

Chapter 8

BACKYARD COMPOSTING



I. Introduction	2	V. Using Compost	14
II. The Composting Process	2	A. Benefits of Compost	14
A. Process Basics	2	B. Application	14
B. Decomposers	2	C. Compost Quality	15
C. Factors Affecting the Composting Process	4	VI. Alternatives to Composting	15
III. Composting Methods	7	A. Grass Recycling	16
A. Piles	7	B. Mulching	16
B. Bins and Ventilated Containers	7	C. Worm Composting	16
C. Barrels and Tumblers	7	D. Soil Incorporation	16
IV. Making and Managing a Compost Pile	8	VII. Plans for Constructing Composting Bins	16
A. Materials	8	A. Wooden-Pallet Holding Unit	17
B. Additives	9	B. Wire-Mesh Holding Unit	17
C. Inoculants	10	C. Snow-Fence Holding Unit	17
D. Location	10	D. Wood-and-Wire, Three-Bin Turning Unit	17
E. Volume	10	E. Wooden Three-Bin Turning Unit	17
F. Building Compost Piles	10	F. Worm Composting Bin	17
G. Turning	11	G. Concrete-Block Holding Unit	17
H. Moisture Management	12	H. Concrete-Block, Three-Bin Turning Unit	18
I. Odor Management	12	Further Reading	18
J. Troubleshooting	12		
K. Judging When Composting Is Finished	12		

Chapter 8

Backyard Composting

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I. Introduction

Composting is the biological decomposition of organic matter. We practice it to recycle unwanted organic materials, such as yard trimmings and food scraps, and to produce compost, a valuable soil amendment. Finished compost takes on many of the characteristics of humus, the organic fraction of soil. Like humus, compost improves garden soils and aids in plant growth.

While composting occurs naturally, human intervention can accelerate it. The quality of the compost and the production speed depend upon several factors that human composters can manipulate.

II. The Composting Process

A. Process Basics

Composting is an aerobic, or oxygen-requiring, process. The microorganisms and other biological decomposers responsible for composting consume oxygen along with the organic materials and produce primarily compost, carbon dioxide, water vapor, and heat (Fig. 1). The heat that is produced raises the temperature of the composting materials.

The oxygen consumed during the process must continually be replaced by air movement through the materials. Because the penetration of air may be inadequate or inconsistent, some decomposition inevitably occurs under anaerobic conditions (without oxygen). Anaerobic decomposition is slower than aerobic decomposition, produces little heat, and creates odorous byproducts. The challenge for the composter is to minimize anaerobic decomposition by creating and maintaining conditions that favor the desired decomposers.

B. Decomposers

Decomposers are the microorganisms and invertebrates that accomplish composting. Naturally occurring microorganisms, such as bacteria, fungi, and actinomycetes, account for most of the decomposition, as well as the rise in temperature that occurs in the compost process. Invertebrate animals, such as mites, millipedes, insects, sow bugs, earthworms, and snails, produce much of the physical decay where the temperature is relatively cool (below 90°F).

Different decomposers prefer different organic materials and environmental conditions. A diverse microbial population represents a healthy compost pile. If the environment becomes unsuitable for a particular decomposer, that organism will become dormant, die, or move to a more hospitable area of the pile. Changing conditions during the composting process lead to an ever-changing ecosystem of decomposer organisms.

1. Microorganisms: food and water.

- a. Bacteria are the workhorses of the compost pile. They are the most numerous and active decomposers. Bacteria generally prefer moist conditions and attack the easily decomposed materials such as green vegetation, food scraps, and manure.
- b. Actinomycetes (a branching type of bacteria) and fungi (yeast and molds) attack the more resistant materials that bacteria use less efficiently. Fungi are particularly good at decomposing woody materials. These groups of organism are also more tolerant of dry conditions than bacteria. They become more important near the

end of the process when the resistant organic compounds remain (e.g., cellulose and lignin compounds). The filaments, molds, and spores formed by fungi and actinomycetes are often visible in the later stages of composting.

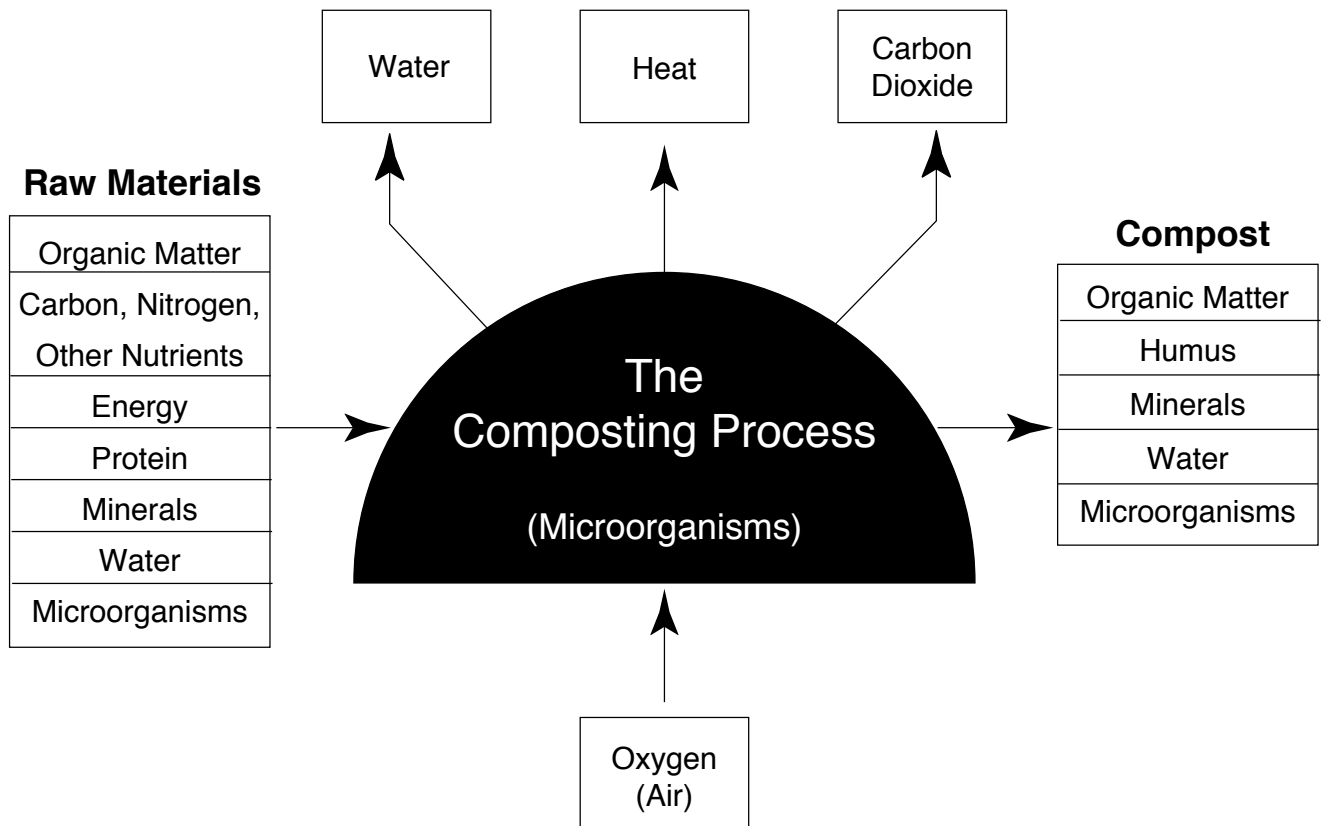
2. Aerobic vs. anaerobic microorganisms.

- a. Aerobic organisms provide the most rapid and effective composting. They thrive at oxygen levels greater than 5 percent (fresh air is approximately 21 percent oxygen).
- b. Anaerobic bacteria prevail when oxygen is scarce. Anaerobic conditions are undesirable in a compost pile because the decomposition products are often odorous. For example, a common product of anaerobic decomposition is hydrogen sulfide that smells like rotten eggs. Other odorous anaerobic products, some with aptly descriptive names like “putrescine” or “cadaverine,” are formed from organic nitrogen compounds.

3. Microorganisms and temperature—Microorganisms are grouped according to the temperatures in which they thrive.

- a. Psychrophilic organisms work in the lowest temperature range and have an optimum temperature of about 55°F. Mesophilic organisms thrive at temperatures between 70° and 100°F. Thermophilic organisms are heat-loving and operate in a range between 113° and 155°F. If the temperature rises above 140°F, even the thermophilic microorganisms begin to suffer and decomposition slows.
- b. Aerobic microorganisms are the most important initiators of decomposition and temperature rise within the compost pile. The initial temperature of the compost pile is usually near ambient air temperature. Psychrophilic bacteria typically begin the decomposition. Their activity generates a small amount of heat that increases pile temperature. This change in environment

Fig. 1. The composting process.



allows mesophilic organisms to dominate. In turn, the more rapid decomposition by mesophilic bacteria further increases the pile temperature and creates an environment for the thermophiles to thrive. Later, as the compost matures, temperature decreases, mesophilic bacteria again dominate, and finally psychrophiles and invertebrates return.

- c. Although microorganisms are the primary decomposers in a compost pile, larger organisms also play a significant and beneficial role. Callemacroorganisms, invertebrates, or secondary decomposers, these organisms include nematodes, flat worms, earthworms, snails, slugs, mites, springtails, beetles, ants, fly larvae, grubs, centipedes, millipedes, and sow bugs. Macroorganisms feed on plant tissue, partially decomposed organic matter, or other organisms. In the process, they break particles into smaller pieces, mix and transport nutrients, convert materials into forms that microorganisms can digest, and add their own byproducts and cell tissue to the compost. Macroorganisms are not tolerate of thermophilic temperatures. As temperatures rise above 90°F, they will die, become dormant, or escape to the soil or cooler sections of the pile. They will return after the temperature falls to tolerable levels.

C. Factors Affecting the Composting Process

1. Aeration—Rapid aerobic decomposition can only occur in the presence of sufficient oxygen. Aeration replaces the oxygen-deficient air fresh oxygen-rich air inside the compost pile. It also removes heat, water vapor, carbon dioxide, and other gaseous products of the composting process. Aeration occurs naturally by diffusion, wind, and when warm air (heated by the compost process) rises through the pile and draws in cool, fresh air from the surroundings.
 - a. Porosity: The compost pile's porosity and moisture content affect air movement through the pile. Porosity is a

measure of the spaces between particles within the compost pile. These spaces provide a path for air circulation. Porosity suffers as the composting material becomes wetter because the material in the pile becomes heavier and more compacted. Adding coarse materials, such as leaves, straw, or cornstalks, increases the pile's porosity, resists compaction, and promotes good aeration.

- b. Turning: As composting proceeds and the materials decompose, they shrink in size and begin to settle. Settling reduces the pile's air spaces and restricts aeration. Regular mixing of the pile, referred to as turning, reverses the effects of settling. Although turning recharges the pile with fresh air, its main effect is to fluff up the material. This increases the pile's porosity and improves natural air circulation. Turning also blends the composting materials and breaks apart clumps of materials. Because of these benefits, turning speeds the composting process.
2. Moisture—Microorganisms need moisture. Water serves as a medium for chemical reactions and provides a means for movement of nutrients and microorganisms. On the other hand, too much water makes the materials soggy and heavy, hindering aeration as explained above.
 - a. Generally, a moisture content in the range of 40 to 60 percent provides adequate moisture without limiting aeration. In practice, the acceptable level of moisture depends on the materials that you are composting. Coarse or fluffy materials such as leaves or straw can be wetter than 60 percent moisture content and still aerate well. Absorbent materials may need to be well above 40 percent moisture to compost rapidly.
 - b. The "squeeze" test is an easy way to gauge the moisture level of composting materials. The material should feel damp to the touch, but not dripping wet. Water should drip from the mate-

rial only when you squeeze it tightly in your hand. If you can't squeeze water out, the pile is too dry (see Section IV, Subsection H on "Moisture Management," page 7-12).

3. Carbon-to-nitrogen ratio (browns and greens)—Microbial decomposers obtain many nutrients from the composting materials but carbon (C) and nitrogen (N) are the nutrients that affect the process the most. Microorganisms primarily use carbon compounds as an energy source and ingest nitrogen for protein.
 - a. Because they require a balance of both nutrients, the proportion of carbon to nitrogen is important when combining organic materials to make compost. The ideal ratio (C:N) of these two elements is about 30 parts carbon to 1 part nitrogen by weight. At this 30:1 ratio, microorganisms decompose organic material quickly. When the C:N ratio is higher, the shortage of nitrogen slows decomposition. When the C:N ratio is too low, excess nitrogen is lost to the atmosphere in the form of ammonia gas. In concentrated amounts, this can lead to odor problems. Generally, C:N ratios within the range of 20:1 to 50:1 yield good compost in a reasonable time without odor problems.
 - b. Most composting materials, by themselves, do not contain C and N in the right ratio (Table 1). Still, you can

achieve the desired C:N ratio by mixing several materials together in appropriate proportions. We refer to the materials used and their proportions as a "recipe."

Note: In a backyard or home composting situation, it is impractical for you to be precise when developing recipes. You can roughly predict the C:N ratios of mixtures from estimated C:N ratios of the ingredients as in Table 1. An easier approach is to develop recipes by thinking of carbon sources as "browns" and nitrogen sources as "greens" and then combining brown and green materials in rough proportions. For example, a mix of one to three volumes of browns (dry leaves) to one volume of greens (fresh grass clippings) often produces a C:N ratio in the 30:1 to 50:1 range.

4. Surface area and particle size—Most microbial activity occurs along particle surfaces, where oxygen is available from the adjacent air spaces. Because surface area increases as particle size decreases, chopping, shredding, or cutting material into smaller pieces usually speeds decomposition. There is a limit to this benefit. Smaller particles also decrease the pore size and structure and restricts aeration. Therefore, some compromise is necessary. Usually a mixture of particles in the range of 1/8 inch to 2 inches (in the largest dimension) gives good results.
5. Degradability—The nature of the materials largely determines the speed at which composting occurs. Not all organic materials decompose at the same rate.
 - a. Overall, microorganisms easily digest materials made from sugars, starches, proteins, and fats such as food scraps, manure, and green vegetation. Typically, nitrogen-rich materials or "greens" are the first to decompose in the composting process.
 - b. Materials such as straw and plant stems contain a large amount of cellulose that takes longer to decompose.

Table 1. Typical carbon to nitrogen ratios of selected home composting materials.*

	Material	C:N ratio
BROWNS	Dry leaves	60:1
	Corn stalks	60:1
	Straw	80:1
	Shrub trimmings	50:1
	Waste paper	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.

Woody materials contain a biologically resistant compound called lignin. Raw wood products, including sawdust, are particularly difficult to decompose biologically and pass through the composting process with little change. Paper, a wood derivative, decomposes relatively fast because of the processing it receives in the papermaking process. You can improve the degradability of a biologically-resistant material by reducing its particle size and ensuring that adequate amounts of nitrogen and water are available.

6. Temperature—Heat, generated by microorganisms, raises the temperature of the compost pile. Depending on the pile size, moisture content, and the material that you are composting, pile temperatures will rise temporarily to 100° to 120°F and may even surpass 160°F. Temperatures between 90° and 140°F promote rapid composting. Microbial activity decreases as the temperatures reach 140°F or higher. Many of the organisms die when temperatures exceed 160°F.
 - a. Because microbial activity and the heat generated are related directly, temperature is a useful guide in understanding how well composting is progressing. Rising temperatures reflect increased microbial activity. Warm, steady temperatures indicate steady activity. Falling temperatures suggest that the compost microbial activity is decreasing, either because the compost is maturing or because a problem, such as lack of oxygen or moisture, exists.

You can easily measure temperatures in your home compost pile with a dial thermometer with a 12-inch stem (available from garden stores and catalogs). You also can use the clues in Table 2 to judge the temperature level.

- b. Home composting piles tend to be small and are frequently short of nitrogen. Therefore, if high temperatures (above 120°F) are reached at all, they are usually sustained for only short periods of time. Piles typically get hot soon after adding a large load of green material, such as grass clippings, and then gradually cool. High temperatures have the advantage of killing pathogenic organisms and weed seeds. Moderate temperature also result in effective composting, however. It is not important to achieve high temperatures if the materials being composted are not diseased and do not contain many seeds.
7. Time—Depending on the composting method, materials, and conditions, it can take several weeks to several years to produce finished compost. Methods that involve little or no turning usually require more than a year to produce mature compost. With regular turning, adequate moisture, and a good mixture of carbon (brown) and nitrogen (green) materials, compost is ready for use in 3 to 4 months. With daily turnings and highly degradable material, you can reduce the composting time to less than a month. Frequent turning is of little benefit if you are using slow decomposing materials or if the C:N ratio is high (too many browns). These materials need time, more than oxygen, to decompose.

Because an immature compost can cause damage to plants, it is best to be conservative in judging when composting is finished (see Section IV, Subsection K, “Judging When Composting Is Finished,” page 7-12).

Table 2. Indirect clues of compost pile temperature level*.

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 of the pile looks or smells charred	Too high—undesirable

*These are rough guidelines. Actual conditions depend on factors such as pile size, materials, and composting stage.

III. Composting Methods

The container and the manner and frequency of turning characterize backyard composting methods. Common backyard methods include piles, bins, ventilated containers, and rotating barrels

A. Piles

1. A freestanding pile or heap is the simplest form of composting, and it works very well. You can add materials to the pile as they become available or stockpile until you have sufficient materials to make a good sized heap. In either case, it is helpful to have two or three piles—one for fresh material, another in the active composting stage, and possibly a third for maturing compost. To generate enough heat to raise the pile temperature, an actively composting pile should be 3 to 5 feet wide and at least 3 feet high. Larger piles retain heat better, but as piles grow in height they become more difficult to aerate.
2. You can turn piles regularly or not at all. A pitch fork is the typical turning device, although you can use other tools to loosen the pile. If the pile receives little or no turning, then add highly degradable materials only in moderation.

B. Bins and Ventilated Containers

Bins are managed in almost the same manner as piles. Compared to piles, bins more neatly contain the composting materials and allow you to stack them higher. Certain types of bins also discourage animal pests and keep rain away from the composting materials. See pages 7-16,17,18 for the wide variety of bins that you can use. They differ in cost, construction materials, ventilation, and ease of turning. Some bins are expensive or require effort to build while others need little assembly and may even be free. Backyard composting bins are sometimes grouped into two basic categories: (1) holding units that let the materials decompose undisturbed, and (2) turning units that allow regular turning of the composting material. The distinction between holding and turning bins easily becomes blurred. Some structures typically used for turning often can

serve as holding units and holding bins can be turned.

1. Holding bins—Generally made of light materials, holding bins are easy to take apart and move. Once the bin is apart, you can turn or harvest the finished compost. Common bin materials include circles of wire fencing or hardware cloth, old wooden pallets tied together, snow fencing, or wire mesh framed in wood. You can make stationary bins with wooden slats or by stacking together landscape timbers, concrete blocks, or rocks. In all cases, the bin should allow air flow through the sides and back. Aeration aids will improve air circulation. Examples include pallets, placing aeration mats or branches under piles and branches, or inserting perforated pipes or wire tubes vertically into the composting materials. Several manufactured holding bins are available. Some are intended to compost food scraps. Most of these are closed containers with air vents in the sides. Others have vents only at the bottom and top of the bin. These bins are not designed to maintain aerobic conditions completely. They control odors by enclosing the materials—and the odor—inside the container. Yard trimmings and food scraps are added at the top, and compost is removed from the bottom.
2. Turning bins—Turning units contain the composting materials while providing easy access for turning. Materials are either turned in place or shifted back and forth between adjacent bins. Turning bins are similar to the stationary holding bins described above, but with features such as an open side, removable walls, and multiple bins. Turning units with a series of three bins are popular. Similar to the three-pile system, one bin contains fresh material, the second actively composted material, and the third holds maturing compost.

C. Barrels and Tumblers

Rotating barrels or drums turn the materials inside as they spin like a clothes dryer (via a

hand crank) or tumble end-over-end. There are many manufactured models, although you can make rotating barrels yourself. One commercial model uses a solar-powered electric motor to continuously rotate the drum. Some drums and multisided tumblers are designed to be rolled along the ground. All of these composting units include some means of aeration plus loading and unloading features. Because you must load the barrels in batches, it is necessary to store fresh materials. As an alternative, you can use two drums—while one drum is composting, the other is being loaded with fresh material. Given a large enough batch of material, rotating barrels should generate high temperatures.

The idea behind rotating barrels is to make turning effortless. Therefore, the material will be turned more often and decompose faster. Several manufacturers claim their product can produce finished compost 2 weeks (although 1 month is a more realistic goal). In order to achieve quick composting, other factors including easily degraded and shredded materials, proper moisture, and C:N ratios must accompany the benefits of frequent turning.

IV. Making and Managing a Compost Pile

Composting is a natural and flexible process. It will take place under a wide range of conditions and methods regardless of either the efforts or neglect of human composters. Nevertheless, good management helps the process along and minimizes nuisances. Management determines how soon the compost is produced. For example, turning a compost pile weekly can yield compost in 1 to 2 months, with adequate moisture content and a good combination of materials.

Without turning, composting takes 6 months to 2 years. You can make excellent-quality compost either way.

A. Materials

Almost all natural organic materials will decompose, but not everything belongs in the backyard compost pile as you can see in Table 3. Generally, you can compost garden vegetation, landscape trimmings, and most plant-derived food scraps without concern.

1. It is prudent to avoid composting plants harboring disease, or treated with persistent herbicides, or carrying many seeds and insects. Also, it is a good idea to keep out certain noxious weeds, including morning glories (bindweed), and grasses (such as quackgrass) with rhizomatous root systems. Backyard compost piles do not reliably produce the high temperatures necessary to thoroughly kill

Table 3. Materials that you should and should not compost (adapted from NRAES-43, “Composting to Reduce the Waste Stream”).

YES	NO
Aquatic plants	Oily foods (attract pests)
Bread	Butter
Branches—chipped	Bones
Brush—chipped	Cheese
Coffee grounds	Fish scraps
Corn cobs	Lard
Cut flowers	Mayonnaise
Egg shells	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 roots
Sod	Plants with severe insect infestation
Tea leaves and bags	Weeds that have gone to seed
Vegetables	
Vegetable trimmings and tops	Possible sources of toxins
Weeds without seeds	Black walnut leaves
Wood ash	Cedar chips, bark, branches
Wood chips	Grass treated with persistent herbicides
Wool waste	

rhizomes, weed seeds, and plant diseases. For the same reason, do not add cat and dog manure, which may contain pathogens, to backyard piles. Avoid adding fatty and oily foods because they tend to attract animal pests (rodents, skunks, dogs, and cats). Also, oily foods are quick to decompose and may generate odors.

2. Another group of materials to be cautious about are those that may contain natural or manufactured compounds that are toxic to either plants or the composting decomposers. Examples include grass and vegetation containing persistent herbicides, leaves from black walnut trees, and cedar wood. Even if these materials decompose, the compost might retain some of the toxins. If you want to compost these materials, segregate them from the other materials. Also, use the compost only where the toxins will not have a negative effect. For example, use composted walnut leaves as mulch for walnut trees or use herbicide-treated grass compost as lawn top-dressing.
3. The degradability of materials is also a consideration. Highly degradable materials such as grass clippings, food scraps, and manure, require more turning and attention (see odor control). Slowly degradable materials need shredding and time for composting, even with regular turning. Chop or shred before composting branches, plant stems, and other thick or large particles of material. The less degradable a material is, the more important shredding becomes. Also, chop whole pieces of fruit and vegetables to break the protective barrier of the skin or peel.

B. Additives

Some composters add lime, wood ash, inorganic fertilizers, and organic nutrient sources into compost piles to enhance the compost or the composting process. These additives are not necessary to composting. Depending on the compost pile conditions, they may speed the process or provide no benefit at all.

1. Lime—Rarely helpful to the composting process, lime is added sometimes to neutralize acidic materials and organic acids formed during composting. The effect of these acidic conditions, however, is seldom damaging. Composting decomposers can work at a relatively low pH (acidic) and further decomposition tends to push the pH toward neutral. Lime also encourages ammonia loss, especially if the C:N ratio is low (a lot of greens).
2. Wood ash—Although wood ash adds mineral nutrients to the compost, it has little effect on the composting process. Like lime, wood ash increases pH and encourages ammonia loss. Usually, the composting process is not adversely affected by the amount of wood ash that a household wood stove generates.
3. Inorganic fertilizers—Because backyard composting piles usually lack nitrogen, inorganic fertilizers tend to speed the composting process. The compost is not greatly affected. Inorganic fertilizers should be dissolved in water and mixed into the compost pile. You can only approximate the correct amount of fertilizer to add. For example, a pile of dry leaves generally requires about 2.4 ounces of nitrogen per bushel (about 4 cubic feet). Table 4 lists the corresponding amount of various types of fertilizers. Use less fertilizer as you add more greens to the pile. If you add too much fertilizer, nitrogen will be lost to the atmosphere as ammonia or leached from the pile into the ground. In part, this occurs because the

Table 4. Amount of various nitrogen sources needed to supply 2.4 ounces of nitrogen (adapted from NRAES-43, “Composting To Reduce the Waste Stream”).

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

nitrogen from fertilizer is available to the decomposers more quickly than the carbon from the organic materials.

4. Organic nutrient sources—Concentrated organic sources of nitrogen such as manures, dried blood, fish meal, fish emulsion, and cottonseed meal are better sources of nitrogen. Compared to inorganic fertilizers, these sources release nitrogen that more closely matches the availability of organic carbon.

C. Inoculants

Soil, vegetation, food scraps, compost, and the environment contain the desired organisms in ample quantities to start the composting process. Some composters claim to see faster composting after using inoculants. Others have found no difference. In any case, inoculants, activators, or compost starters are not necessary.

D. Location

The pile should not be in contact with trees, wooden fences, and buildings because the compost will accelerate wood decay and metal corrosion. Also, spontaneous combustion (self-ignited fire) within a backyard composting pile is a remote yet possible danger.

1. Shelter—A sheltered location is an asset because wind both cools and dries the pile. Direct sunlight can be undesirable. Although it provides warmth in the winter, sunlight dries the pile in the summer.
2. Water—The location should provide access to water as you will need to water piles frequently during the summer. You are more likely to keep piles moist if the water source is convenient—for example, within reach of a garden hose. Avoid poorly drained locations that gather standing water because materials will become waterlogged.
3. Space—Finally, the location should provide enough space to turn the pile and to stockpile raw materials and finished compost, if necessary.

E. Volume

A pile or bin should be large enough to generate and hold in heat, yet small enough to allow air to reach its center. As a general

rule, the minimum pile or bin dimensions should be 3 by 3 feet at the base and 3 feet high. Piles and bins that are larger than 5 feet high or 5 feet wide are difficult to aerate and require more turning.

Pile volume is most important during the cold season. Therefore, start new piles in the summer and gradually enlarge them as winter approaches.

F. Building Composting Piles

You can construct compost piles gradually from the ground up by adding material as they become available, and in batches by stockpiling materials until you have accumulated a certain amount. This is rarely an either/or choice—a pile or bin can grow both gradually and in batches. Adding fresh material in large quantities is more likely to produce high temperatures but it also increases the chance of odors and requires more turning.

1. Mixing or layering ingredients—The most important task in constructing a pile is to mix together the appropriate ingredients, including water. Blend brown and green ingredients well for microorganisms to obtain a balance of both carbon and nitrogen. Some composters add materials without mixing and rely on subsequent turnings to blend the ingredients. Others add brown and green materials in successive layers, 3 to 6 inches thick, with the first and last layers consisting of coarse brown materials as in Fig. 2. Another variation intersperses layers of soil, fertilizer, or manure among the brown and green layers. Layering provides an easy and visual way to proportion materials. The layers, however, make a poor blend of materials. Turning is necessary to mingle the brown and green materials together.
2. Burying materials—When adding to piles continuously, bury materials (certain food scraps) that might attract flies and pests 6 inches beneath the surface of open piles and bins. If the pile is not dry or frozen, the material will partially decompose in 1 to 2 weeks. Then you can turn the pile as desired. When adding food materials in large quantities, mix

them into the pile, cover them, and then turn the pile a week or so later. If you are using enclosed bins and barrels, you do not need to bury materials.

3. Insulating the pile—Placing a layer of coarse material at the base of piles and bins improves aeration and insulates them from the colder ground. The base layer also absorbs liquids that may leak from above. Appropriate materials include dry leaves, corn stalks, straw, wood chips, and compost. You also can use these materials to cover the surface of piles. A 3- to 6-inch outer layer protects piles from heat and moisture loss and helps to contain odors.

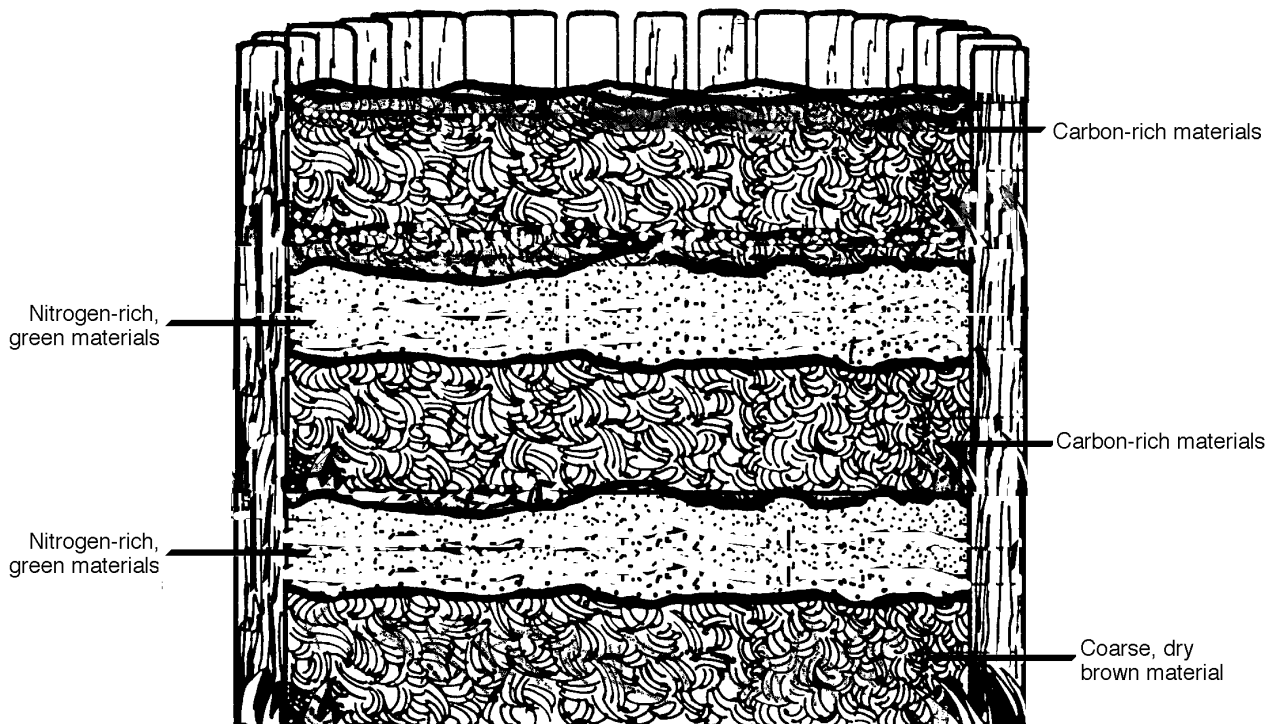
G. Turning

Although turning is not essential to backyard composting, it performs several beneficial functions. It improves aeration by increasing porosity and charging the pile with fresh air. It also blends materials, breaks apart particles, and removes heat, water vapor, and other gases contained in the pile. Turning speeds the process and helps in managing temperature, moisture, and odors.

There are few hard-and-fast rules for turning composting materials. You can do it on a regular schedule (weekly), when you add fresh materials, occasionally at your convenience, or in response to the pile's conditions. Turn piles according to the following guidelines.

1. To speed the process and promote high temperatures—In most cases, the more often you turn a pile, the faster it composts. Therefore, the pile is more likely to achieve high temperatures. Turning is effective with moderately to highly degradable materials. It has limited effect on slowly degradable materials.
2. To blend materials—Turn piles when materials are poorly-mixed, when different sections of the pile show differences in consistency, color, moisture, temperature, or odor.
3. To cool the materials—Turn piles when temperatures become too high (above 140°F).
4. To aerate materials—Turn piles when odors begin to develop (see Subsection I on “Odor Management” on page 7-12) or

Fig. 2. Building compost piles by layering.



when other signs of anaerobic conditions appear such as an unexpected temperature drop or compacted, matted, or slimy-looking materials.

5. To drive off moisture—Turn piles when the materials become saturated from rain or with the addition of wet materials.
6. To add moisture—Turn piles when adding water. Otherwise, water is difficult to distribute throughout the pile.

H. Moisture Management

1. Lack of moisture—The most common ailment of composting piles in arid climates is lack of moisture. Without substantial rain, you must add water to piles (perhaps weekly) to keep the process going. The more you turn a pile, the more water you should add. You can reduce moisture loss by decreasing the turning frequency, sheltering piles from wind and sun, increasing pile size, and using bins with covers and small ventilation openings.
2. Too much water—A less frequent problem, you should turn piles that are too wet to distribute water within the pile and to encourage evaporation.
3. Moisture test—Although the surface of the pile appears dry, the materials a few inches below should look and feel damp. Use the squeeze test to test for adequate moisture (see Section II, Subsection C-2 on page 7-4). If the pile needs water, add it with a trickle hose or sprinkler. Because water moves slowly through the mass of composting materials, turn the compost while adding the water. To conserve fresh water, you can routinely add “used” water from certain household (for example, water from washing or cooking vegetables) and garden activities.

I. Odor Management

Most backyard composting materials present little odor risk. Still, odors can occur as a result of neglect or the wrong combination of materials and conditions. The best way to manage odors is to avoid anaerobic conditions—keep the pile from becoming too wet, turn at the first hint of odors, maintain a mix with at least as much brown ma-

terial as green, and generally maintain good pile porosity.

1. Degradable materials—Highly degradable materials such as grass, manure, and food scraps require particular attention. Mix the materials thoroughly within the pile. If you add these materials in large quantities (more than one-quarter of the pile volume), then turn the pile regularly. Unturned piles and holding bins do not provide the air flow needed to aerobically decompose large quantities of grass, manure, and food. If turning is not practical or if odors are a sensitive problem, it may be best to avoid composting these materials.
2. Correcting odors—The remedy for an odorous pile is to supply more oxygen by turning and by increasing the pile’s porosity (e.g., adding coarse brown materials). Disturbing the pile will release the odorous compounds, so the odor may become more intense for a brief period. If a pile develops strong odors, turning it might aggravate the nuisance. You can allow the odorous pile to decompose undisturbed and the odors should gradually dissipate. Do not add water or fresh material except for an insulating, odor-absorbing layer of coarse dry materials on the surface. Instead, start a new pile. When the odorous pile becomes tolerable, turn it and combine it with a new pile.

J. Troubleshooting

The most prevalent problem associated with backyard composting is slow decomposition. The first suspected cause is excessive drying of piles, followed closely by a lack of nitrogen (not enough fresh green material). Poor aeration caused by wet or compacted materials, also can hinder the composting rate. In this case, odors may accompany the problem. Other occasional difficulties include pests, ammonia-like odors, and extremely high temperatures. See Table 5 for troubleshooting guidelines.

K. Judging When Composting Is Finished

Composting does not stop at a particular point. Biological decomposition of the raw materials and the compost continues almost

indefinitely. The compost becomes usable, and we consider the process finished when the decomposition rate slows to the point that the compost will not create odors nor adversely affect plants as it continues to decompose. Judging when the pile reaches this

point is part of the art of composting. Signs of mature compost include the following:

1. The expected composting time period has elapsed since you last added materials to the pile (see Section II, Subsection C-7 on page 7-6).

Table 5. Troubleshooting guidelines for home composting piles.

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 rigid particles.	Turn pile and/or mix in coarse brown materials—straw, chipped wood, etc.
Ammonia odor	Too much nitrogen; not enough carbon	Pile includes a lot of grass, food, or manure	Mix in more brown carbon-rich material—leaves, sawdust, etc.
Slow decomposition	Not enough moisture	Pile is barely damp to dry inside.	Add water and/or wet materials and turn pile.
	Not enough nitrogen, or slowly degradable materials	There is an abundance of brown materials in the pile—wood, leaves, etc. and the pile is not dry.	Add green material or nitrogen fertilizer, or shred materials, or be patient—it will happen.
	Not enough oxygen—anaerobic conditions	Pile is dense, looks matted or slimy with hint of rotten odor.	Turn pile. Add course or dry material as needed.
	Pile is cold—small volume	Pile is less than 3 ft high and the weather is near freezing.	Add fresh material and turn pile. Increase pile size.
	Pile is totally frozen	Frozen clumps within the pile	Wait for spring, and then turn.
	Compost is mature	Pile conditions are good.	None needed
Not reaching high temperatures (over 120°F)	Small volume	Pile is less than 3 ft high.	Increase pile size.
	Not enough nitrogen	Pile is more than 3 ft high. Weather is above freezing.	Add green material or nitrogen fertilizer.
	Cold weather	Pile is more than 3 ft high; below freezing weather.	Insulate surface of pile with compost, straw, leaves, etc.
Pile is too hot (over 140°F)	Pile is too large	Pile is more than 5 ft high.	Divide into smaller piles.
	Not enough air flow—poor ventilation	Pile is less than 5 ft high, but fairly dense and moist.	Turn pile. Decrease pile size.
	Pile is becoming too dry. Not enough evaporative cooling	Pile is less than 5 ft 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 the pile surface	Bury food 6 inches beneath the pile surface.
	Meat, fish, or oily foods in the pile	Evidence of digging in the pile	Remove food from pile, or turn into the pile center, or use a pest-proof composting bin.

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

Note: Unfortunately, an unfinished compost can exhibit some of these traits. Therefore, be sure several of these signs (the more, the better) are present before harvesting the compost. To be safe, allow the compost to cure in small piles, about 3 feet high, for a month or two after you judge the process to be complete.

V. Using Compost

Use compost as a soil amendment for flower and vegetable gardens, as a mulch around trees and shrubs, as a top-dressing for lawns, and as a component of potting soil. Most compost will greatly benefit plants, but unfinished compost, or compost stored under anaerobic conditions, can harm seedlings or sensitive plants. Therefore, compost quality is important.

A. Benefits of Compost

1. Improves soil structure—The addition of compost gives soil a crumbly texture and increases the soil's porosity so that plant roots can more easily penetrate it. When mixed with a sandy soil, compost adds moisture and nutrient holding capacity. 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.
2. Buffers pH changes—Most composts have a near-neutral pH and the ability to buffer pH changes in the soil.

3. Attracts beneficial soil organisms—Compost contains a large and diverse population of biological organisms plus organic matter that attracts earthworms and other beneficial soil organisms. These traits contribute to compost's ability to suppress certain soilborne plant disease.
4. Contains trace mineral and plant nutrients—Although compost is not normally considered a fertilizer, it does contain trace minerals and small quantities of major plant nutrients. The amounts of nutrients depend on the materials composted. Typically composts made from yard trimmings have N concentrations in the range of 0.5 to 1 percent with P and K ranging from 0.2 to 0.5 percent. Most of the nitrogen and phosphorus are released slowly, over a period of several years, and in a pattern that tends to follow the growth patterns of plants.

B. Application

See Table 6 for general guidelines for applying compost. Because we use compost primarily as a soil amendment and not as a fertilizer, the amount of compost you apply is not critical. As a rule, use more compost for poorer soils.

1. As a mulch or top-dressing—You can apply compost continually as a mulch or top-dressing for gardens and lawns. The organic matter and nutrients will gradually work their way into the soil.
2. As a soil amendment—The best time to add compost as a soil amendment is when you prepare the garden bed or lawn surface before planting. Mix the compost with soil to at least three times the depth of the thickness of the compost layer that you are applying. For example, mix a 1-inch thick layer of compost into the top 3 to 4 inches of soil; mix a 2-inch layer to a depth of 6 inches or more. If only a small amount of compost is available, incorporate it in seed furrows or mix it with soil for each annual or perennial plant's transplant hole following the 1 to 3 compost-to-soil ratio.
3. As a potting mix—Compost should not comprise more than one-third of the pot-

ting mix by volume. A popular compost-based mix is one part peat moss, one part vermiculite or perlite, and one part compost, by volume.

C. Compost Quality

1. Quality depends on use—The required qualities of a compost depend on its intended use. Compost intended as a top-dressing for lawns should not have particles greater than 1/4-inch in size. It is often necessary to pass a top-dressing compost through a 1/4-inch screen. Compost used as a soil amendment can have large particles but should not contain a high percentage of wood. Soil microorganisms compete with the garden plants for nitrogen as they decompose the remaining wood. Gardens that are amended with wood compost require extra applications of nitrogen fertilizer. Compost that looks and feels more like a collection of small wood chips than soil is better suited as a mulch than a soil amendment. Make this judgment after mixing the compost because small particles tend to settle to the bottom of undisturbed compost piles leaving a blanket of wood particles on the surface.

2. Cure compost before using—Immature compost and compost produced or stored under anaerobic conditions may contain organic acids and alcohols that can harm plants. These conditions are not common in backyard composting because piles and bins tend to be small. Nevertheless, it is wise to cure mature compost for a month or more before using it. Store or cure compost in piles that are relatively short—3 feet or less. If you have stored compost in a large pile, spread it on the ground and allow it to air out for a day or more (the longer, the better). Maturity and other quality factors become increasingly important if you use the compost in a more concentrated manner. For example, compost used in potting mixes requires closer scrutiny than compost used as a soil amendment.

VI. Alternatives to Composting

Composting is not the only way to make good use of home and garden residues. Worm composting produces a high quality soil amendment via a different biological process. Grass recycling, soil incorporation, and mulching are other ways to recycle garden and food residues without the management demands of composting.

Table 6. Guidelines for applying compost.

Landscape use	Approximate application rate (lb per 1,000 sq ft)	Equivalent thickness of compost	Comments
Soil amendment for gardens and lawn establishment	3,000 to 9,000	1 to 3 inches	Mix with soil to a depth of about 4 to 9 inches. Use more compost for poor soils.
Soil amendment for planting trees and shrubs	3,000 to 9,000	1 to 3 inches	Mix with soil over an area of 2 to 5 times the root ball width and to a depth of 6 to 10 inches. Use more for poor soils.
Top-dressing for lawns	400 to 800	1/8 to 1/4 inch	Broadcast evenly over lawn surface. Best applied after thatching or core aerifying.
Top-dressing for gardens and shrubs	400 to 1,500	1/8 to 1/2 inch	Spread evenly then lightly work into the soil.
Landscape or garden mulch	1,500 to 6,000	1/2 to 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.

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

A. Grass Recycling

Usually, the compost pile is not the best destination for grass clippings. The simplest way to recycle grass clippings is to leave them on the lawn. This benefits the lawn by returning nutrients and organic matter to the soil. This alternative also keeps herbicide-treated grass out of the compost pile.

“Grasscycling” works best with proper mowing, fertilizing, and watering practices.

B. Mulching

You can use many organic residues from the home, garden, or landscape as mulches with little or no decomposition or preprocessing. Placing organic mulches on the soil surface controls weeds, reduces evaporation, lessens soil erosion, and moderates the soil temperature (keeps it cooler in the summer, warmer in the winter). Types of yard trimmings that you can use as mulches include grass clippings, leaves, pine needles, and chipped branches and shrub-trimmings. All of these materials are suitable for surface mulching around trees, shrubs, and other perennial plantings.

Shred leaves with a lawn mower or commercial shredder before using them as a mulch. Unshredded leaves tend to limit water and oxygen movement into the soil. Apply fresh grass clippings in layers that are not more than 1 inch thick. Otherwise they will mat together and limit air movement. A brief period of composting or drying can approve the appearance and performance of several mulching materials including leaves, grass clippings, and chipped wood.

C. Worm Composting

Worm composting, or vermicomposting, relies on worms to digest food scraps, paper, manure, and vegetation. In the process the worms leave behind castings that form a high-quality soil amendment called “vermicompost.” The type of worms used are red worms, not common soil dwelling worms.

Worms need a dark, cool, moist, and aerobic environment. Therefore, mix food and “bedding” in shallow layers in closed boxes or bins to compost. The bedding provides a light, airy habitat for the worms. Typical

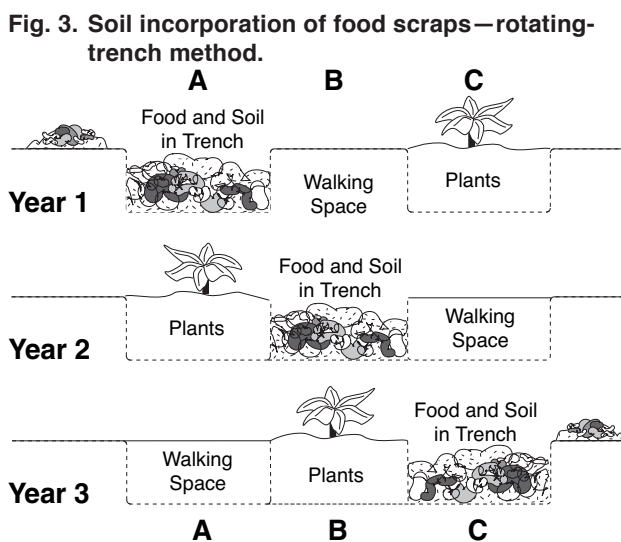
bedding materials include shredded paper, straw, peat moss, and sawdust. Worms work best at temperatures between 50° and 70°F (10° - 20°C), so a basement or other cool space is a good location for a worm bin. If the bin freezes or gets too hot, the worms die. You can harvest and use the compost when the bin contents become fairly uniform, dark, and soil-like in texture. This usually takes 3 to 6 months.

D. Soil Incorporation

Incorporating food scraps into the soil is an alternative method for recycling nonfatty food scraps. Within a month to a year, the food material will decompose to fertilize established or future plantings. The time period depends on the soil temperature, the number of organisms in the soil, and the carbon content of the food. Chop the food scraps, mix with the soil at the bottom of an 8- to 12-inch deep hole or trench, and cover completely with clean soil. One system of soil incorporation rotates garden space among food trenches, rows of crops, and walkways as in Fig. 3. Soil incorporation is difficult, if not impractical, during the winter when ground is frozen or snow covered.

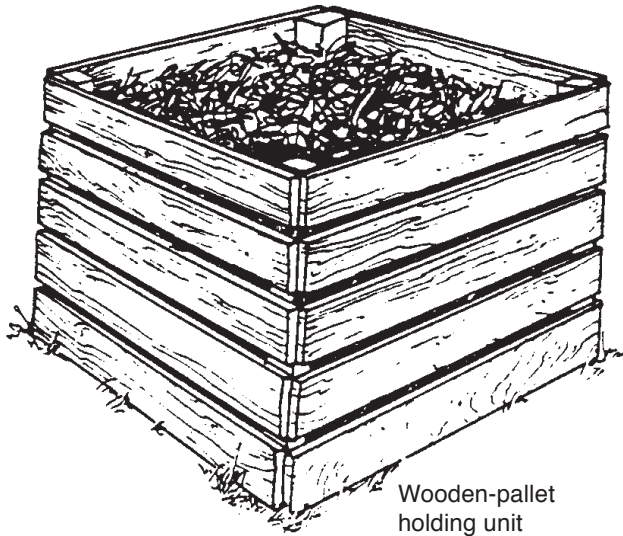
VII. Plans for Constructing Composting Bins

You can make compost bins from readily available materials. Types of enclosures include woven-wire fencing (hog wire, chicken wire, chain link), wood-slat fencing (snow fence), cement blocks, bricks, or scrap lumber.



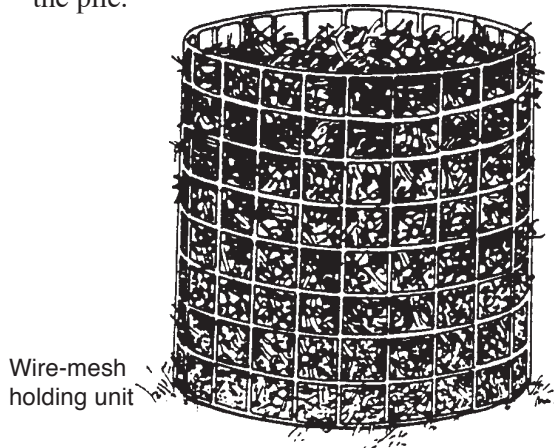
A. Wooden-Pallet Holding Unit

You can build an inexpensive compost bin with wooden pallets or pressure-treated lumber. Used pallets are available from manufacturers and landfills.



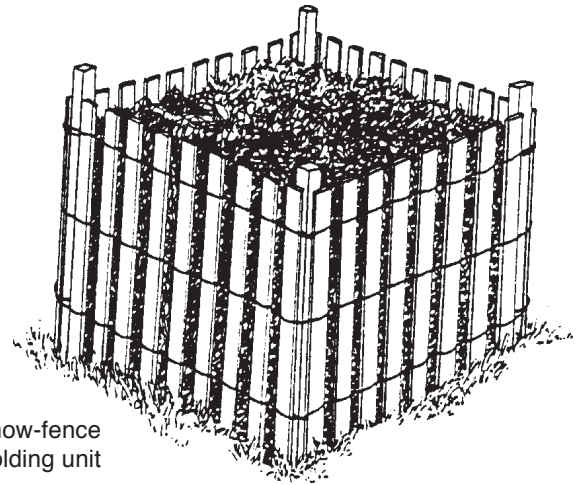
B. Wire-Mesh Holding Unit

Use either galvanized chicken wire or hardware cloth to build an inexpensive wire-mesh holding unit. (You also can use nongalvanized chicken wire, but it won't last very long.) Posts provide more stability for a chicken wire bin, but make the bin difficult to move. A wire-mesh bin without posts is easy to lift and provides access to the already "done" compost at the bottom of the pile.



C. Snow-Fence Holding Unit

A snow-fence holding unit is simple to make. It works best with four posts pounded into the ground for support.



D. Wood-and-Wire, Three-Bin Turning Unit

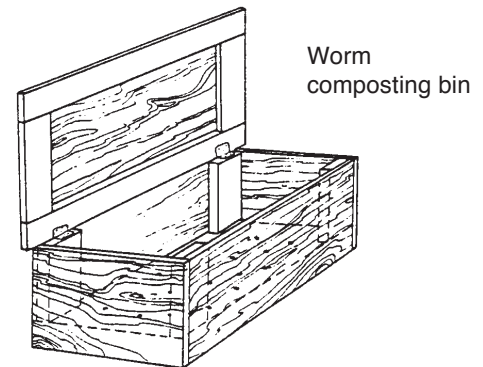
You can use a wood-and-wire, three-bin holding unit to compost large amounts of yard, garden, and kitchen wastes in a short time. Relatively inexpensive to build, it is sturdy, attractive, and should last a long time.

E. Wooden Three-Bin Turning Unit

This turning unit is a permanent, sturdy structure made of pressure-treated lumber.

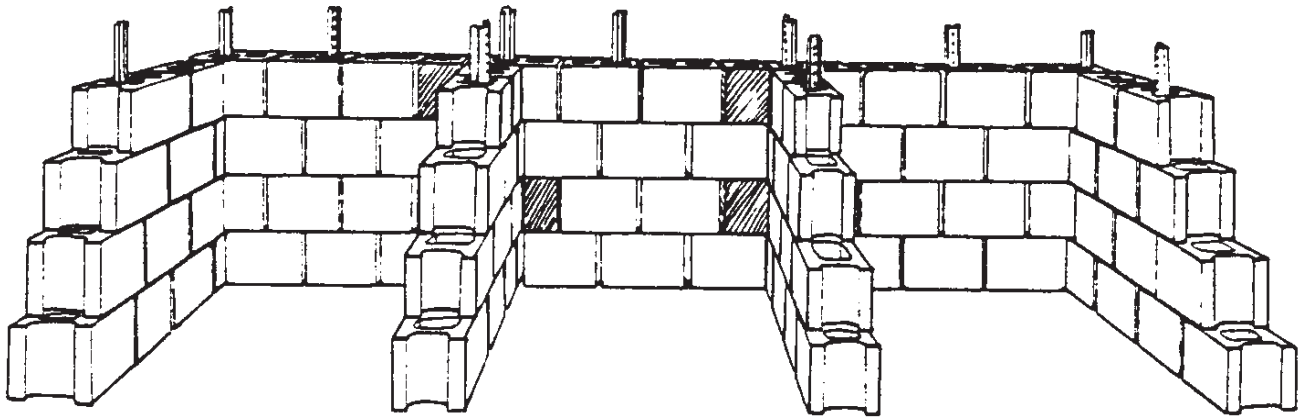
F. Worm Composting Bin

Worm composting is a suitable option for apartment buildings or homes with no yard space. The worms stay in the bin and eat household scraps, and the bin gives off little odor.



G. Concrete-Block Holding Unit

A concrete-block holding unit is sturdy, durable, and easily accessible. Leave about 1/2 inch between each block to let in air. Stagger the blocks and drive wooden or metal posts through the holes in the blocks to stabilize the bin.



Concrete-block, three-bin turning unit

H. Concrete-Block, Three-Bin Turning Unit

A concrete-block turning unit looks like three concrete-block holding units in a row. It is sturdy and, if used blocks are available, it is inexpensive to build.

Further Reading

Books

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Urban Home Composting, Rodent-Resistant Bins and Environmental Health Standards. City Farmer, Canada's Office of Urban Agriculture, Vancouver, BC.

Booklets and Pamphlets

University of Idaho Extension

- CIS 1066 Composting at Home
- CIS 1016 Don't Bag It! Recycle Your Grass Clippings
- CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes