introducing strains of microorganisms that are effective in breaking down organic matter, and 2) increasing the N and micronutrient content of the pile.

The cultures of compost bacteria sold commercially (called inoculants) are reported to improve the action of a compost pile. Some people claim they see faster composting using commercial inoculants. Researchers at Virginia Polytechnic Institute and Virginia State University, however, found no difference whether or not commercial inoculants were used. Following the instructions found in this chapter for creating and maintaining a compost pile is really all a gardener needs to have composting success.

MASTER GARDENER TIP

Leave a large enough area around your compost pile to provide good air circulation and workspace.

PLACING A COMPOST PILE

Where you put a compost pile is important for several reasons. A location that provides enough space to turn a pile and stockpile raw materials for later use is ideal. Additionally, easy access to water is helpful since the pile may need to be watered frequently, especially when adding new materials and during the summer. Avoid poorly drained sites if you live in an area with frequent rain. A sheltered location for the pile in windy areas is important since wind both cools and dries a pile. Having direct sunlight on a pile is desirable because it provides warmth in winter, but sunlight can also dry it in areas with hot summer temperatures. Using trees for shade is a benefit for the gardener and pile in areas with extreme summer heat, but make sure a pile is not right next to the trunk. Roots can grow into a compost pile that is not moved or turned (passive pile). Avoid placing a pile close to a house, fence, or other wooden structures since the pile could possibly accelerate wood decay, metal corrosion, or staining of siding. Although spontaneous combustion (self-ignited fire) within a backyard compost pile is rare, it should still be considered a remote danger.

MASTER GARDENER TIP

Use the squeeze test to check the moisture level in the compost pile.

Maintaining a Compost Pile

MOISTURE

Several factors affect the composting process, but moisture and oxygen levels are two very important ones. Water serves as a medium for chemical reactions and the movement of nutrients and microorganisms within a compost pile. Water is also essential for efficient microbial action and uniform heating of the compost. Water is periodically needed if little to no rainfall has occurred or the climate has been hot or windy. The compost "squeeze test" is a simple way to gauge the moisture level of composting materials; if you squeeze tightly, you should be able to wring out a drop or two of moisture.

Although the surface of a pile may appear dry, materials a few inches below should look and feel damp. If the pile needs water, add it with a trickling hose or sprinkler. Since water moves slowly through the mass of composting materials, turning compost while adding water often helps distribute moisture. To conserve fresh water, "used" water from certain gardening (pot rinsing) or household activities (washing or cooking vegetables) could be employed. If house water is softened, limit the amount used in composting because composting concentrates the salt levels in the compost.

A moisture content of 40%–60% is adequate without limiting pile aeration. In practice, an acceptable level of moisture depends on the materials being composted. Coarse or fluffy materials such as plant stems or straw can have a higher moisture content than 60% yet still be well aerated. Absorbent materials, however, may need less than a 40% moisture content to avoid compaction or slowing of the composting process.

OXYGEN

Rapid aerobic decomposition only occurs in the presence of oxygen. The oxygen consumed by microbes during the composting process must continually be replaced by air movement through a pile. Aeration of a pile occurs naturally by diffusion and wind and when warm air (heated by the composting process) rises through the pile and draws in cool, fresh air from outdoor surroundings. Microorganisms in a compost pile thrive at oxygen levels greater than 5% (fresh air is approximately 21% oxygen). To maintain adequate oxygen levels, periodic turning of the pile is important. Turning aerates the pile, helps remove heat, and removes excess water vapor, carbon dioxide, and other gaseous products of the composting process. Inadequate oxygen levels in the pile can lead to anaerobic conditions. This type of composting is slow, produces little heat, and creates odorous by-products.

MASTER GARDENER TIP

Improve organic matter degradability by chopping or shredding to reduce the particle size of materials.

DEGRADABILITY, PARTICLE SIZE, AND POROSITY

The nature of the materials added to a compost pile determines the speed at which decomposition occurs. Degradability and particle size are linked. Grass clippings, manure, and food scraps are highly degradable items. If they make up more than one-quarter of a pile's volume, the pile will need to be turned regularly to prevent compaction. Tough materials that contain large amounts of cellulose and lignin, like plant stems, straw, wood, and pine needles, require chopping or shredding to reduce particle size and to help accelerate decomposition. Wood often passes through the composting process with little change. However, paper, a wood derivative, decomposes quickly due to the processing it undergoes during the papermaking operation.

Most microbial activity occurs along particle surfaces, where oxygen is readily available. Because surface area increases as particle size decreases, chopping or shredding materials speeds up decomposition. Cutting up whole pieces of fruit or vegetables destroys the protective barrier of the skin or peel. Maintaining the particle size between ⅛ inch to 2 inches is key to ensuring materials are composted. Pieces that are smaller than ⅛ inch decrease pore size and pile structure, which can restrict aeration.

The compost pile's porosity affects oxygen as well as moisture content. Porosity is a measure of the spaces between particles within the pile. These spaces provide a path for air circulation. Porosity suffers when the material in the pile becomes overly wet and heavy or compacted. Adding coarse items such as straw or chopped-up cornstalks helps increase porosity in a compacted pile.

MASTER GARDENER TIP

Investing in a four-tined potato fork makes turning a compost pile easier than using a shovel.

TURNING THE PILE

Several common farm tools are used to turn a compost pile, like a pitchfork, a shovel, or a flat four-tined potato fork (sometimes called a garden fork). The last is easy to work with because of its shorter handle and handgrip. It is more maneuverable in tight spaces than any long-handled tool.

Turning a compost pile performs several beneficial functions. As the pile shrinks in size and begins to settle, turning fluffs it up, increases porosity, and allows oxygen back in. It can also break up clumps and blend materials. Turning the outer edges of the pile into the center is especially important to ensure that all parts of the pile have a chance to undergo the heat necessary to kill weed seeds and pathogens.

How frequently a pile is turned is up to the gardener. A pile can be turned every time fresh materials are added or in response to a pile's condition, such as a lack of moisture or odors developing. Turning gives the gardener a chance to add moisture when needed or to add browns when a pile becomes too wet. If the pile's temperature has risen too high (above 140°F), turning cools it. If the temperature continues to climb too high even after turning, **do not** add water since this can exacerbate the problem. Instead, flatten or scatter the pile to cool it, then rebuild it into two smaller piles, using more browns to offset the overabundance of greens or N that was added. Frequent turning is of little benefit with slow decomposing materials like wood or when the C:N ratio is high due to too many browns. These materials just need more time to decompose.

With highly degradable and shredded materials that have adequate moisture and oxygen levels, and a proper C:N ratio, daily turnings may finish up a pile within a few weeks. Weekly or monthly turnings are more realistic and can yield finished compost in about 2–4 months. Without any turnings, a passive pile on the ground may take as much as 1–2 years to decompose. To speed up a pile that is not turned frequently, add aeration by raising the pile off the ground. Construct the pile on top of a raised wooden platform or on a pile of branches. Adding a bundle of dried cornstalks or perforated 4-inch plastic PVC pipe vertically into the center of the pile also helps aerate it.

MASTER GARDENER TIP

Generally, smells in a compost pile are caused by too much moisture or too much N or greens.

ODORS

Most backyard composting presents little risk of odor development. Still, it can occur because of the wrong combination of materials used in a pile or poor pile conditions (too wet or compacted). The best way to manage odors is to correct whatever is causing them right away. Turn the pile at the first hint of an objectionable odor. An ammonia-like smell tells you the compost is immature and has too many greens; add some browns and continue the composting process. If the pile has become soggy, add some coarse carboniferous materials. In an area where it rains frequently, a plastic tarp might be needed to cover the pile.

Anaerobic bacteria are responsible for unpleasant smells, but they cannot live in an oxygenated environment. That is why turning the pile regularly is important. One gaseous product that is produced under anaerobic conditions is hydrogen sulfide, which smells like rotten eggs. Other odorous products that may form in the pile have aptly descriptive names like putrescine or cadaverine. If a pile has turned anaerobic **do not** add water or greens. Disturbing the pile releases a strong burst of odors, while leaving it undisturbed results in fewer odors released gradually over time. Instead, cover the pile's surface with an insulating, odor-absorbing layer of coarse dry materials. The smells should gradually dissipate as the pile decomposes. When the pile becomes more tolerable to work, make a new pile.

MASTER GARDENER TIP

Position your back to the wind when turning a compost pile and wear a mask if you have respiratory concerns.

SAFETY HAZARDS

All outdoor activities and sports have built-in safety issues and composting is no different. Potential of fire (see Placing a Compost Pile) and odors have already been discussed. Because of the many dry materials used or stored near composting sites, avoid smoking in composting areas. Since composting deals with fungi (yeast and molds), various microorganisms, and plenty of dust and airborne particles, wear a mask and keep your back to the wind when building, turning, or harvesting the pile. Aspergillosis is a fungal infection or allergic response that some people have after contacting the *Aspergillus* genus of fungi. It most often occurs in those with suppressed immune systems. Wearing a mask and rubber gloves and washing your hands after handling compost are simple sensible precautions. Repetitive lifting of a heavy-loaded fork or shovel can cause muscle aches or injuries if a gardener does not have adequate strength or uses improper body alignment. Lift only amounts that you feel comfortable with and, if necessary, turn a pile less frequently if muscle strain develops.

TROUBLESHOOTING

The most prevalent problem associated with backyard composting is slow decomposition. The first suspected cause is excessive drying of the pile, followed closely by a lack of N or greens. Poor aeration from overly wet or compacted materials also hinders the rate of composting or allows odors to develop. Other occasional difficulties include visiting pests or too high a temperature from an overabundance of greens. Table 5 lists various ways to identify and remedy composting problems.

MASTER GARDENER TIP

To have a quality compost product, start with an adequate ratio and volume in the pile, consistent moisture, and good air circulation.

Table 5. Troubleshooting guidelines for a compost pile. N, nitrogen; C, carbon.

Problem	Possible Causes	Clues	Remedy
Rotten odor	Anaerobic conditions because of excess moisture	Pile feels and looks soggy	Turn pile and/or mix in dry materials
	Anaerobic conditions because of poor porosity and compaction	Pile looks dense, matted, or slimy with few or no large particles	Turn pile and/or mix in coarse brown materials — straw, chipped wood, etc.
Ammonia odor	Too much N; not enough C	Pile includes a lot of grass, food scraps, or manure	Mix in browns — C-rich materials.
Slow decomposition	Not enough moisture	Pile is barely damp to dry inside	Add water and/or wet materials and turn pile
	Not enough N or slowly degradable materials	There is an abundance of brown materials in the pile — wood, straw, etc., pile is not dry	Add greens or N fertilizer, shred materials more, be patient, wood takes longer
	Not enough oxygen — anaerobic conditions	Pile is dense and looks matted or slimy, with hint of rotten odor	Turn pile and add coarse or dry material as needed
	Pile is cold — small volume	Pile is less than 3 feet high, weather is near freezing	Add fresh material, turn pile, increase pile size
	Pile is totally frozen	Frozen clumps within the pile	Wait for spring, then turn pile
	Compost is mature	Pile conditions are good	None needed
Not reaching high temperatures (over 120°F)	Small volume	Pile is less than 3 feet high	Increase pile size
	Not enough N	Pile is more than 3 feet high, weather is above freezing	Add green material or N fertilizer
	Cold weather	Pile is more than 3 feet high, weather is below freezing	Insulate top of pile with compost, straw, leaves, etc.
Pile is too hot (over 140°F)	Pile is too large	Pile is more than 5 feet high	Divide into smaller piles
	Not enough airflow — poor ventilation	Pile is less than 5 feet high, but dense and moist	Turn pile and decrease pile size
	Pile is becoming too dry. Not enough evaporative cooling.	Pile is less than 5 feet high and only slightly damp	Add water and turn pile
Pests attracted to compost pile (flies, bees, dogs, cats, rodents, skunks, etc.)	Exposed food scraps	Food scraps at or near surface of pile	Bury food 8 inches beneath the pile surface
	Meat, fish, or oily foods in pile	Evidence of digging in pile	Remove food from pile or move it into center of pile center. Use a pest-proof composting bin.

Containing the Compost

STATIONARY AND MOVABLE BINS

Bins are managed the same as a freestanding pile, but they neatly hold the compostables and may allow a gardener to stack materials higher because their design is more self-supporting. Inexpensive compost bins can be made from readily available materials and, depending on their design, they can be built tightly enough to discourage animal pests or to incorporate a roof or lid that seals out the rain.

A wide variety of bin designs are available. They differ in cost, construction materials, method of ventilation, and ease of turning. Some require an effort to build while others need little assembly. Composting bins are divided into **stationary holding units** that allow materials to compost in place and **temporary holding units** that are made light enough to disassemble and move, which facilitates compost turning. Once a bin is taken apart, moved and reassembled, compost can be turned back into it or harvested if finished. Some gardeners use temporary turning units as stationary holding units.

Temporary holding units are generally made of light construction materials. Some common building materials for these types of bins include woven-wire fencing, wood-slat fencing (snow-fence), wooden pallets, or even scrap lumber. A bin made from snow fence materials is simple to make and works more effectively with support posts at each corner (Figure 3).

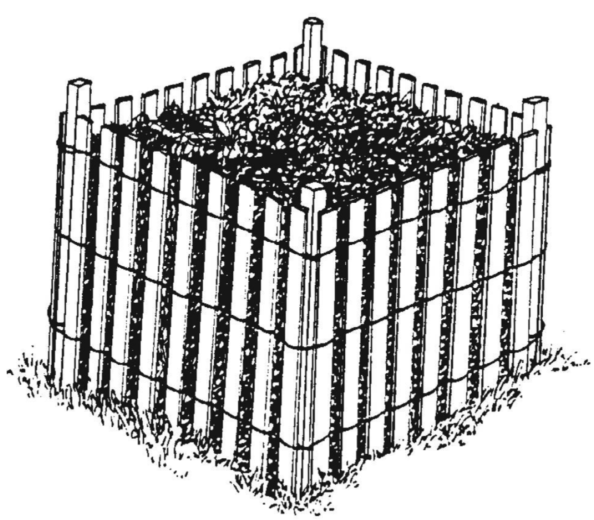

Figure 3. Snow fence–holding unit.

To construct an inexpensive wire mesh bin, use galvanized chicken wire, pig wire, or hardware cloth (sometimes called welded wire mesh). The openings in hardware cloth are smaller than chicken or pig wire, typically between 0.25 and 0.5 inch. Nongalvanized wire can be used, but it will not last as long. Attach the circle of wire to a wooden slat or t-post to provide more stability (Figure 4).

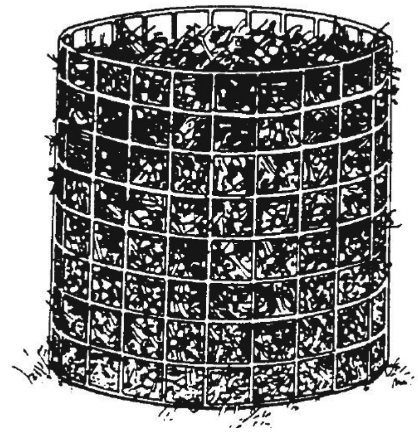

Figure 4. Wire mesh–holding unit.

Stationary holding units are usually more substantially constructed with thicker boards (Figure 5), stacked landscape timbers, bricks, or concrete cinder blocks. They are not intended to be moved. Stationary bins incorporate some access for turning and removal of compost such as one open side or removable boards on one wall. Whichever design is chosen, the bin should allow airflow through all sides.

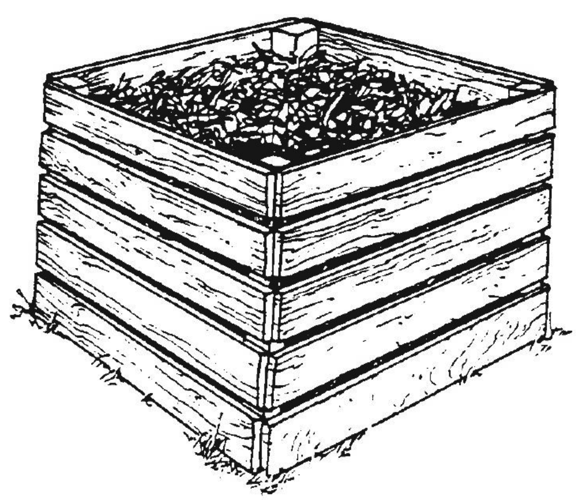

Figure 5. Wooden-pallet holding unit.

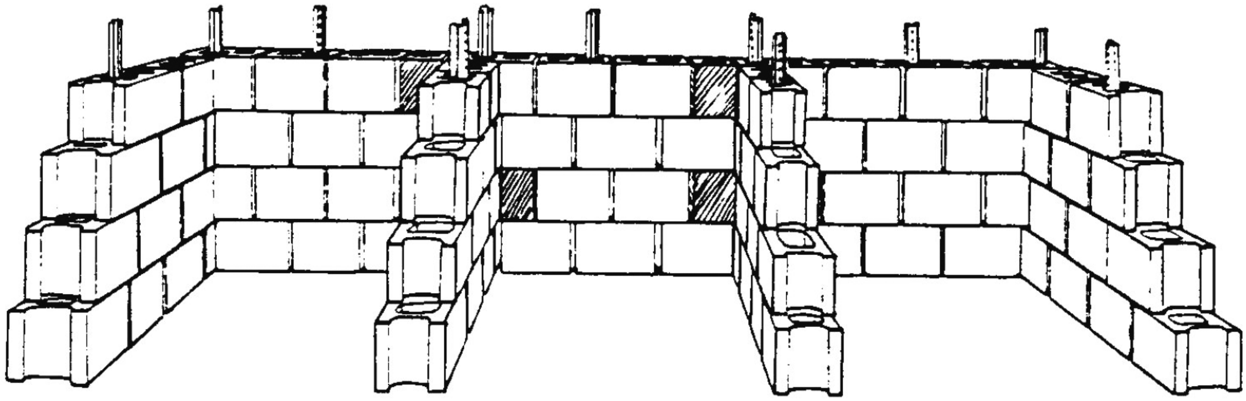

Figure 6. Concrete-block three-bin turning unit.

A bin made of concrete blocks with an open front is sturdy, durable, and easily accessible. Leave at least ½ inch between each block for air movement and stagger the joints. Driving metal rebar or t-posts through the upturned holes in the blocks stabilizes the bin (Figure 6).

A series of three connected bins is a popular design. One bin could hold fresh materials ready for use, a second might hold actively composting material, and a third could store finished compost. Another idea is to alternate turnings between two of the units, leaving one open to receive compost, and reverse the order next time.

MASTER GARDENER TIP

A purchased tumbler unit is an attractive way to compost in a small area, especially for those living in subdivisions that may have open compost pile restrictions.

ROTATING BARRELS AND DRUMS

Rotating barrels (sometimes called tumblers) eases the burden of turning a compost pile because a user spins the compost via a hand crank, tumbling the collection end-over-end. The idea is that because barrels make turning more effortless, users will do it more frequently, thus speeding up the decomposition process. Achieving finished compost quickly is determined by more factors than just frequent turning, however, including size of the materials, their degradability, proper moisture and oxygen levels, and a proper C:N ratio. Because there is no contact with the ground in a barrel, adding a shovelful of soil to the compostables helps increase the diversity of microbial life in the compost. All rotating compost units include some form of aeration holes built into the unit, interior baffles to move the materials, and loading/unloading doors.

Rotating units are handy and compact, but they are not reliable for hot composting due to the difficulty of reaching and maintaining high temperatures within the barrel's limited volume. Materials break down, just more slowly. Some commercial manufacturers claim their rotating compost units can produce finished compost in two weeks, but four weeks is more realistic. Since barrels and drums are closed containers, they keep compostables out of sight, which is a plus for urban areas or subdivisions with restrictions to open compost piles.

Many commercially manufactured rotating compost bin models are available. Most attach to a metal support structure that raises the barrel aboveground so it can be turned (Figure 7). One type rests on a very low platform only inches aboveground.

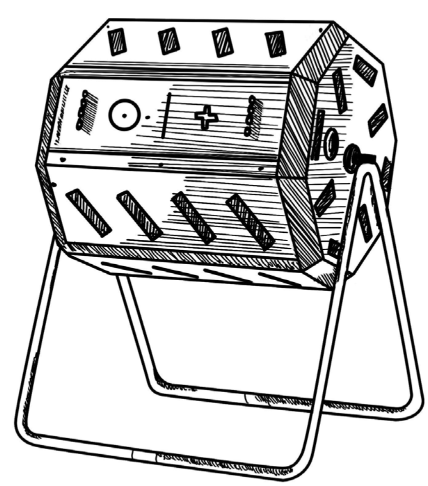

Figure 7. Rotating compost bin.

Its platform has built-in wheels that help rotate the barrel right onto the platform. Another model uses a solar-powered electric motor to rotate its drum. A few other types sit directly on the ground, rolled or pushed end over end to turn the compost.

WHEN IS COMPOST FINISHED?

Judging when a pile reaches the finished point is part of the art of composting. Composting does not really stop at a particular point. The biological decomposition of raw materials continues almost indefinitely until it becomes stable humus in soil. Compost becomes usable and considered finished or mature when the decomposition rate slows so much that the product no longer feels warm, does not create odors, nor adversely affect plants it is used around. To be safe, allow the finished compost to cure in small piles about 3 feet high for a month or two after you judge the process to be complete. Signs of a mature or finished compost include the following:

1. The compost is consistent and has a dark brown color, crumbly texture, and earthy odor.
2. Except for pieces of wood, the compost shows little evidence of the original materials added to the pile.
3. The moist pile remains cool and does not become warmer after turning.
4. Earthworms and other invertebrates have inhabited the compost pile.
5. The moist compost does not develop offensive or stale odors when stored in a closed plastic bag at room temperature for two weeks.

Benefits of Compost

The addition of compost improves soil structure, giving soil a crumbly look and feel. It also increases its porosity and organic matter content. When mixed with sandy soil, compost improves the moisture and nutrient-holding capacities. In heavy clay soil, compost particles bind with clay particles to form loose aggregates of soil that drain better and resist surface crusting and erosion. Most finished compost will have a near-neutral pH and the ability to buffer pH changes in a soil.

Although compost is not considered a fertilizer, it contains trace minerals and small quantities of major plant nutrients like phosphorus and potassium. The amount of nutrients in the compost depends on the materials composted. Nitrogen concentrations can be in the range of 0.5%–1% with phosphorus and potassium ranging from 0.2% to 0.5%. Most of the N and phosphorus are released slowly, over a period of several years, and in a pattern that tends to follow the growth patterns of plants.

Compost contains a large and diverse population of biological organisms plus organic matter that attracts earthworms and other beneficial soil organisms. This trait contributes to a compost's ability to help suppress certain soilborne plant diseases. In general, the addition of compost to most soil types improves soil health.

MASTER GARDENER TIP

Finished or mature compost is often called *humus* by gardeners, although it differs greatly. According to soil scientists, humus is a complex stable component found in native soils.

How to Use Compost

Finished compost can be used in many ways: as a mulch around trees and shrubs, as a soil amendment for gardens and landscapes, as top-dressing after core aerating a lawn, and as a component of potting soil (Table 6). Added to soil, compost benefits plants and soil structure, but using unfinished compost or compost stored under anaerobic conditions can harm seedlings and sensitive plants.

MULCH

Compost applied as mulch is placed on the top of the soil. Mulching helps reduce moisture loss, soil temperature, and suppresses weeds, while also providing supplemental organic matter and nutrients. Microorganisms in the soil slowly integrate and decompose the mulch into the soil. Compost is a good choice for use around trees and shrubs due to its soil-enhancing qualities. Apply woody composts to a layer of 2–4 inches. If the compost is finely textured, use only ½–2-inch-thick layer to provide oxygen flow to the root zone. Keep the mulch several inches away from the tree or shrub trunk to reduce the risk of decay or smothered roots.

Table 6. Amounts of compost to use. Helpful numbers: A 1-inch-deep layer covering 1,000 square feet requires about 3 cubic yards of compost. Compost weighs about 30–40 pounds per cubic foot (about 800–1,000 pounds per cubic yard).

Landscape Use	Approximate Application Rate (lb/1,000 sq ft)	Equivalent Thickness of Compost	Comments
Soil amendment for gardens and lawn establishment	3,000–9,000	1–3 inches	Mix with soil to a depth of about 4–9 inches. Use more compost for poor soils.
Soil amendment for planting trees and shrubs	3,000–9,000	1–3 inches	Mix with soil over an area of 2–5 times the root-ball width and to a depth of 6–10 inches. Use more for poor soils.
Top-dressing for lawns	400–800	⅛–¼ inch	Broadcast evenly over lawn surface. Best applied after thatching or core aerifying.
Top-dressing for gardens and shrubs	400–1,500	⅛–½ inch	Spread evenly then lightly work into the soil.
Landscape or garden mulch	1,500–6,000	½–2 inches	Spread evenly over surface. Use the higher rate with coarse woody composts.
Potting mix	Not more than one-third by volume		Blend with peat moss, sand, perlite, vermiculite, or bark.

SOIL AMENDMENT

Compost applied as a soil amendment can be used at any time of the year. In spring it add it as a soil amendment when preparing a garden bed or lawn area before planting. Mix compost into the soil to a depth at least three times the depth of the compost layer (for example, mix a 1-inch-thick layer of compost into the top 3–4 inches of soil). If only a small amount of compost is available, incorporate it into seed furrows or mix with the backfill soil for each transplant following the 1:3 compost-to-soil ratio.

TOP-DRESSING

Screen top-dressing compost to ¼ inch or smaller. Compost can easily be made uniform in size by sifting it through a welded wire-mesh screen with ¼-inch openings. Although compost with larger particle sizes is acceptable to use in a garden area as a soil amendment, avoid compost with a high percentage of wood since soil microbes will compete with garden plants for N to break down the wood. Gardens amended with woody compost require extra applications of N fertilizer to offset the N deficiency that the plants will show. This deficiency problem is usually evident in raised beds and gardens where an excessive amount of woody compost or raw plant materials are used to create the soil. In an undisturbed compost pile, small particles often tend to settle to the bottom, leaving wood pieces on the surface of the pile. Collect the woody compost to use as another source of mulch around trees and shrubs in the landscape.

Other Methods of Composting

SHEET, PIT, AND TRENCH COMPOSTING

Composting directly on or in soil works well for those who have small amounts of organic materials to recycle. Soil is rich in microbes, so decomposition should not take too long. Sheet composting is the process of spreading shredded organic materials on the soil surface in fall, as though it were a mulch, and allowing them to break down through the fall and winter into spring. These materials can be tilled into the soil although it may not be necessary. If it is objectionable for you or your neighbor to view these raw materials, cover them with a light layer of straw.

Pit composting is a way to dispose of small amounts of kitchen or yard scraps. It can be done any time the ground is not frozen. Simply dig a 12-inch hole (or deeper), add the items, cover them with at least 8 inches of soil, and let the soil microbes work on them. Choose different locations in your garden for the pits.

Trench composting is especially easy if a garden is planted in rows. Bury organic materials in narrow trenches next to planting rows (Figure 8). Rotate the trenches so that last year's planting rows become this year's trenches. In time, the entire garden may eventually be amended with "in-ground" compost.

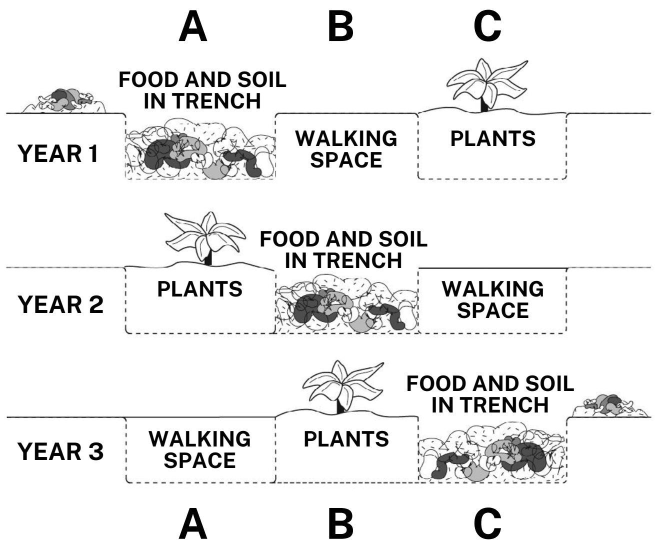

Figure 8. Soil incorporation of food scraps—rotating-trench method among food trenches, rows of crops, and walkways.

HÜGELKULTUR

Hügelkultur (pronounced hoo-gul-culture) means "hill culture" or "hill mound." This type of composting involves building up a raised bed or mound of organic materials. Start by digging a 1-foot-deep trench, fill it with logs and branches, and next add greens and browns like green and dried leaves, straw, grass clippings, cardboard, newspaper, wood chips, and aged manure. Once the mound is built to the desired height, cover it with six inches of soil, planted and mulched like a regular raised garden bed.

The gradual decay of the wood is said to be a long-term source of nutrients and as it composts, it generates heat to extend the growing season for the plants growing above it. Also, the logs and branches act like a sponge, storing rainwater during drier times. Hardwoods break down slowly and last longer while softwoods disintegrate more quickly. Woods that should not be used in the bed are walnut (juglone toxin), black locust (will not decompose), and redwood (heartwood will not decompose). The disadvantage to Hügelkultur is that the breakdown of wood uses much of the N from the pile so it will need to be added back in.

BOKASHI

Bokashi is an anaerobic option that breaks down kitchen waste by fermentation. The Bokashi mix is made with wheat bran, molasses, water, and a type of microbe called "elective microorganism" and applied to the waste in a sealed airtight container. Once the material completely ferments, the leftover solids are buried outdoors, where soil microbes finish decomposing them. The kitchen waste can include meat, bones, fats, and dairy products.

The equipment required is two straight-sided buckets, a tight-fitting lid and the bokashi culture to start the decomposition process. Drill holes in the bottom of one of the buckets to allow the liquid created to drain into the lower bucket and place it on top of a brick or other block that is inside the bucket without the holes. This allows the collected liquids to be used outdoors to amend the soil. The collected liquid has a high acidity level and is carefully diluted at a ratio of 1 part collected liquid to 100 parts fresh water. The remaining solids are pit composted.

The benefit of using this fermentation process is that meat, fat, and bones can be decomposed. The Bokashi composting fermentation process is completed in a couple of weeks; however, the entire composting of the leftover items in the soil takes several months and you cannot plant near where the fermented material is buried.

VERMICULTURE (WORM COMPOSTING)

Worm composting (vermiculture) relies on worms to digest paper, manure, and vegetation (mostly vegetable and fruit leftovers). During the breakdown process the worms leave behind their manure (castings) that are a high-quality soil amendment called **vermicompost**. Worm composting is a suitable option for apartment buildings or homes without yard space. The worms live in an enclosed bin that gives off very little odor (Figures 9–11). The type of worms used for vermicomposting are red worms (*Eisenia fetida*), not the common soil-dwelling earthworms that most people are familiar with. Red worms need a dark, cool, moist, and aerobic environment. Mix their food and bedding in shallow layers in a closed box or bin. The bedding provides a light, airy habitat for the worms to move around in and they eat the food provided. Putting bedding material on top of their food helps reduce fruit fly populations from entering the food. Typical bedding materials include shredded paper, straw, peat moss, and sawdust. Do not use paper that has a sheen or plastic coating.

Keep the bin in a cool place. Many keep it under the sink in the kitchen for convenience, but a basement is a good location as well. Worms live and work effectively at temperatures between 50°F and 70°F (10°C–20°C). If the bin freezes or gets too hot, the worms die. Knowing when to harvest the bin contents is often done by sight. When the material in the bin becomes uniform, dark, and soil-like in texture, harvest it and use the compost. This usually takes 3–6 months. To learn how to properly remove the worms from their rich vermicompost, check the references at the end of this chapter or those in online sites.

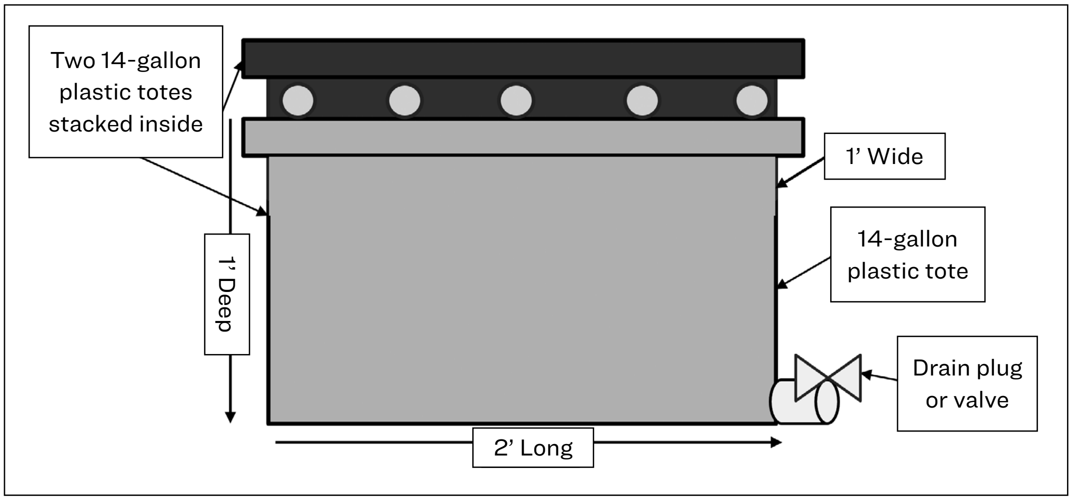

Figure 9. Side view of fourteen-gallon double-stacked plastic tote diagram. Adapted from Angima et al. 2011.

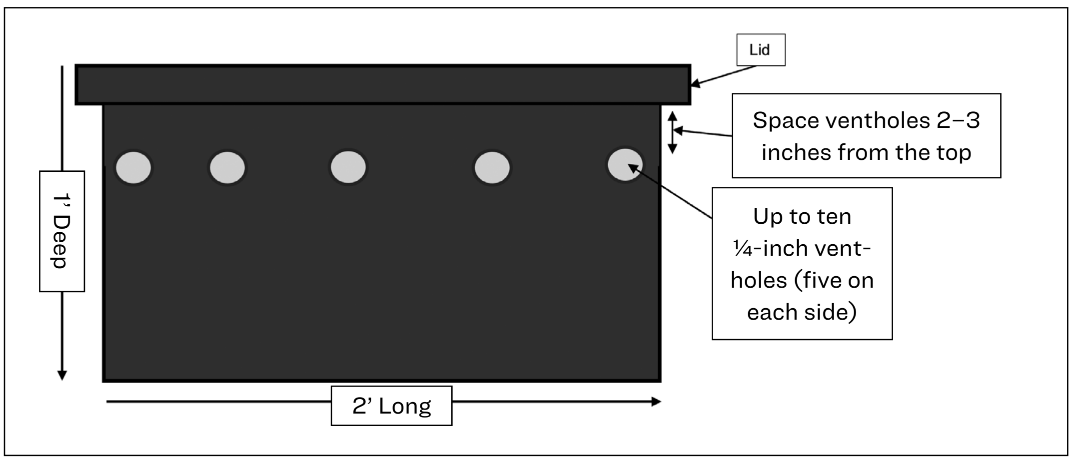

Figure 10. Side view of inner fourteen-gallon tote. Adapted from Angima et al. 2011.

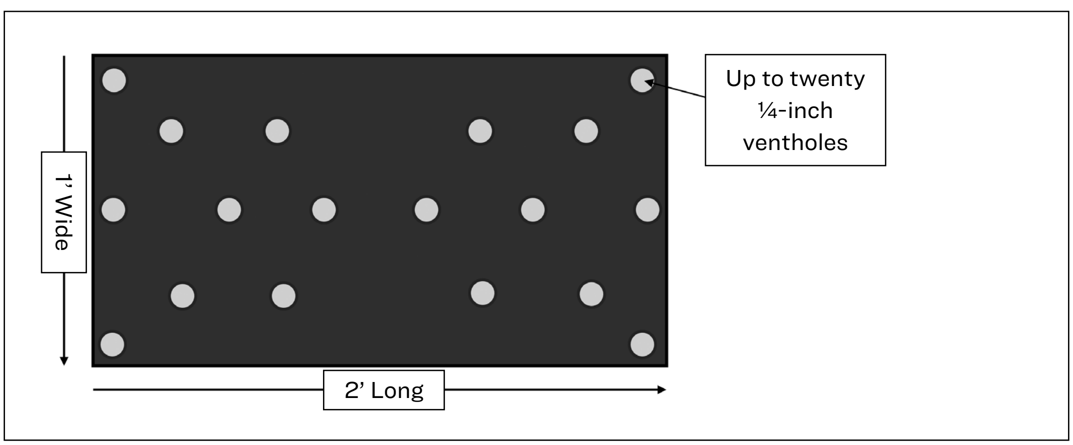

Figure 11. Bottom view of inner fourteen-gallon tote. Adapted from Angima et al. 2011.

Further Reading

BOOKS

Angima, S., M. Noack, and S. Noack. 2011. *Composting with Worms*. (EM9034). Aurora: Oregon State University Extension.

Appelhof, M., and J. Olszewski. 2017. *Worms Eat My Garbage, 35th Anniversary Edition: How to Set Up and Maintain a Worm Composting System: Compost Food Waste, Produce Fertilizer for Houseplants and Garden, and Educate Your Kids and Family*. North Adams, MA: Storey.

Balz, M. 2021. *No Waste Composting: Small Space Waste Recycling, Indoors and Out*. Beverly, MA: Cool Springs Press.

Benton, C. ed. 1994. *Establishing a Home Composting Program in Your Community*. Seattle, WA.

Campbell, S. 1998. *Let It Rot: The Gardener's Guide to Composting*. 3rd ed. Pownal, VT: Storey Communication.

Canada's Office of Urban Agriculture. n.d. *Urban Home Composting: Rodent-Resistant Bins and Environmental Health Standards*. Vancouver, BC.

Dickson, N., T. Richard, and R. Kozlowski. 1991. *Composting to Reduce the Waste Stream*. (NRAES-43). Ithaca, NY: Cornell Cooperative Extension/Natural Resource, Agriculture, and Engineering Service.

Footer, A. 2014. *Bokashi Composting: Scraps to Soil in Weeks*. Gabriola, BC: New Society.

Martin, D., and B. Pleasant. 2008. *The Complete Compost Gardening Guide*. North Adams, MA: Storey.

Martin, D., and G. Gershunny. ed. 2018. *The Rodale Book of Composting, Newly Revised and Updated: Simple Methods to Improve Your Soil, Recycle Waste, Grow Healthier Plants, and Create an Earth-Friendly Garden*. New York: Rodale Books.

BOOKLETS AND PAMPHLETS

University of Idaho Extension

BUL 982	*Vermicomposting at Home*
CIS 1016	*Don't Bag It! Recycle Your Grass Clippings*
CIS 1066	*Composting at Home*
CIS 1194	*Composting and Using Backyard Poultry Waste in the Home Garden*

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