NRAES–43

COMPOSTING TO REDUCE THE WASTE STREAM

A Guide to Small Scale Food and Yard Waste Composting

Northeast Regional Agricultural Engineering Service

COOPERATIVE EXTENSION

This Publication is Printed on Recycled Paper

Fair Use of this PDF file:

Composting To Reduce The Waste Stream
A Guide to Small Scale Food and Yard Waste Composting, NRAES-43

Written by:
Nancy Dickson, Tellus Institute, Boston, MA
Thomas Richard, Cornell University, Ithaca, NY
Robert Kozlowski, Cornell University, Ithaca, NY

ACKNOWLEDGMENTS

The development of this guide was inspired by the *Master Composter Resource Manual*, prepared by the Seattle Tilth Association and the Seattle Engineering Department's Solid Waste Utility. Sections of the guide were derived, with permission, from the *Master Composter Resource Manual*. Appendix A was adapted, with permission, from "Composting: Wastes to Resources," by J.F. Bonhotal and M.E. Krasny. The wooden three-bin turning unit plan was developed by T.J. Cook of the Department of Agricultural and Biological Engineering at Cornell University. A number of the figures are based on concepts illustrated by T.R. Sayre in "Composting: Wastes to Resources." The descriptions and illustrations of decomposer organisms are based on the work of Dr. D.L. Dindal of the SUNY College of Environmental Science and Forestry in Syracuse, New York. R.A. Kline, formerly of the Department of Vegetable Crops at Cornell University, also contributed to the development of this guide.

The authors appreciate the efforts of those people that reviewed the content of the bulletin and offered suggestions for improvements. The authors especially thank the following persons, whose suggestions significantly affected the content of the bulletin:

Joel Allen
Extension Association Director
Cornell Cooperative Extension
Columbia County, NY

Mary Appelhof
Flowerfield Enterprises
Kalamazoo, MI

John W. Bartok, Jr
Extension Professor of Agricultural Engineering
Department of Natural Resources Management and Engineering
University of Connecticut

Thomas J. Cook
Lecturer
Department of Agricultural and Biological Engineering
Cornell University

Daniel L. Dindal
Distinguished Teaching Professor of Soil Ecology
SUNY College of Environmental Science and Forestry
Syracuse, NY

Francis R. Gouin
Professor of Ornamental Horticulture
University of Maryland at College Park

Lee P. Grant
Associate Professor of Agricultural Engineering
University of Maryland at College Park

Carolyn Klass
Senior Extension Associate
Department of Entomology
Cornell University

Charles Mazza
Program Leader–Urban Horticulture Program
Cornell Cooperative Extension
New York City

J. Robert Nuss
Professor of Ornamental Horticulture
The Pennsylvania State University

Robert Rynk
Food Engineering Department
University of Massachusetts at Amherst

Maarten van de Kamp
Massachusetts Department of Food and Agriculture
Boston, MA

Russell W. Welser
Cooperative Extension Agent
Cornell Cooperative Extension
Ontario County, NY

Fredrick W. Wheaton
Professor of Agricultural Engineering
University of Maryland at College Park

The Northeast Regional Agricultural Engineering Service (NRAES) is an official activity of thirteen land grant universities and the U.S. Department of Agriculture. The following are cooperating members:

University of Connecticut
Storrs, CT

University of Delaware
Newark, DE

University of the District of Columbia
Washington, DC

University of Maine
Orono, ME

University of Maryland
College Park, MD

University of Massachusetts
Amherst, MA

University of New Hampshire
Durham, NH

Rutgers University
New Brunswick, NJ

Cornell University
Ithaca, NY

The Pennsylvania State University
University Park, PA

University of Rhode Island
Kingston, RI

University of Vermont
Burlington, VT

West Virginia University
Morgantown, WV

COMPOSTING TO REDUCE THE WASTE STREAM

A Guide to Small Scale Food and Yard Waste Composting

Written by:
Nancy Dickson, Tellus Institute, Boston, MA
Thomas Richard, Cornell University, Ithaca, NY
Robert Kozlowski, Cornell University, Ithaca, NY

Technical Editing by Martin Sailus, NRAES Director
Editing and Design by Rachel A. Crowe, NRAES Editor
Illustrations by Patricia L. Sobel

NORTHEAST REGIONAL AGRICULTURAL ENGINEERING SERVICE
152 Riley-Robb Hall
Cooperative Extension
Ithaca, New York 14853

Table of Contents

CONTENTS	PAGE

Tables and Figures

LIST OF TABLES

LIST OF FIGURES

NRAES–43
January, 1991
Reprinted with minor revisions July, 1991

INTRODUCTION

Composting transforms organic waste into a soil-like material called compost. Compost can enrich the soil used for gardens, lawns, and house plants. Reducing the waste stream is part of the solution for solid-waste disposal problems. The quantity, composition, and source of the waste describe the waste stream. Composting yard, garden, and some food wastes where they occur reduces the waste stream and creates a valuable soil amendment. By encouraging home composting, communities can reduce the costs and environmental problems associated with municipal garbage collection and processing.

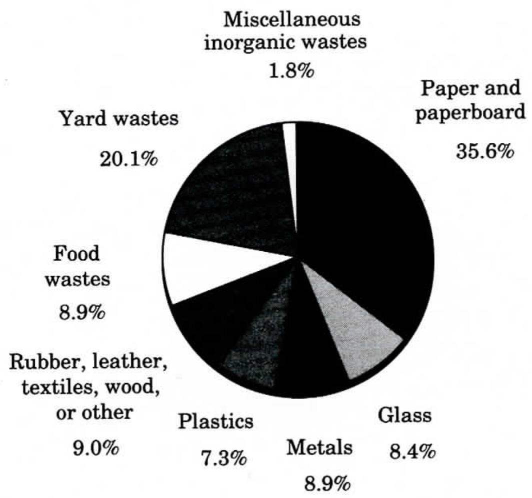


Fig. 1. A characterization of the waste stream in the United States.
Source: Franklin Associates, 1988.
From a chart by Tori Wishart.

Yard waste is a prime candidate for composting. Figure 1 shows that, on a nationwide basis, yard wastes make up approximately 20 percent of the residential waste stream. Yard wastes in the U.S. work out to about 230 pounds per person per year. Food wastes add another 100 pounds per person per year. Yard wastes are abundant at particular seasons, and because they are usually kept separate from other home wastes they are accessible for composting.

Traditional yard waste disposal methods have long been environmentally unsound and are becoming increasingly expensive. Yard wastes placed in landfills can result in methane gas production, acidic-liquid drainage from the landfills, and other problems. Incineration is no better, because burning wet yard wastes requires energy and generates air pollution. Composting at home saves transportation and disposal costs, and provides an environmentally sound way to manage wastes. Composting offers people an opportunity to contribute to, and benefit from, part of the solid-waste solution.

Potential benefits to households include lower waste-disposal costs, a convenient way to handle wastes, and a free soil amendment that will increase the health, productivity, and beauty of the landscape. Home composting could be an important part of every community's solid-waste solution.

This guide promotes small-scale composting of yard, garden, and vegetative food waste. It includes information that may be useful to various audiences. Community leaders, volunteers, teachers, and cooperative extension agents will find it useful for developing educational programs to promote home composting.

The guide will also assist small-scale composters who want to know more about composting science than they can learn from locally produced publications. The guide includes a glossary of terms, and an appendix that provides instructions for building various compost systems. Those interested only in guidelines on how to compost should review Chapter 2, titled "Methods of Composting and Composting Alternatives." This chapter reviews five composting methods and two alternatives to composting that will reduce the waste stream. Chapter 3, "Making and Maintaining a Compost Pile" presents descriptions of materials, methods, and trouble-shooting for traditional compost piles.

CHAPTER 1

The Composting Process

Composting is the biological decomposition of organic matter. While decomposition occurs naturally, it can be accelerated and improved by human intervention. An understanding of the composting process is important for producing a high-quality product and preventing operating problems. The microorganisms and invertebrates that decompose yard and food wastes require oxygen and water. Products of the composting process include soil-enriching compost, carbon dioxide, heat, and water. Figure 2 illustrates a simplified composting equation.

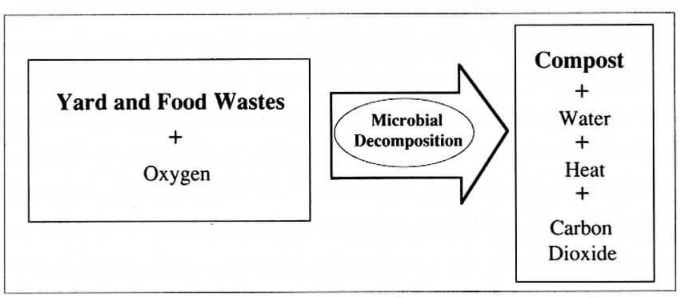


Fig. 2. A simplified equation of composting.

The heat produced increases the temperature in the compost pile from near-ambient temperature to as high as 160°F. The increased temperature results in increased water evaporation. As the process nears completion (after one month to one year), the pile temperature once again approaches ambient air temperature. The conversion of carbon in waste to carbon dioxide results in a reduction in both the weight and the volume of the pile. Nitrogen contained in yard and food waste is necessary for microorganisms to carry out decomposition efficiently. Compost comprises microorganisms and invertebrates, their skeletons and decomposition products, and organic matter that is not readily degradable by these organisms. Organic matter that is difficult to decompose helps form the physical structure of compost.

Finished compost takes on many of the characteristics of humus, the organic fraction of soil. The rate at which the final product (compost) is achieved and the magnitude of the temperature variation during the composting process depend upon factors discussed throughout this guide.

DECOMPOSERS

Decomposers are the microorganisms and invertebrates that accomplish composting. Naturally occurring microorganisms complete most of the chemical decomposition in the material being composted. These microorganisms include bacteria, molds or fungi, actinomycetes, and protozoa. Tiny invertebrate animals, such as mites, millipedes, insects, sowbugs, earthworms, and snails, are the primary agents of physical decay. They break up waste debris and transport microorganisms from one site to another.

The ease with which organic materials are composted depends on the type of decomposers, the type of organic material being composted, and the composting method used. For example, many decomposer organisms can utilize the carbon in sugars of a maple leaf, while fewer decomposers can use the carbon in cellulose or lignin fibers of paper or wood. The carbon in plastics is not generally biodegradable at all. As carbon compounds decompose, a portion of their carbon is converted to microbial and invertebrate cell structure; most is converted to carbon dioxide, which is lost to the atmosphere.

Different decomposers prefer different organic materials and temperatures; therefore, the more diverse the microbial population, the better. If the environment becomes unsuitable for a 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. Decomposer activity diminishes when the microorganisms can not readily consume the remaining organic material.

Microorganisms in Composting

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. Some microbes require oxygen to function; others do not. Those requiring oxygen are preferred in composting. Also, different microorganisms thrive in different temperature ranges. The goal in constructing and managing a compost pile is to create an environment suitable for the desired microorganisms.

Aerobic versus Anaerobic Microorganisms

Aerobic organisms thrive at oxygen levels greater than 5 percent (fresh air is approximately 21 percent oxygen). They are the preferred microorganisms, since they provide the most rapid and effective composting. Anaerobes thrive when the compost pile is oxygen deficient, that is, in anaerobic conditions. Decomposition by anaerobic microorganisms is sometimes referred to as fermentation.

Anaerobic conditions are undesirable in a compost pile. The products of anaerobic decomposition can be odorous. The most common product of anaerobic decomposition is hydrogen sulfide, which smells like rotten eggs. Other anaerobic decomposition products, such as cadaverine and putrescine, also cause offensive odors. In addition, anaerobic processes can generate acids and alcohols that are harmful to plants.

The ease with which organic materials are composted depends on the type of decomposers, the type of organic material being composted, and the composting method used.

Aerobic Microorganisms and Temperature

Among all the bacteria, molds or fungi, actinomycetes, and protozoa, the aerobic bacteria are the most important initiators of decomposition and temperature increase within the compost pile. Psychrophilic bacteria work in the lowest temperature range and have an optimum temperature of about 55°F (13°C). Mesophilic bacteria thrive at temperatures between 70° and 100°F (21°-38°C). Thermophilic bacteria are heat-loving and thrive in a range between 113° and 155°F (45°-68°C). Each category includes many strains of bacteria.

The initial temperature of the compost pile usually is related to the ambient air temperature. If the initial pile temperature is less than 70°F (21°C), psychrophilic bacteria begin decomposition. Their activity generates a small amount of heat and produces an increase in pile temperature that changes the environment for dominance by mesophilic bacteria. In turn, the more rapid decomposition by mesophilic bacteria can further increase the pile temperature to create an environment where the thermophiles can thrive. Later, as the thermophilic bacteria in the pile decline in number and temperature decreases, mesophilic bacteria again become dominant.

While high temperatures have the advantage of killing pathogenic organisms and weed seeds, moderate temperatures encourage the growth of mesophilic bacteria, the most effective decomposers. If the material being composted is not diseased and does not contain seeds, there is no need to be concerned about achieving high temperatures. Many decomposers are killed or become inactive if temperatures rise above 140°F (60°C). The rise and fall of temperature during the process will depend on the material being composted, the composting method used, and the water available for evaporative cooling.

Food Web of the Compost Pile

The food web of the compost pile is illustrated in Figure 3. The waste in the compost pile provides food for the first level of decomposers. Cellulose decomposition by microorganisms begins soon after the compost pile is established. Fungal mycelia quickly penetrate all parts of the heap, and early fruiting bodies of mesophilic fungi grow on the surface. Later, thermophilic actinomycete colonies can give the surface a gray appearance.

The availability of readily digestible food results in maximum microorganism growth and a temperature increase. During the heating period, soil invertebrates either die, become dormant, or migrate to cooler parts of the pile. These organisms return when the temperature declines. First-level consumers attract, and become food for, second-level consumers. Other mites and springtails eat fungi. Tiny, feather-winged beetles feed on fungal spores. Nematodes ingest bacteria. Protozoa and rotifers present in water films feed on bacteria and plant particles. Predaceous mites and pseudoscorpions prey upon nematodes, fly larvae, collembolans, and other mites. Free-living flatworms ingest gastro-pods, earthworms, nematodes, and rotifers. Third-level consumers, such as centipedes, rove beetles, ground beetles, and ants, prey on second-level consumers. Mites, millipedes, sow bugs, snails, and slugs ingest plant tissue. Soft tissues of decaying plants and animals support the growth of roundworms and potworms. Minute flies lay eggs that hatch into larvae. The larvae then feed on wastes. Earthworms ingest, digest, and reshape organic matter. These activities of invertebrates tend to mix material, break larger particles into smaller ones, and transform organic material into more digestible forms for microorganisms.

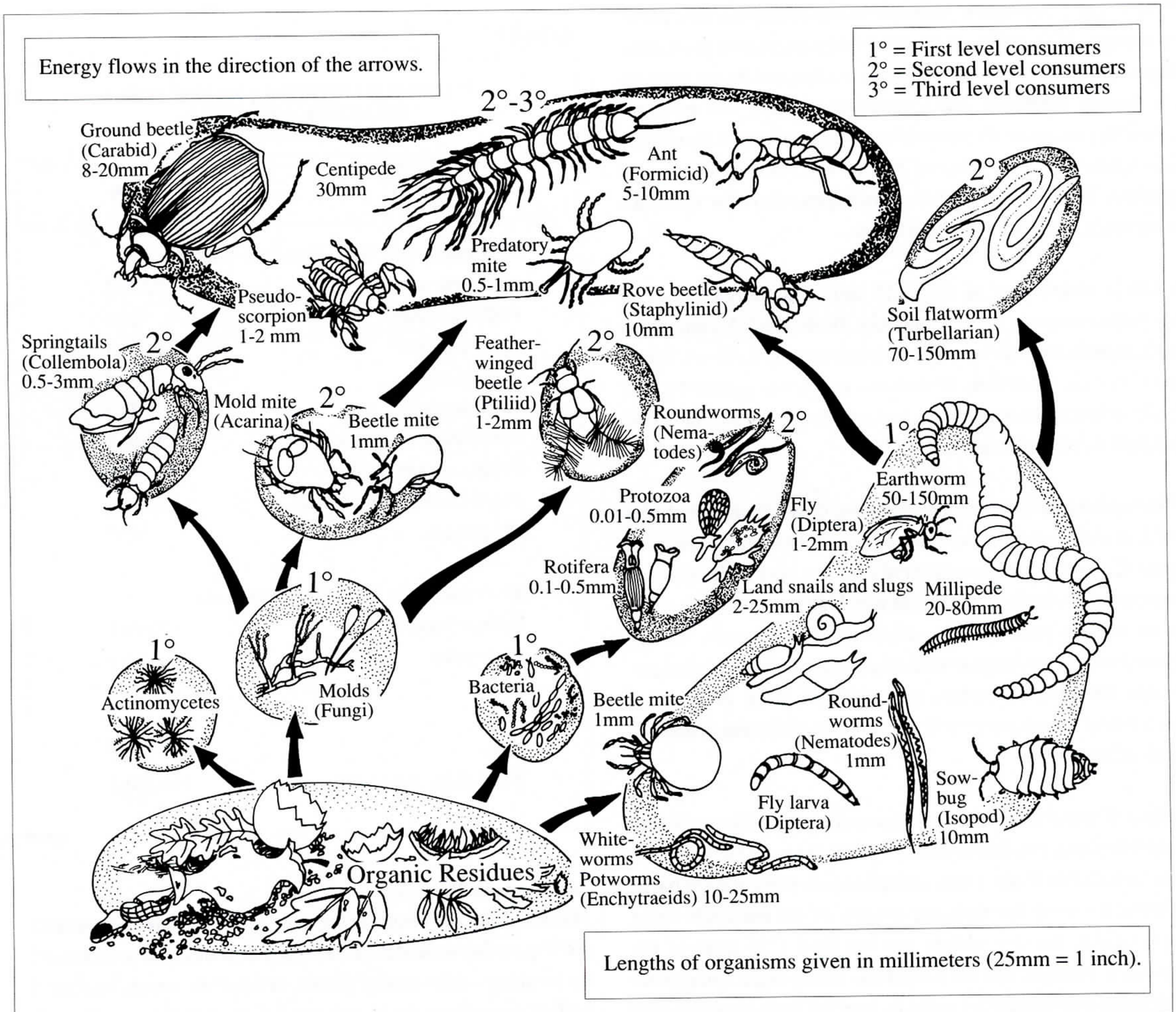


Fig. 3. The organisms in the food web of the compost pile.

Redrawn, by permission, from D.L. Dindal, *Ecology of Compost*, 1971.

FACTORS AFFECTING THE COMPOSTING PROCESS

All natural organic material eventually decomposes. The length of the composting process depends on a number of factors:

- carbon and nitrogen contents of the material
- amount of surface area exposed
- moisture
- aeration
- temperatures reached during composting

Carbon-to-Nitrogen Ratios

When combining organic materials to make compost, the carbon-to-nitrogen (C:N) ratio is important. Microorganisms in compost digest (oxidize) carbon as an energy source, and ingest nitrogen for protein synthesis. The proportion of these two elements should approximate 30 parts carbon to 1 part nitrogen by weight. C:N ratios within the range of 25:1 to 40:1 result in an efficient process. Table 1 lists carbon-to-nitrogen ratios for materials commonly included in compost piles.

Given a steady diet at this 30:1 ratio, microorganisms can decompose organic material quickly. When the C:N ratio is too high, there is too little nitrogen and decomposition slows. When the C:N ratio is too low, there is too much nitrogen and it will likely be lost to the atmosphere in the form of ammonia gas. This can lead to odor problems.

Most materials available for composting do not fit this ideal 30:1 ratio, so different materials must be blended to meet the ratio. In general, coarse, dried-out material contains very little nitrogen. For example, woody materials are very high in carbon. However, green wastes, such as grass clippings, fresh weeds, kitchen refuse, and manure, contain relatively high proportions of nitrogen. Proper blending of carbon and nitrogen helps ensure that composting temperatures will be high enough for the process to work efficiently.

Although proper blending is necessary, it can be difficult to blend materials to achieve this ratio exactly. For example, the C:N ratio data included in Table 1 were calculated on a dry-weight basis. Without knowing the moisture content of the materials being used, neither the dry weight nor the final C:N ratio of the combined material can be estimated. Small-scale composters seldom have the equipment, or the inclination, to measure moisture contents. Also, the C:N ratios in Table 1 are only estimates. For instance, brown grass clippings from a dry lawn will have less nitrogen than lush, green clippings. Clippings from lawns that have been abundantly fertilized will have an even higher nitrogen content. Likewise, the leaves from different types of trees vary in their C:N balance.

Blending of materials to achieve a workable C:N ratio is part of the art of composting. Table 1 is provided as a guide. If a high-nitrogen material, such as grass clippings, is being composted, it should be blended with a high-carbon material, such as chopped leaves. With experience, small-scale composters will develop procedures that result in workable mixtures for the materials being composted.

TABLE 1

CARBON TO NITROGEN RATIOS FOR SELECTED MATERIALS
(BY WEIGHT)

MATERIAL	C:N
MATERIALS WITH HIGH NITROGEN VALUES	
Vegetable wastes	12-20:1
Coffee grounds	20:1
Grass clippings	12-25:1
Cow manure	20:1
Horse manure	25:1
Horse manure with litter	30-60:1
Poultry manure (fresh)	10:1
Poultry manure (with litter)	13-18:1
Pig manure	5-7:1
MATERIALS WITH HIGH CARBON VALUES	
Foliage (leaves)	30-80:1
Corn stalks	60:1
Straw	40-100:1
Bark	100-130:1
Paper	150-200:1
Wood chips and sawdust	100-500:1

Surface Area/Particle Size

Microbial activity occurs at the interface of particle surfaces and air. The surface area of material to be composted can be increased by breaking it into smaller pieces, or by other means. Increased surface area allows the microorganisms to digest more material, multiply faster, and generate more heat. Although it is not essential to break materials into small pieces for composting, it

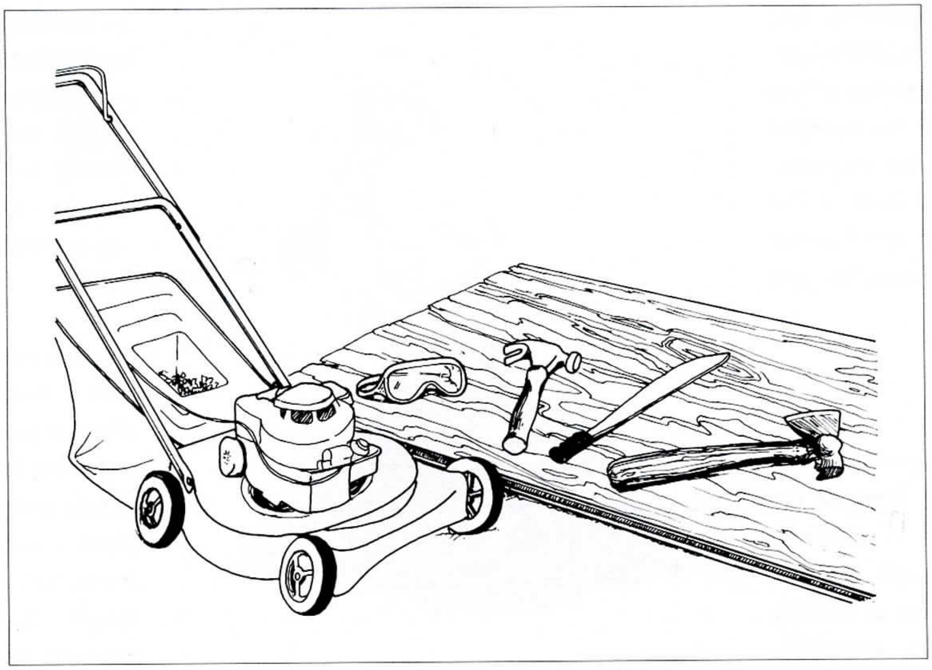


Fig. 4. Some common tools used to increase the surface area of materials to be composted.

does accelerate the process. This may be important when space is limited.Materials can be chopped, shredded, split, or bruised to increase their surface areas. A wide range of shredders and chippers is available, from large models used by tree services to small, hand-cranked types. For many yard wastes, cutting materials with pruning shears or with a hatchet on a piece of plywood is adequate. Even some pounding with a hammer will create entry points for decomposer organisms. An easy way to shred fallen leaves is to mow them before raking. The shredded leaves can then be collected directly with a mower-bag attachment. Some tools for increasing surface area are shown in Figure 4. Figure 5 illustrates the use of pruning shears to increase the surface area of a branch.

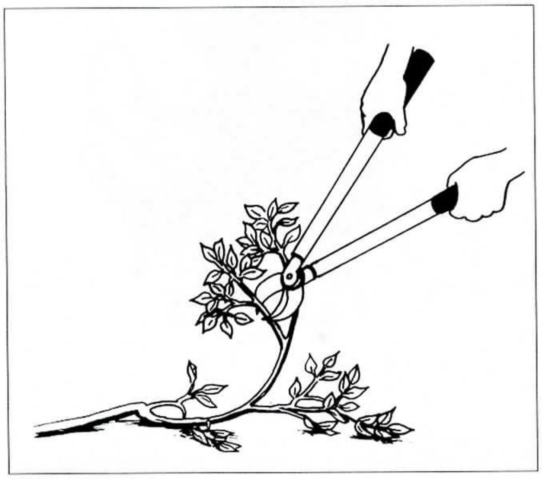


Fig. 5. The use of pruning shears to cut branches into small pieces.

Aeration

Aeration replaces oxygen-deficient air in the center of the compost pile with fresh air. Rapid aerobic decomposition can only occur in the presence of sufficient oxygen. Aeration occurs naturally when air warmed by the compost process rises through the pile, drawing in fresh air from the surroundings. Wind also stimulates aeration. Air movement through the compost pile is affected by porosity and moisture content.

Porosity refers to the spaces between particles in the compost pile and is calculated as the volume of spaces, or pores, divided by the total volume of the pile. If the material is not saturated with water, these spaces are partially filled with air that can supply oxygen to decomposers and provide a path for air circulation. As the material becomes water saturated, the space available for air decreases.

Compacting the compost pile reduces its porosity. Excessive shredding can also impede air circulation by creating smaller particles and pores. Adding coarse materials, such as leaves, straw, or cornstalks, can increase the pile porosity, although some coarse materials will be slow to decompose. As the compost process proceeds, the porosity decreases, restricting aeration. Regular mixing of the pile, referred to as turning, fluffs up the material and increases its porosity. Turning enhances aeration in a compost pile. In small-scale composting, turning is usually accomplished using a pitchfork or shovel, as illustrated in Figure 6, on page 8.

A special compost-aeration tool available from many garden supply companies offers another way to help get air into the pile. The tool is pushed into the pile and turned as it is pulled out, as illustrated in Figure 7. The propeller at the end folds out on the upstroke, loosening materials and admitting more air.

Fig. 6. The use of a pitchfork to turn compost and aerate the pile.

Moisture

Microbial decomposition occurs most rapidly in thin liquid films on the surfaces of particles. A moisture content of 40-60 percent provides adequate moisture without limiting aeration. If the moisture content falls below 40 percent, the bacteria will slow down and may become dormant. When the moisture content exceeds 60 percent, nutrients are leached, air volume is reduced, odors are produced (due to anaerobic conditions), and decomposition is slowed. The "squeeze" test is an easy way to gauge the moisture content of composting materials. The material should feel damp to the touch, with just a drop or two of liquid expelled when the material is tightly squeezed in the hand, as shown in Figure 8. If the pile becomes too wet, it should be turned and restacked. This allows air to circulate back into the pile and loosens the materials for better draining and air drying. Adding dry material, such as straw or sawdust, can also remedy an excess moisture problem.

If the pile is too dry, it can be watered with a trickling hose. A more effective practice is to turn the pile and rewet materials in the process. Certain materials will shed water or adsorb it only on their surface. Dead leaves, sawdust, hay, straw, dried weeds, and vegetables must gradually be moistened until they glisten. Then the squeeze test should be used to evaluate the moisture content.

Temperature

Heat generated by microorganisms as they decompose organic material increases compost pile temperatures. Pile temperatures between 90° and 140°F (32°-60°C) indicate rapid composting.

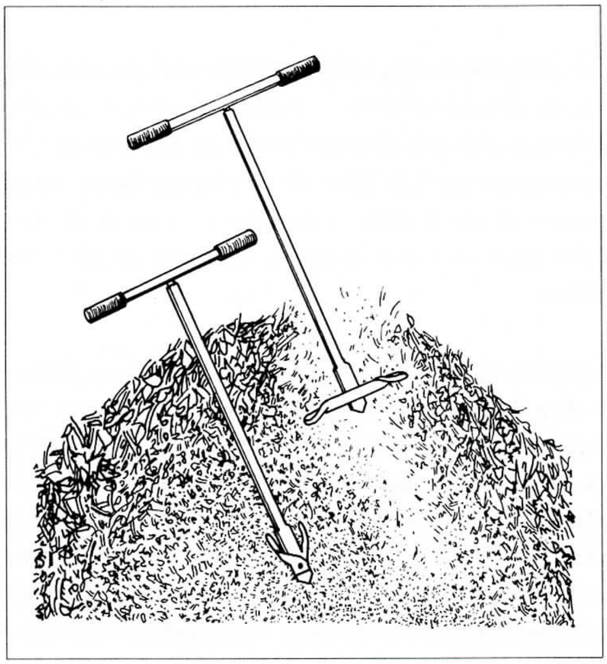


Fig. 7. The action of a compost aeration tool.

Fig. 8. The squeeze test, used to estimate the moisture content of the compost pile.

Fig. 9. A temperature probe, used to monitor compost pile temperatures.

Temperatures greater than 140°F (60°C) reduce the activity of many of the most active organisms. A temperature probe, as shown in Figure 9, or a soil thermometer, can be used to keep track of pile temperatures. While backyard composters may not be interested in monitoring pile temperature, a temperature probe is excellent for demonstration and useful for serious composters. Appendix B lists a number of businesses that distribute temperature probes.

SUMMARY

The compost process depends on all the factors discussed: carbon-to-nitrogen ratios, surface area, aeration, and moisture content. The art of small-scale composting is balancing these factors to achieve the final product in the desired time frame.

Under optimum conditions and with frequent turning, useable compost might be produced in as little as one month. However, composting can survive most forms of benign neglect, especially if a one- to two-year wait for finished compost is acceptable. The composting method chosen will be influenced by when the finished compost is needed.

CHAPTER 2

METHODS OF COMPOSTING AND COMPOSTING ALTERNATIVES

This chapter discusses five methods of composting: holding units, turning units, heaps, soil incorporation, and worm composting. In addition, two alternatives to composting that reduce the waste stream are also discussed: using organic wastes as mulches, and leaving grass clippings on lawns. The proper approach depends on the time that finished compost is desired, the materials to be decomposed, and the space available for composting.

> *The proper approach depends on the time that finished compost is desired, the materials to be decomposed, and the space available for composting.*

The approach chosen dictates the time commitment; for example, mulched paths can be replenished every other year, while turning units require weekly maintenance. If vegetative kitchen wastes are to be composted without other materials, soil incorporation or worm composting should be used. If kitchen wastes will be mixed with yard wastes, the turning method is recommended. However, holding units or heaps may work when precautions are taken to minimize pest problems. Turning the pile frequently helps avoid pest problems. Yard wastes are generally not susceptible to pest problems, so they can be composted in slower, low-maintenance holding units.

HOLDING UNITS–THE SLOW METHOD

Holding units are containers or bins that hold yard and garden waste until composting is complete. Using a holding unit is the easiest, but slowest, way to compost. Material should be added to the holding unit as it is generated; no turning is required. Nonwoody materials, such as grass clippings, crop wastes, garden weeds, and leaves, will compost in holding units, but decomposition can take from six months to two years. The process can be hastened by chopping or shredding wastes, mixing high-nitrogen and high-carbon materials, maintaining proper moisture, or turning the pile.

Composting vegetative kitchen wastes in a holding unit will require additional management to avoid pest problems. The kitchen wastes should be turned into the pile as they are added, and pest-proof sides and a cover may be needed. If these precautions do not prevent pest problems, kitchen wastes should not be placed in the pile. The next chapter provides more information on materials that should and should not be composted.

Holding units are often made of light materials so that they can be taken apart easily and moved. Possible materials include circles of wire fencing or hardware cloth, old wooden pallets wired or tied together, snow fencing, or wire framed in wood. Figure 10 illustrates different types of holding units.

Holding units are often made of light materials so that they can be taken apart easily and moved.

Permanent holding units can be made by stacking landscape timbers or concrete blocks, or mortaring bricks or rocks together. In either case, the unit should be constructed to allow air transfer through the sides and back. It is helpful to have two or three of these stationary units—one for fresh wastes, another for maturing compost, and possibly a third for finished compost. Details for holding unit construction are included in Appendix A.

Since yard and garden wastes will be added continuously, the stage of decomposition will vary from the top to the bottom of each compost pile. Generally, the more finished compost will be found near the bottom of a pile, and partially decomposed materials near the top. Once the compost at the bottom of a pile is finished, it can be removed and used.

Finished and unfinished compost can be separated by removing the holding unit from around the compost pile and setting it down nearby. Less decomposed materials from the top of the old pile can be moved into the empty holding unit until finished compost is uncovered. A pitchfork may be useful for this procedure. If a permanent holding unit is used, the unfinished compost must be removed and placed in an adjoining unit. The finished compost can then be used, and the holding unit will be ready to receive additional yard wastes.

TURNING UNITS–THE FAST METHOD

Turning units can compost nonwoody yard wastes, along with vegetative kitchen wastes, in two months or less. Turning units complete this process efficiently and safely. Wastes in turning units must be mixed on a regular basis. Frequent turning speeds composting by providing aerobic bacteria with the oxygen they need to break down materials. Turning units take two general forms: either a series of bins, as shown in Figure 11, on page 12, or a horizontally mounted rotating barrel, as shown in Figure 12, on page 12.

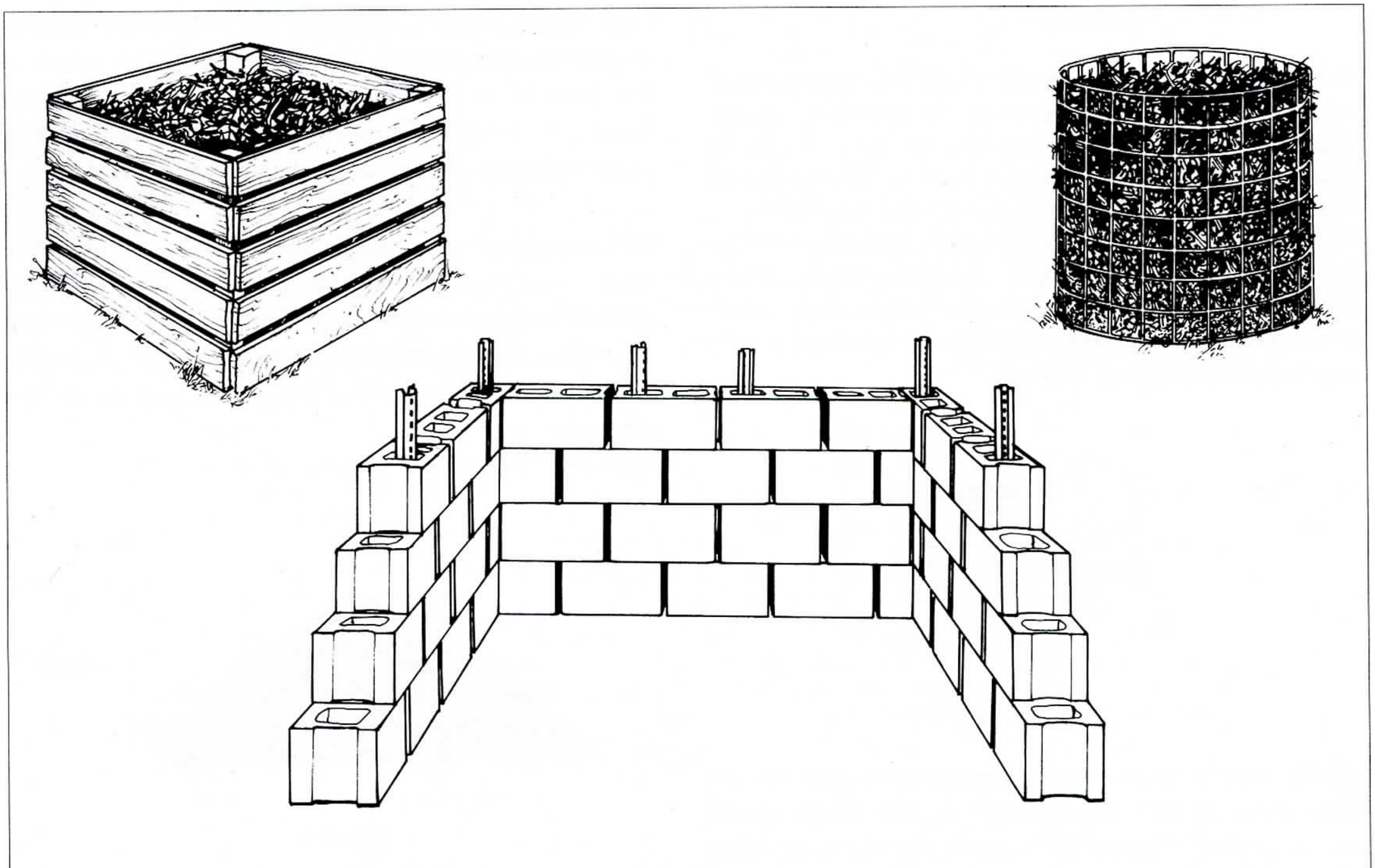


Fig. 10. Examples of three different types of holding units.

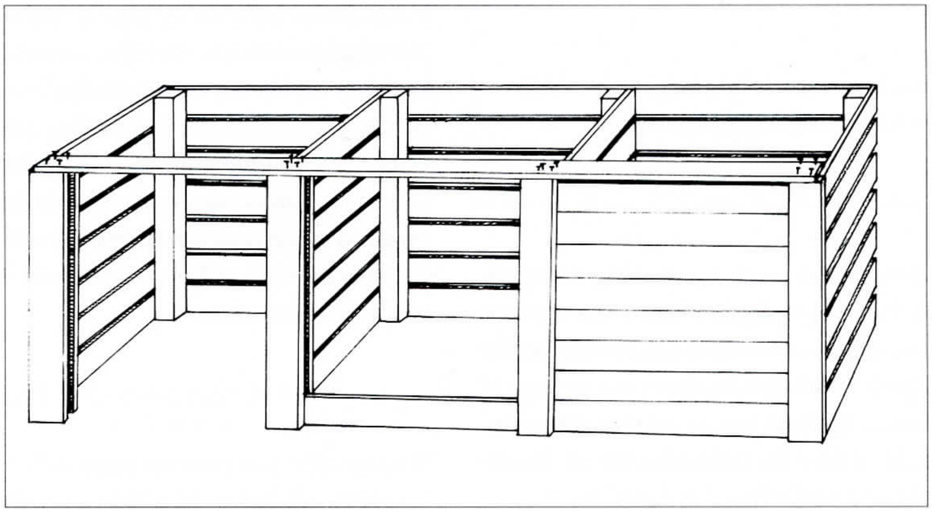


Fig. 11. A wooden turning unit, with three compartments and removable front boards.

The high temperatures produced when piles are turned (every five to ten days) offer important advantages. Temperatures from 90°F to 140°F (32°-60°C) will:

- kill major disease organisms and fly larvae
- help kill weed seeds
- provide the environment necessary for the most efficient decomposer organisms

Materials to be composted should be added to turning units in stockpiled batches, rather than in smaller amounts over time. Materials should be stockpiled until enough accumulate to fill the 3 foot x 3 foot x 3 foot bin, to fill one bin of the three-bin turning unit, or to almost fill a barrel composter to the prescribed level. Prior to composting, food wastes should be stockpiled in a pest-proof container, such as a plastic, five-gallon bucket. After a day's accumulation of food waste is added, a layer of sawdust can be added to reduce odor. When the container is full, it should be topped off with a layer of sawdust.

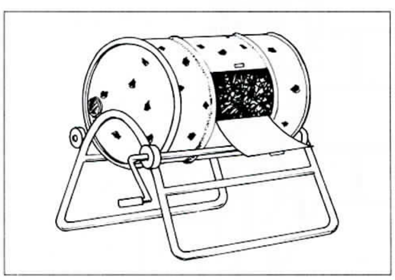


Fig.12. A rotating barrel composter.

Turning systems require careful preparation of materials and frequent maintenance. These units may also require greater expense or effort to buy or build. However, the expense and effort will yield finished compost in a comparatively short time. The construction and management of compost piles are discussed in detail later in this guide.

HEAPS

Heap composting is similar to turning-unit and holding-unit composting except that it does not require a structure. As illustrated in Figure 13, a heap should measure about 5 feet wide and 3 feet high; its length will vary depending upon the amount of materials used. Materials can be added as they become available, or stockpiled until sufficient materials are available to make a good sized heap. It is best to have two heaps. When the first one is large enough, it should be allowed to decompose undisturbed. Additional waste can then be added to the second heap.

The pile may be turned regularly, or not at all. If the heap will be turned, vegetative waste can be composted along with yard waste. If the pile will not be turned, adding vegetative waste may attract pests. Covering the heap with a layer of yard waste, mulch, or soil will help prevent moisture loss and may reduce pest problems.

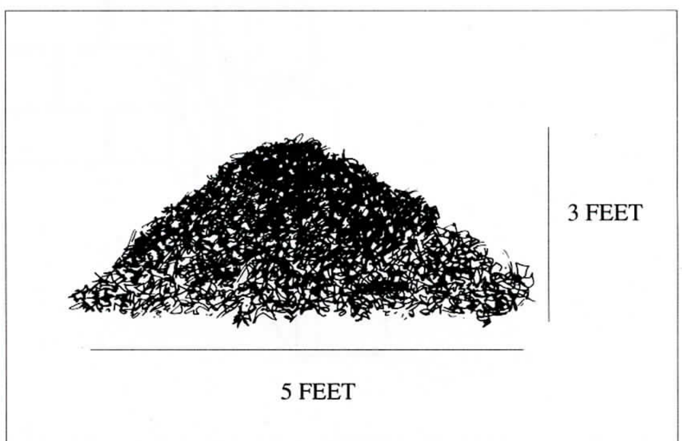


Fig. 13. The width and height of a compost heap–the length can vary according to the materials available.

INCORPORATION

Incorporating food wastes into the soil well below ground surface is the simplest method for composting nonfatty food wastes. With time, the wastes will break down to fertilize established or future plantings. The wastes will decompose in one month to one year, depending on the soil temperature, the number of organisms in the soil, and the carbon content of the wastes.

Nonfatty food wastes can be incorporated outside the dripline of trees or shrubs, or buried in fallow areas of gardens. The hole must be large enough to allow the waste to be buried under at least 8 inches of soil, as shown in Figure 14. Burying to this depth discourages animals from digging up the waste. Chopped food wastes should be mixed into the soil before they are buried. Care must be taken to avoid damaging large roots when digging near trees and shrubs. Incorporation of meat, bones, or other fatty food wastes may attract pests.

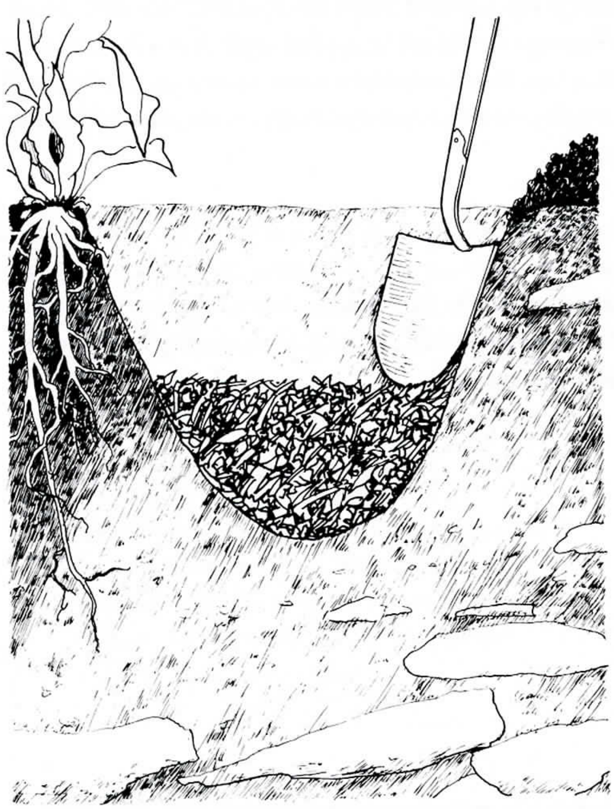


Fig. 14. The technique of soil incorporation, accomplished by digging a hole, mixing waste with soil, and covering the waste with at least 8 inches of additional soil.

WORM COMPOSTING

During worm composting, worms digest food waste, leaving behind high-quality castings called "vermicompost." Worms work most efficiently at temperatures between 50° and 70°F (10°-21°C), which makes worm composting an appropriate composting option for a basement or other semi-heated indoor space. In a properly managed worm composting bin, odors and flies should not be a problem. Some people even keep their worm bins in their kitchens.

Worms turn...food wastes and bedding into a high-quality soil amendment suitable for use with house plants, vegetable seedlings, and flowers.

In a worm composting system, "red worms" (not soil-dwelling worms) are placed in a bin with bedding and food wastes. Red worms, also known as red wigglers, evolved in manure piles and are efficient processors of food waste and other organic material. The classified sections of many popular fishing and gardening magazines contain current listings of firms that market red worms.

A shallow wooden box with a lid will serve as a good worm composting bin, as shown in Figure 15. Appendix A provides instructions for building a worm bin. Bins constructed according to this design will provide dark, moist environments that encourage worms to feed on food wastes. Worms need to be "bedded" within these boxes. Peat, sawdust, and other cellulose materials, or shredded and moistened newspaper or corrugated cardboard make good bedding. The bedding should be wetted so that it is 50 to 75 percent water, by weight. The dry bedding should be weighed and the weight multiplied by three to determine the weight of water to mix in. A layer of moistened bedding approximately 8 inches deep should be added to the bin before the worms are added. The bin should be left uncovered until the worms work down into the bedding, away from the light. All healthy worms will have moved into the bedding within an hour.

Vegetable and fruit scraps can be incorporated by digging a small hole in the bedding, placing the wastes in the hole, and then covering the hole with bedding. Small amounts of meat scraps can also be composted using this method. Inorganic and potentially hazardous material, such as chemicals, glass, metal, or plastic, should not be incorporated. Burial spots must be rotated so that wastes are distributed throughout the bin. The bin should be kept moist, but not wet.

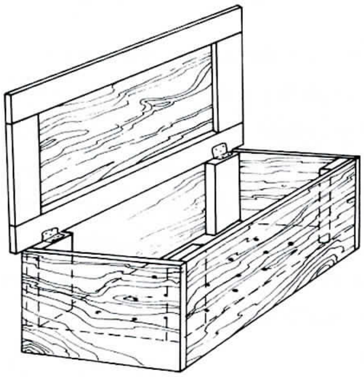


Fig. 15. A worm composting bin.

Compost can be harvested and used when the bin contents have become fairly uniform, dark, "worm castings." This usually takes three to six months. Finished compost can be harvested by moving it to one side of the bin, and then adding fresh bedding to the empty side. The worms will migrate to the fresh bedding within one month. The finished compost can then be removed, and new bedding added in its place.

Worms turn the food wastes and bedding into a high-quality soil amendment suitable for use with house plants, vegetable seedlings, and flowers. Worm bins work best if sized and stocked according to the amount of waste to be handled. Surface area is more important than depth in sizing a worm system. Generally, every pound of food waste to be composted per week will require 1 square foot of surface area. Two pounds of worms are needed for every pound of garbage produced per day. Mary Appelhof's book, *Worms Eat My Garbage*, explains further how to determine the size of the worm bin and calculate the quantity of bedding and worms required for an efficient system.

MULCHING ALTERNATIVE

Using organic waste as a mulch is an alternative to traditional composting that also reduces the waste stream. Organic mulches placed on the soil surface control weeds, reduce evaporation, modify the soil temperature (making it cooler in the summer and warmer in the winter), and reduce soil erosion. Mulches can be used around plants in the garden, or as soft "paving" for paths and play areas. An ideal mulch material is inexpensive, stays in place, reduces weed growth, and reduces evaporation of soil moisture while improving water penetration.

The types of yard waste that can be used as mulches include lawn clippings, leaves, pine needles, and chipped branches. Commercial by-products, such as bark chips, sawdust, buckwheat hulls, and wood chips, are also used. All of these are suitable for surface mulching around trees, shrubs, and other perennial plantings. Sawdust and pine needles tend to acidify soil and are therefore recommended for plants such as blueberries, rhododendrons, and some evergreens.

When mulching in annual flower and vegetable gardens, it is best to avoid materials such as wood chips and sawdust. Wood chips and similar materials break down slowly and have C:N ratios from 100:1 to 500:1, as noted in Table 1. When turned into soil, wood chips compete with plants for nitrogen and may limit plant growth. If woody wastes are used in an annual garden, they should be pulled aside when tilling, or balanced with a high-nitrogen source, such as bloodmeal or a nitrogen fertilizer, before they are turned under.

Lawn clippings, pine needles, leaves, and even seaweed are better mulches than woody materials in gardens. These materials break down quickly, and are less likely to compete with existing plants for nitrogen when incorporated into soil. Fresh lawn clippings should not be applied more than 1 inch thick because they tend to mat and reduce water penetration. Adding fresh lawn clippings to other materials will provide additional nitrogen for plants.

Leaves should be shredded and collected with a mower-bag attachment before they are used as mulches. Leaves that are not shredded tend to limit water and oxygen movement into the soil. Leaves should be allowed to degrade slightly before they are used as mulch material.

Using organic waste as a mulch is an alternative to traditional composting...Organic mulches placed on the soil surface control weeds, reduce evaporation, modify the soil temperature, and reduce soil erosion.

Wood chips make an excellent path and play-area material, since they decompose slowly and cushion the surface of the ground. Wood chips that have been stored in large, possibly anaerobic piles can initially be phytotoxic, and may need to be aerated before use.

In commercial landscaping, ground or chipped bark is the most common form of mulch. Chipped waste from tree-pruning and tree-removal operations can often be obtained, free of charge, from a tree service or town utility company. Any leaves on the branches will decompose rapidly and add to the beauty of the mulch.

GRASS CLIPPING ALTERNATIVE

The compost pile may not always be the best destination for grass clippings. The simplest way to dispose of grass clippings is to leave them on the lawn. This actually benefits the grass by returning nutrients and organic matter to the soil. Frequent mowing and even distribution of grass clippings can provide nitrogen equivalent to one fertilizer application.

The cutting height and growth rate of grass should determine its frequency of mowing. Grass ought to be cut when it is 1 1/2 to 2 1/2 inches long, and the clippings should be less than 1 inch long for faster decomposition. Grass in the shade should be cut taller than that in the sun. Ideally, no more than one-third of the blade surface area should be cut at any one time. If more than one-third of the grass blade is removed, size reduction of clippings may be necessary. Mulching mowers are now available for this purpose. Clippings that are too long to be left on the lawn can be composted, or used as mulches.

> *The simplest way to dispose of grass clippings is to leave them on the lawn...leaving grass clippings on the lawn will not contribute to thatch build-up.*

Lawns should be mown when they are dry, so that clippings can filter down to the soil without clumping. Excessive use of nitrogen fertilizers can cause overly dense growth. Unless a densely grown lawn is cut frequently, clippings will take longer to reach the soil and decompose. Contrary to popular opinion, leaving grass clippings on the lawn will not contribute to thatch build-up. Thatch refers to dead grass roots and stems that accumulate on the lawn surface. If excessive thatch levels already exist, they can be reduced through mechanical thatching, or top dressing with compost.

CHAPTER 3

Making and Maintaining a Compost Pile

This chapter discusses materials, construction, maintenance, and troubleshooting for a compost pile. These principles can be applied to the turning units, holding units, and heaps that were defined in the previous chapter. Turning a compost pile weekly can yield compost in one to two months with the right combination of materials and moisture content. Without turning, decomposition takes six months to two years. Excellent-quality compost can be made either way. When selecting a composting method, consider economy, neatness, permanence, need for finished compost, and time available for maintenance.

MATERIALS

Almost all natural, organic material will compost, but not everything belongs in the compost pile. Some wastes attract pests; others contain pathogens that can survive the compost process, even if the pile gets hot. Table 2 divides materials according to whether or not they cause these types of problems.

As shown in Table 2, fatty food wastes, such as meat or bones, should be avoided. They attract rodents, raccoons, dogs, cats, flies, and other pests; and they can cause odors. Cat and dog manures can contain harmful pathogens that are not always killed by the heat of the compost pile. Manures also attract cats and dogs to the pile.

The art of composting is discovering the mix of materials that will provide the best environment for the compost process.

Plants harboring diseases, or suffering severe insect infestations, should not be added to the compost pile. Certain pernicious weeds, including morning glories, buttercups, and grasses (such as quack grass) with rhizomatous root systems, may not be killed if the pile does not heat up. Piles containing these types of weeds must be turned to encourage the high pile temperatures that will kill them.

Another consideration in choosing materials to go into the compost pile is the time they need to break down. Woody materials, such as wood chips, branches, and twigs can take up to two years to break down unless they are finely chipped or shredded. Their high C:N ratios indicate that they require a lot of nitrogen to decompose, so they may slow the decomposition of other materials. Other materials that break down slowly include: corn cobs, husks, and stalks; sawdust; straw; apple pomace; and some nut shells. These materials should be cut into small pieces to increase their surface areas and mixed with high-nitrogen materials, such as manure or fresh grass clippings.

TABLE 2

MATERIALS THAT SHOULD AND SHOULD NOT BE IN A COMPOST PILE			
YES		NO	
Aquatic weeds	Leaves	Butter	Mayonnaise
Bread	Paper	Bones	Meat
Coffee grounds	Sawdust	Cat manure	Milk
Egg shells	Straw	Cheese	Oils
Evergreen needles	Sod	Chicken	Peanut butter
Fruit	Tea leaves	Dog manure	Salad dressing
Fruit peels and rinds	Vegetables	Fish scraps	Sour cream
Garden wastes	Wood ash	Lard	Vegetable oil
Grass clippings	Wood chips		

Materials that break down slowly should be mixed with easily decomposed materials to allow the pile to get hot. If a high-nitrogen source is not available, high-carbon wastes should be used as mulches. (The process is described earlier in this guide.) While materials such as wood chips and straw break down slowly, they also are bulking agents that improve the pile structure, allowing air circulation. If composting dense, high-nitrogen materials, such as manure, the addition of a bulking agent may be required to facilitate the process.

The art of composting is discovering the mix of materials that will provide the best environment for the compost process. Mixing materials of different sizes and textures helps to provide a structurally stable and well-drained compost pile. Diverse material also helps maintain the right C:N ratio and an efficient process.

TABLE 3

PERSISTENCE OF SOME COMMON HERBICIDES IN SOIL		
COMMON NAME	TRADE NAMES	LONGEVITY IN SOIL (MONTHS)
Benefin	Balan, Balfin	4-8
DCPA	Dacthal	4-8
Bensulide	Betasan, Prefar	6-12
Glyphosate	Roundup, Kleenup	< 1
2,4-D	(many formulations)	1-2
MCPP	(many formulations)	1-2
Dicamba	Banvel	3-12

Source: Rosen, et. al., 1988.

Some gardeners are concerned about composting grass clippings that have been treated with pesticides. Table 3 lists the persistence of some common lawn herbicides in soil. Composting, as an accelerated decomposition process, biodegrades many compounds faster than soil degradation. If yard waste has been composted at least one year, pesticide residues should not be a problem when the compost is used.

Sod can be incorporated into a compost pile; it can also be composted in a holding system with or without a structure. Large quantities of fresh, stripped sod should be piled with the roots up and grass down. The sod should then be wetted thoroughly and covered with a tarp, to keep light out. A large pile of sod may take one to three years to decompose completely. Small quantities of sod will decompose more quickly if broken into small pieces and mixed with other wastes in holding or turning units.

ADDITIVES

Inoculants, activators, and lime are compost pile additives. Inoculants are dormant microorganisms; activators contain sugar or a nitrogen source, such as ammonium sulfate; and lime increases compost pile pH. Inoculants are rarely needed, since earth, leaves, kitchen scraps, and finished compost already contain ample bacteria that can work readily on their own. The only activator that may be needed is a nitrogen source, since nitrogen is usually the limiting nutrient. Nitrogen accelerates the decomposition process if the materials to be composted do not include a material with a low C:N ratio, such as manure or grass clippings (see Table 1). Other nutrients added through the application of organic or chemical fertilizers will have little effect on the composting process.

If additional nitrogen is needed, approximately 0.15 pounds actual nitrogen per 3 bushels (approximately 4 cubic feet) of leaves should be added. Table 4 lists estimated amounts of particular nitrogen sources that should be added to leaves. For instance, 7 ounces (about 1 cup) of ammonium nitrate is equivalent to 0.15 pounds. The nitrogen source is usually mixed with water and sprinkled in a compost pile as it is constructed.

During the initial stages of decomposition, the compost pile produces organic acids and the pH may drop. However, since composting organisms perform best at a pH between 4.2 and 7.2, it is best not to add lime to adjust pH. Adding lime converts ammonium nitrogen to ammonia gas, creating an odor problem. As the compost matures, pH will rise, typically to between 6.0 and 8.0 for finished compost.

TABLE 4

AMOUNTS OF VARIOUS NITROGEN SOURCES NEEDED TO APPLY 0.15 POUNDS (2.4 OZ) NITROGEN

Nitrogen Source	% Nitrogen	Ounces to Apply
Ammonium nitrate	33	7.0
Calcium nitrate	15	16.0
Urea	46	5.2
Dried blood	12	20.0
Fish meal	10	24.0

LOCATION

A good location is helpful for a successful compost pile. Direct sunlight in the summer dries the pile. Exposure to high winds can dry and cool the pile, slowing the decomposition process. The pile location should not interfere with lawn and garden activities. Water should be readily available. There should also be enough space for temporary storage of organic wastes. Good drainage is important; otherwise, standing water could impede the decomposition process. The compost pile should not be located against wooden buildings or trees; wood in contact with compost may decay.

VOLUME

A pile should be large enough to hold heat and small enough to admit air to its center. As a rule of thumb, the minimum dimensions of a pile should be 3 feet x 3 feet x 3 feet (1 cubic yard) to hold heat. The maximum dimension to allow air to the center of the pile is 5 feet x 5 feet x any length.

A pile should be large enough to hold heat and small enough to admit air to its center.

If space is a limiting factor, the pile sides should be insulated so that higher temperatures can be maintained in a much smaller volume. Smaller, commercially available units can be insulated with foam board. Piles larger than 5 feet tall and wide may need to be turned to prevent their centers from becoming anaerobic. As the material decomposes, the pile will become smaller. A yard stick can be used to keep track of, or demonstrate, volume reduction.

PILE CONSTRUCTION

Compost piles can be constructed by adding stockpiled material in batches or by placing materials in the piles as they become available. The batch method accelerates the composting process if the combined materials have the right C:N ratio and if the materials are mixed. Guidelines for constructing a compost pile are given in Appendix C.

PILE MAINTENANCE

Maintenance of the compost pile involves turning the pile and adding water to maintain conditions conducive to the composting process. If the pile is not turned, decomposition will occur, but at a slower rate. The following maintenance procedure will yield compost in the shortest time.

In a pile constructed according to the method described in Appendix B, the pile temperature will increase rapidly and soon reach about 110°F. After about a week, the pile should be opened to the air and any compacted material should be loosened. Then the pile should be reconstructed; material previously on the top and sides of the pile should be moved to the center.

Maintenance of the compost pile involves turning the pile and adding water to maintain conditions conducive to the composting process.

At the second turning (after about another week), the material should be a uniform coffee-brown color and moist. The relatively undecomposed outer layer can be scraped off and turned back in to the center of the pile. The center material should be spread over the outer layer of the reconstructed pile. By the third turning, the original materials should not be recognizable. At each turning, the moisture content should be checked using the squeeze test described earlier. Water should be added, if necessary.

During the first few weeks of composting, the pile should reach a peak temperature of about 140°F. If temperatures surpass 140°F, the pile should be turned to cool it off. Extremely high temperatures can kill many beneficial organisms. If the pile does not reach at least 120°F, more nitrogen or water may be needed. Cold weather can also prevent the pile from heating. Piles that give off strong ammonia smells contain too much nitrogen, and may need more high-carbon ingredients.

Simple carbohydrates and proteins provide most of the energy for the initial, rapid stages of decomposition. When the more resistant materials, such as lignins and cellulose, become the main food sources, the activity in the pile will slow down. Less heat will be produced, and the temperature will begin to fall to about 100°F. Even after the temperature falls, the compost will continue to stabilize slowly.

The compost will be finished when the pile cools off and decreases to about one-third of its original volume (depending on the original ingredients). It will be dark, crumbly, and have an earthy odor. The C:N ratio will be less than 15:1, approaching the value of humus in soil, and the temperature usually will be within 10°F of ambient air temperature. Unfinished compost can be phytotoxic, especially to seedlings and newly established plants. Therefore, compost must be allowed to decompose thoroughly before use.

AVOIDING PESTS

Given a comfortable, or even nourishing, environment, rodents and other animals may be attracted. Rats are probably the most undesirable pests. In a hospitable environment with plenty of food, they can multiply very quickly and can become disease transmitters. Therefore, it is crucial to keep high-protein and fatty food wastes out of the compost pile in areas where pests may be a problem. Meat and fish scraps, bones, cheeses, butter, and other dairy products should be excluded if pests are a problem. Bread and other high-carbohydrate or high-sugar wastes can also attract pests.

Many flies, including houseflies, can spend their larval phase as maggots in compost piles. To control their numbers, compost piles with food in them must be turned frequently to encourage heating (larvae die at high temperatures). The piles should also be covered with finished compost or a dry material that has a lot of carbon in it, such as straw. Food waste can be incorporated into soil, as described previously, to avoid pest problems in compost piles. Pest-proof sides and covers may also be installed on compost units to help control pests.

TROUBLESHOOTING

The solutions to most compost problems are often fairly simple. Table 6, on the inside back cover, explains how to troubleshoot common compost problems.

CHAPTER 4

USING COMPOST

Compost can enrich flower and vegetable gardens and improve soil around trees and shrubs. It can also be used as a soil amendment for house plants and planter boxes, or as a lawn top-dressing when screened. While most compost will greatly improve soils for plants, unfinished compost, or compost resulting from anaerobic decomposition, can contain acids or alcohols that can harm seedlings or sensitive plants.

Compost improves the structure of soil ...it [also] contains both plant nutrients and essential trace elements.

BENEFITS OF COMPOST

Compost improves the structure of soil. When mixed with a sandy soil, compost holds moisture and inorganic minerals. Compost particles hold soil together, and give it a crumbly texture. The addition of compost increases the soil's porosity so that plant roots can more easily penetrate it.

In heavy clay soil, compost particles bind with clay particles to form larger particles. Surface water can drain between the larger particles, while, the compost portions hold moisture inside the particles for plant uptake. Surface layers of soil conditioned with compost retain water better, and resist surface crusting and erosion.

Compost attracts earthworms and provides them with food, so they breed rapidly. The tunnels that earthworms create aerate the soil and improve drainage, and the earthworms' burrowing brings up minerals from the subsoil, making them available to plants. Earthworms contribute to good soil structure. They coat soil particles with humus, and stimulate the growth of fungi that bind the soil particles together.

Although compost is considered a soil conditioner, rather than a fertilizer, it contains both plant nutrients and essential trace elements. Some chemical fertilizers release elements so quickly that rain can leach them away before plants derive much benefit. In compost, most of the nitrogen and phosphorus are held in organic form and released slowly. The nutrients in compost are therefore available throughout the growing season.

Current research by several plant pathologists indicates that incorporation of specific types of compost into soil will suppress several soilborne diseases on crops such as turf grass, peas, beans, and apples. This research may have important implications for compost use in coming years.

APPLICATION

Compost is usually applied annually. The thickness of compost application is determined by the landscape use, as indicated in Table 5. The best time to dig compost into a garden bed is during preparation of the bed for planting. If only a small amount of compost is available, it can be incorporated in the seed furrow, or a handful can be added to each transplant hole of annual or perennial plants. Large quantities can be used to transplant trees or shrubs or to renovate or replace a lawn. Compost is also an excellent top-dressing around flower and vegetable plants, shrubs, and trees.

For general soil enrichment, the soil should be turned thoroughly, and compost mixed with the top 4 to 6 inches. Mixing fresh clippings with compost provides additional nitrogen for plants and makes an excellent mulching material. Care must be taken when incorporating compost around plants to avoid injuring plant roots growing near the surface. Compost as a surface mulch (or top-dressing) provides nutrients that will gradually work their way to the roots; it also provides protection from both temperature extremes and erosion caused by hard rain. Compost requirements for a given area can be calculated by noting that 3.1 cubic yards, or 67 bushels, of compost are needed to cover 1,000 square feet with a 1-inch-deep layer of compost.

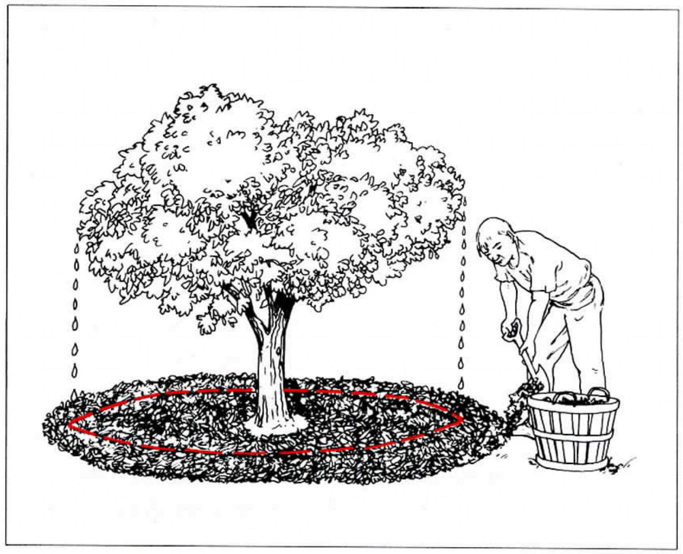


Fig. 16. The application of compost, as a mulch, around a tree.

When applying compost as a mulch under trees and shrubs, the first step involves removing the grass mat from the tree trunk or shrub base to several feet beyond the dripline. The dripline is defined by the outer edge of the plant's branches, as shown in Figure 16. Compost should then be worked into the upper 2 inches of soil (with care to avoid root damage). Applying compost will help reduce moisture and keep the soil cool.

TABLE 5

COMPOST APPLICATION GUIDELINES

Landscape Use	Approximate Rate (lbs/1,000 sq. ft.)	Comments
Lawn and athletic field establishment	3,000 to 6,000 (1 to 2 inches)	Incorporate into top 4 to 6 inches of soil
Lawn topdressing	400 to 800 (1/8 to 1/4 inch)	Broadcast uniformly on grass surface
Shrub and tree maintenance	200 to 400 (1/16 to 1/4 inch)	Work into soil or use as a mulch
Container mix	Not more than 1/3 by volume	Blend with perlite, vermiculite, sand, or bark

Source: USDA publication ARM–NE–6, August, 1979.

Compost applied to lawns must be finely ground, so that the grass is not smothered. One way of applying the compost is to use an aerator to slice up the sod. A 1/8-inch to 1/4-inch covering of fine compost should be applied. A rake or a rotary mower should be used to distribute the compost into the crevices. Compost applied in this manner will provide the grass roots with moisture and nutrients and prevent soil compaction.

Fine-textured compost can also be used in potting mixture formulations. No more than one-quarter to one-third, by volume, of the potting mix should be compost; higher levels can result in excess nutrient levels. Special care must be taken when using compost for starting seedlings. While recent research indicates that some well-aged compost can help prevent damping-off disease of seedlings, fresh compost may be phytotoxic and should not be used.

Compost containing brownish bits of stems and stalks is still undergoing decomposition. Such compost should be screened before it is applied to lawns or used in potting mixes. The screening procedure is illustrated in Figure 17. A simple screen can be made with 1/2-inch hardware cloth and a wooden frame.

Fig.17. A method for screening compost to be used on lawns or with potted plants.

CHAPTER 5

Using This Guide as an Educational Resource

This guide can be used by volunteers, teachers, and community leaders to start educational programs on home composting. Information from this guide should be organized to emphasize that composting does not require vast amounts of time, resources, or technical know-how.

The specific needs and interests of various audiences must be assessed before educational programs can be planned. Answers to the following questions should be obtained:

- What is the nature of the material to be composted?
- How much time and energy are available for managing the composting process?
- What space is available to build a composting unit? What is the nature of that space: public, or private?
- What physical or monetary resources are available for building supplies and equipment?
- How will the composted material be used?
- What experience has the individual, family, or community had with composting?

The answers to these questions dictate the portions of this guide to be emphasized in an educational program. Not all audiences need be exposed to the detail of the entire guide. After the character and needs of each audience have been identified, a number of methods can be used to relay the desired message about composting. Press releases directed at weekly community newspapers or newsletters could be used to make people aware of composting and its benefits. Also, such press releases could publicize additional educational opportunities (such as seminars, workshops, or demonstrations) or announce the availability of detailed composting brochures.

Aside from providing information to the general public about composting, it may be worthwhile to work with state, county, and community organizations to promote the merits of composting. For example, service organizations, newcomer groups, and gardening clubs could be approached to sponsor special community composting projects. Local school systems and libraries often are anxious to have volunteers present workshops and demonstrations. Elected officials can usually make arrangements for demonstration space at town parks or community centers. In some instances it may be necessary for a public official to become involved in altering local zoning regulations that prohibit accumulations of "wastes" that otherwise could be composted.

Resource people in most communities may be willing to share responsibility for a composting educational effort. Involving such persons early on will enhance feelings of ownership and responsibility for the program.

DEMONSTRATION–EXHIBIT DESIGN

A well-located composting demonstration or exhibit can educate specific groups, such as home owners, apartment dwellers, community gardeners, and groundkeepers about the various composting systems and principles reviewed in this guide. With appropriate illustrations and labeling, a display can provide a self-guided explanation of compost use, composting unit design, and the advantages and potential problems of different composting systems.

Special-event field days provide opportunities for publicity and focused use of compost demonstrations or exhibits. Such displays could be staffed by volunteers trained to provide brief explanations about various aspects of composting. Garden-bed or container plantings grown in soil mixes with, and without, compost could be used to demonstrate the results of using compost.

Compost demonstrations should be established at locations where a cross-section of a community feels comfortable to visit casually and observe. Community or botanical gardens will attract individuals who have some knowledge about compost and its use in the garden, and as such, may demand a more sophisticated level of information. Individuals who visit a demonstration at locations such as a local park or zoo may have limited knowledge or exposure to the basics of composting. These exhibits may require more attention to basic composting definitions and requirements. Several of the most important aspects of composting are outlined below. For more detailed information, the relevant sections of the text should be reviewed.

Types and Characteristics of Compostable Materials

Different sources of organic matter may not necessarily be available at all times. For instance, if bins are set up in late spring, the availability of vegetative growth, grass clippings, and fallen leaves may be limited. It may be necessary to stockpile material in the fall to assure a supply of organic matter for demonstrations during other periods of the year.

Compost Handling Systems

Examples of free-standing piles, holding units, and turning units could be labeled to show differences in management, time, and equipment demands. Temperature differences of compost in the different systems could be recorded on a chart displayed nearby to show the effect of aeration, moisture, and maturity. A rubber liner or glove could be provided to allow visitors to insert their hand into the compost and feel the heat generated at the center of the pile. Plexiglass walls would let viewers see the composting process.

Life Cycle of the Compost Pile

A flow chart depicting the creatures that exist in the compost pile would show the biological changes that occur as the pile matures (See Figure 3). At a manned exhibit, hand lenses and microscopes would enable observation of creatures living in the compost. Children might be interested in collecting (and returning) samples of the compost creatures. A log listing the creatures that were found could be maintained.

Benefits and Use of Compost

Labeled samples of screened and unscreened finished compost would show differences in compost structure. Potential uses for unscreened samples include mulching, general soil incorporation, and potting mixture formulation for larger plants. Finely screened compost could be used in container plantings or as seed cover in the garden.

Open-ended, clear, plastic sleeves (3-6 inches in diameter), containing soil with different proportions of compost could be used as growing containers to demonstrate differences in moisture retention and root movement of rapidly growing plants like corn, peas, or beans. When they are not on display, the root area in the sleeves should be covered (to keep out light) so that the roots will grow out to the edges. All container-grown plants will require regular watering and maintenance.

SUMMARY

The long-term success of any composting education program will require creative and imaginative attitudes on the part of all those involved. No approach, system, or process should be viewed as the "only endorsed" course. The development and exchange of ideas should be encouraged through discussions, suggestion boxes, or backyard research-observation trials. A community "new idea" contest could be developed to encourage and acknowledge new approaches to composting systems, techniques, or materials.

The combined energy and experience of concerned citizens, volunteers, community leaders, and educators will create a team approach that can help make composting an acceptable waste-management option for residents.

Glossary

Actinomycete. A group of microorganisms, intermediate between the bacteria and the true fungi, that usually produce a characteristic branched mycelium–These organisms are responsible for the earthy smell of compost.

Aeration. The process by which the oxygen-deficient air in compost is replaced by air from the atmosphere–Aeration can be enhanced by turning compost.

Aerator. A tool used to create new passages for air and moisture in a compost pile

Aerobic. An adjective describing an organism that can live only in the presence of oxygen gas (e.g., an aerobic organism)

Ambient air temperature. The temperature of the air in the vicinity of the compost pile

Amendment, soil. Any substance (such as lime, sulfur, gypsum, or sawdust) used to alter the properties of a soil (generally, to make it more productive)–Fertilizers are one type of soil amendment. However, many soil amendments (such as soil conditioners) do not have significant fertilizer value.

Anaerobic. An adjective describing an organism that can live or function in the absence of air or free oxygen

Bacteria. A group of microorganisms having single-celled or noncellular bodies–Some bacteria provide a gummy substance (a mucus) that binds soil particles together.

Carbohydrate. Any compound containing only carbon, hydrogen, and oxygen (such as sugars, starches, and cellulose)

Carbon-to-nitrogen ratio. The ratio of the weight of organic carbon (C) to that of total nitrogen (N) in an organic material

Cellulose. A long chain of tightly bound sugar molecules that constitutes the chief part of the cell walls of plants

Chemical persistence. The time a chemical remains in the environment essentially unchanged

Compost. A group of organic residues, or a mixture of organic residues and soil, that have been piled, moistened, and allowed to undergo biological decomposition

Composting. The biological degradation or breakdown of organic matter by a managed process

Cubic yard. A unit of measure equivalent to 27 cubic feet or 22 bushels–A box that is 1 yard wide, 1 yard long, and 1 yard high has a volume of 1 cubic yard.

Damping off disease. The wilting and early death of young seedlings caused by a variety of pathogens

Decomposers. The microorganisms and invertebrates that cause the normal degradation of natural organic materials

Dripline. A line on the ground defined by the outer edge of a plant's branches

Enzymes. Any of numerous complex proteins that are produced by living cells to catalyze specific biochemical reactions

Evaporative cooling. The cooling that occurs when heat from the air or compost pile material is used to evaporate water

Fast composting. An intensive composting method that produces finished compost in one to two months–This method requires frequent turning to maximize aeration. When temperatures of 140°F (60°C) are achieved, a "thermal kill" of pathogens, or "partial sterilization," occurs.

Fungi. A group of simple plants that lack a photosynthetic pigment–The individual cells have a nucleus surrounded by a membrane, and they may be linked together in long filaments called hyphae. The individual hyphae can grow together to form a visible body.

Green manure. Plant material incorporated into the soil, while green, to improve the soil

Herbicides. The agents used to inhibit plant growth or kill specific plant types

Humic acids. The chemical or biological compounds composed of dark organic substances that are precipitated upon acidification of a basic extract from soil

Humus. That more-or-less-stable organic fraction of the soil matter remaining after the major portion of added plant and animal residues have decomposed–Humus is usually dark in color.

Hydrogen sulfide. A gas, H_2S, with the characteristic odor of rotten eggs, produced by anaerobic decomposition

Inoculant. The dried or inactive microorganisms that become active when added to the compost pile

Lawn renovation. The process of conditioning an established lawn so as to improve the stand of grass, resulting in more dense turf (fertilizing, liming, dethatching, enhancing aeration, weed control, etc.)

Leachate. The liquid that results when ground or surface water comes in contact with solid waste, and extracts material, either dissolved or suspended, from the solid waste

Lignin. A substance that, together with cellulose, forms the woody cell walls of plants and the cementing material between them–Lignin is resistant to decomposition.

Mesophilic range. Operationally, that temperature range most conducive to the maintenance of optimum digestion by mesophilic bacteria, generally accepted as between 70° and 100°F (21°-38°C)

Microbe. See microorganism

Microorganism. An organism requiring magnification for observation

Mulch. A material spread over the soil surface to conserve moisture and porosity in the soil underneath and to suppress weed growth–Grass clippings, compost, wood chips, barks, sawdust, and straw are common mulch materials.

Mycelium. The collective term for fungus filaments or hyphae

Noxious weeds. A group of weeds that physically harm cultivated plants by crowding them out

Nutrient-holding capacity. The ability to absorb and retain nutrients so they will be available to the roots of plants

Organic matter. The matter derived from living or once-living organisms that gradually can be broken down to yield important plant nutrients

Oxidize. To chemically combine with oxygen

Pathogen. Any organism capable of producing disease or infection–Often found in waste material, most pathogens are killed by the high temperatures of the composting process.

Peat. The unconsolidated soil material consisting largely of undecomposed, or only slightly decomposed, organic matter accumulated under conditions of excessive moisture

pH. A measure of the concentration of hydrogen ions in a solution–pH is expressed as a negative exponent. Thus, something that has a pH of 8 has ten times fewer hydrogen ions than something with a pH of 7. The lower the pH, the more hydrogen ions present, and the more acidic the material is. The higher the pH, the fewer hydrogen ions present, and the more basic it is. A pH of 7 is considered neutral. Compost decomposes fastest with a pH of around 6.5 (slightly acidic).

Phytotoxic. An adjective describing a substance that has a toxic effect on plants–Immature or anaerobic compost may contain acids or alcohols that can harm seedlings or sensitive plants.

Porosity. The volume of pores divided by the total volume

Red worms. *Eisenia fetidae*, commonly known as red worms, are deep maroon in color. They thrive only in manure or garbage and are rarely found in ordinary soils.

Slow composting. A minimal-effort composting method that produces finished compost in a year or more–Slow composting requires little maintenance.

Soil conditioner. A soil additive that stabilizes the soil, improves its resistance to erosion, increases its permeability to air and water, improves its texture and the resistance of its surface to crusting, makes it easier to cultivate, or otherwise improves its quality

Soil structure. The combination or arrangement of primary soil particles into secondary particles, units, or peds–Compost helps bind soil primary particles to improve the structure of soil.

Soil texture. A characterization of soil type, based on the relative proportions of sand, silt, and clay in a particular soil

Thatch. Dead and drying grass plant parts (such as roots, stems, and shoots) that accumulated above the soil surface of a lawn

Thermophilic. Heat-loving microorganisms that thrive in, and generate, temperatures between 113° and 155°F (45°-68°C)

Topdressing. Applying a layer of compost, or other material, to the surface of soil

Turning unit. A system used to compost large amounts of yard and kitchen wastes in one to two months–Wastes are stored until enough are available to fill an entire bin. Materials are then chopped, moistened, and layered to ensure a hot compost. Piles are turned regularly (weekly) to enhance aeration.

Vermicomposting. The process by which worms convert organic waste into worm castings

Worm castings. The dark, fertile, granular excrement of a worm–Granules are rich in plant nutrients.

Yard waste. Leaves, grass clippings, yard trimmings, and other organic garden debris

Home Composting Educational Materials

BOOKS AND BULLETINS

Characterization of Municipal Solid Waste in the United States: 1960 to 2000. Update 1988. Franklin Associates.

The Complete Book of Composting. (1960) by J.I. Rodale. Rodale Books, Inc., Emmaus, PA 18049. 1007 pp.

Composting: An Introduction to the Rational Use of Organic Waste. (1981) by A Pfirter, A. von Hirscheydt, P. Ott, and H. Vogtmann. Solothurn, Switzerland: Migros-S-Production, Migros Cooperative Aargau.

"Composting and Mulching: A Guide to Managing Organic Yard Wastes." AG-FO-3296. (1990) by C. Rosen, N. Schumacher, R. Mugaas, and T. Halbach. Minnesota Extension Service, Distribution Center, 3 Coffey Hall, 1420 Eckles Avenue, St. Paul, MN 55108.

The Earth Worm Book. (1977) by J. Minnich. Rodale Press, Emmaus, PA 18049. 327 pp.

"Ecology of Compost: A Public Involvement Project." (1971) by D.L. Dindal. SUNY College of Environmental Science and Forestry, Office of News and Publications, 122 Bray Hall, Syracuse, NY 13210.

The Incredible Heap: A Guide to Compost Gardening. (1983) by C. Catlon and J. Gray. St. Martin's Press, Inc., New York, NY 10010.

Let It Rot: the Gardeners Guide to Composting. (1975) by S. Campbell. Garden Way Publishing. Storey Communications, Inc., Pownal, VT 05261. 152 pp.

Master Composter Resource Manual. (1987) by C. Woestendiek, C. Benton, J. Gage, and H. Stenn. 44 pp. Available from: Seattle Tilth Association, 4649 Sunnyside Avenue North, Seattle, WA 98103.

The Rodale Guide to Composting. (1979) by J. Minnich and M. Hunt. Rodale Press, Emmaus, PA 18049. 405 pp.

Use of Sewage Sludge Compost for Soil Improvement and Plant Growth. USDA publication ARM–NE–6, August, 1979. 10 pp.

Worms Eat My Garbage. (1982) by M. Appelhof. Flower Press, 10332 Shaver Rd., Kalamazoo, MI 49002. 100 pp.

BROCHURES AND PAPERS

(for current cost information, contact the distributors).

"**Composting and Mulching: A Guide to Managing Organic Yard Wastes**." C. Rosen, N. Schumacher, R. Mugaas, and T. Halbach. 1990. AG-FO-3296. Available from: Minnesota Extension Service, Distribution Center, 3 Coffey Hall, 1420 Eckles Avenue, St. Paul, MN 55108.

"**Composting: Wastes to Resources**." J. F. Bonhotal and M. E. Krasny. 4-H Leaders/Teachers Guide. Available from: Distribution Center, 7 Research Park, Cornell University, Ithaca, NY 14850.

"**Ecology of Compost: A Public Involvement Project**." D. L. Dindal. 1971. Available from: SUNY College of Environmental Science and Forestry, Office of News and Publications, 122 Bray Hall, Syracuse, NY 13210.

"**Home Composting**." 1989. Brochure 1238CB. Available from: Distribution Center, 7 Research Park, Cornell University, Ithaca, NY 14850.

"**What about Waste?**" J. F. Bonhotal, K. L. Edelstein, and M. E. Krasny. 1990. 4-H Leaders/Teachers Guide. Available from: Distribution Center, 7 Research Park, Cornell University, Ithaca, NY 14850.

Send a self-addressed, stamped envelope for an updated price list on "**Home Composting**" materials from: Seattle Tilth Association, 4649 Sunnyside Avenue North, Seattle, WA 98103.

SLIDE SETS

"**The Decomposer Food Web**." 1980. D. L. Dindal. 70 slides and script focusing on the organisms of aerobic decomposition and composting. Available from: J.G. Press, Inc., Box 351, Emmaus, PA 18049.

"**Home Composting**." 1989. 49 slides and text on home composting. Available from: R. Kozlowski, Extension Associate, Dept. of Floriculture and Ornamental Horticulture, 15-F Plant Sciences Building, Cornell University, Ithaca, NY 14853.

POSTERS

"**Best Ever Composting.**" Available from: Distribution Center, 7 Research Park, Cornell University, Ithaca, NY 14850.

"**How Does Composting Work?**" Available from: Distribution Center, 7 Research Park, Cornell University, Ithaca, NY 14850.

Seven posters (#123CP) are available from: Distribution Center, 7 Research Park, Cornell University, Ithaca, NY 14850.

- "Composting," which lists materials that can be composted
- "Home Composting: Which Method is Best for You?" which includes a three-panel exhibit: "Heap", "Holding Unit", and "Turning Unit"
- "Life Cycle of the Compost Pile," which illustrates the cycle of: living plant material; new compost; bacteria and fungi; partially decomposed compost; worms, beetles, and mites; and finished compost
- "Managing the Compost Pile," which describes temperature, minimum pile size, and water requirements

VIDEO

"**Zoo Doo and You Can Too.**" August 1987. 60 minutes focusing on a composting program at the Seattle Zoo and the demonstration composting facility run by the Community Compost Education Program in Seattle. Co-produced by Dr. P. Connett and R. Bailey. Available from: Video Active Production, Box 322, Rt. 2, Canton, NY 13617.

REFERENCES

Appelhof, M. 1982. ***Worms Eat My Garbage***. Kalamazoo, MI: Flower Press.

Dindal, D. L. 1971. ***Ecology of Compost: A Public Involvement Project***. SUNY College of Environmental Science and Forestry: Office of News and Publications.

Franklin Associates. 1988. ***Characterization of Municipal Solid Waste in the United States, 1960 to 2000: Update 1988.***

Pfirter, A., A. von Hirscheydt, P. Ott, and H. Vogtmann. 1981. ***Composting: An Introduction to the Rational Use of Organic Waste***. Solothurn, Switzerland: Migros-S-Production, Migros Cooperative Aargau.

Rosen, C., N. Schumacher, R. Mugaas, and S. Proudfoot. 1988. ***Composting and Mulching: AGuide to Managing Organic Yard Wastes***. St. Paul, MN: University of Minnesota, Extension Service, Department of Soil Science.

USDA publication ARM–NE–6. August 1979. ***Use of Sewage Sludge Compost for Soil Improvement and Plant Growth***.

Woestendiek, C., C. Benton, J. Gage, and H. Stenn. 1987. ***Master Composter Resource Manual***. Seattle, WA: Seattle Tilth Association.

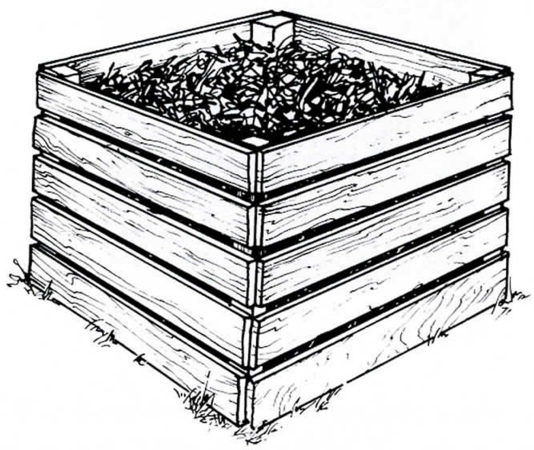
APPENDIXES

CONTENTS PAGE

APPENDIX A: PLANS FOR CONSTRUCTING COMPOST BINS

WOODEN-PALLET HOLDING UNIT

A holding unit can be built inexpensively using wooden pallets, or pressure-treated lumber may be used to make a nicer looking bin. The costs will vary, depending on whether new lumber or pallets are used. Used pallets are often available from manufacturers and landfills.



Materials

- four wooden pallets (Five pallets if you want a bottom in the container), sized to make a four-sided container at least 3 feet x 3 feet x 3 feet
- nails
- baling wire

or

- two eight-foot lengths of 2 x 4 pressure-treated lumber
- five 12-foot lengths of 1 x 6 pressure-treated lumber
- galvanized 8d nails (1 pound)

Tools

- saw
- sledge hammer
- claw hammer
- work gloves

Building a Holding Unit Using Wooden Pallets

1. Nail or wire four pallets together to make a four-sided bin at least 3 feet x 3 feet x 3 feet. The bin is then ready to use.

2. A fifth pallet can be used as a base, to allow more air to get into the pile and to increase the stability of the bin.

Building a Holding Unit Using Lumber

1. Saw the 8-foot lengths of 2 x 4 pressure-treated lumber into four pieces, each 4 feet long, to be used as corner posts.

2. Choose a 3-foot-square site for your compost bin. Use the sledge hammer to pound the four posts into the ground 3 feet apart, at the corners of the square.

3. Saw each of the five 12-foot boards into four 3-foot pieces. Allowing five boards to a side and, starting at the bottom, nail the boards to the posts to make a four-sided container. Leave 2 inches between the boards to allow air to get into the pile.

4. If you wish to decrease your composting time, build a second holding unit so that the wastes in one can mature while you add wastes to the other.

WIRE-MESH HOLDING UNIT

A wire-mesh holding unit is inexpensive and easy to build out of either galvanized chicken wire or hardware cloth. (Nongalvanized chicken wire can also be used, but will not last very long.) Posts provide more stability for a chicken wire bin, but make the bin difficult to move. A wire-mesh bin made without posts is easy to lift, and provides access to the compost that is already "done" at the bottom of the pile while the compost at the top of the pile is still decomposing.

Materials

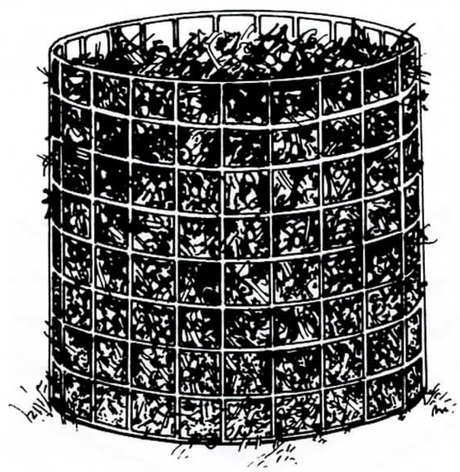
- at least a 10-foot length of 36-inch-wide 1-inch galvanized chicken wire

or

- at least a 10-foot length of 1/2-inch-wide hardware cloth (Note: The maximum bin diameter for a given length of chicken wire is the length of chicken wire divided by 3.14.)
- heavy wire for ties
- three or four 4-foot-tall wooden or metal posts (for chicken wire bin.)

Tools

- heavy-duty wire or tin snips
- pliers
- hammer (for chicken wire bin)
- metal file (for hardware cloth bin)
- work gloves



Building a Wire-Mesh Holding Unit Using Chicken Wire

1. Fold back 3 to 4 inches of wire at each end of the cut piece to provide a strong, clean edge that will not poke or snag, and that will be easy to latch.

2. Stand the wire in a circle and set it in place for the compost pile.

3. Cut the heavy wire into lengths for ties. Attach the ends of the chicken wire together with the wire ties, using pliers.

4. Space wood or metal posts around the inside of the chicken-wire circle. Holding the posts tightly against the wire, pound them firmly into the ground to provide support.

Building a Wire-Mesh Holding Unit Using Hardware Cloth

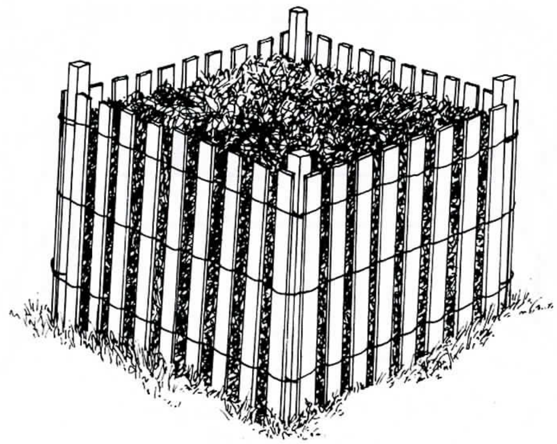
1. Trim the ends of the hardware cloth so that the wires are flush with a cross wire to get rid of edges that could poke or scratch hands. Lightly file each wire along the cut edge to ensure safe handling when opening and closing the bin.

2. Bend the hardware cloth into a circle, and stand it in place for the compost pile.

3. Cut the heavy wire into lengths for ties. Attach the ends of the hardware cloth together with the wire ties, using pliers.

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.



Materials
- four wooden or metal posts, 4-5 feet long (Use pressure-treated lumber for the wooden posts.)
- heavy wire for ties
- a 13-foot length of snow fencing, at least 3 feet tall

Tools
- heavy-duty wire or tin snips
- pliers
- sledge hammer
- work gloves

Building a Snow-Fence Holding Unit
1. Choose a 3-foot-square site for your holding unit, and pound the four wooden or metal posts into the ground 3 feet apart, at the corners of the square.

2. Cut the heavy wire into lengths for ties. Attach the snow fence to the outside of the posts with the wire ties, using pliers.

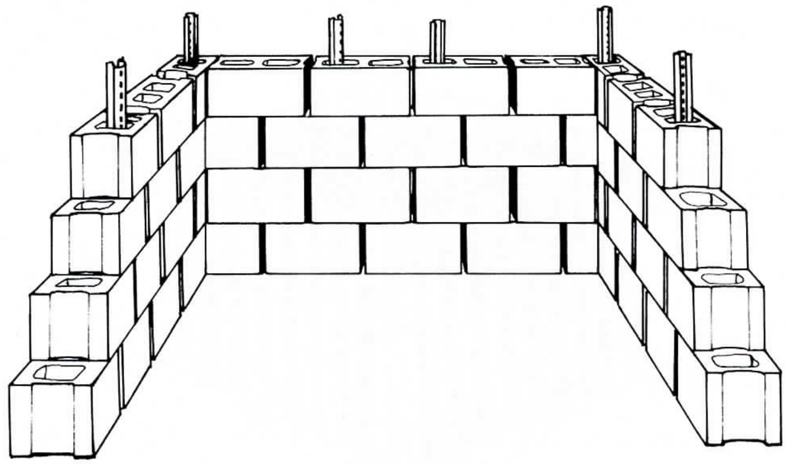
3. Attach the ends of the snow fence together in the same way, forming a 3-foot-square enclosure.

CONCRETE-BLOCK HOLDING UNIT

A concrete-block holding unit is sturdy, durable, and easily accessible. If the concrete blocks must be purchased, a concrete-block holding unit may be slightly more expensive to build than the wire-mesh or snow-fence holding units.

Materials and Tools

- about forty-six concrete blocks for the first bin
- (optional) about thirty-two blocks for a second bin
- wooden or metal posts to stabilize the bin
- work gloves



Building a Concrete-Block Holding Unit

1. Place five concrete blocks in a row along the ground at the composting site, leaving about 1/2 inch between each block to let in air.

2. Place four concrete blocks in another row along the ground perpendicular to, and at one end of, the first row, forming a square corner; leave about 1/2 inch between each block.

3. In the same way, place four concrete blocks at the opposite end of the first row to form a three-sided enclosure.

4. Add a second layer of blocks, staggering them to increase stability and leaving about 1/2 inch between each block. There should be a layer of four concrete blocks on each of the three walls of the enclosure.

5. Add a third layer of blocks, again staggering them to increase stability, with five blocks across the back of the enclosure and three on each side.

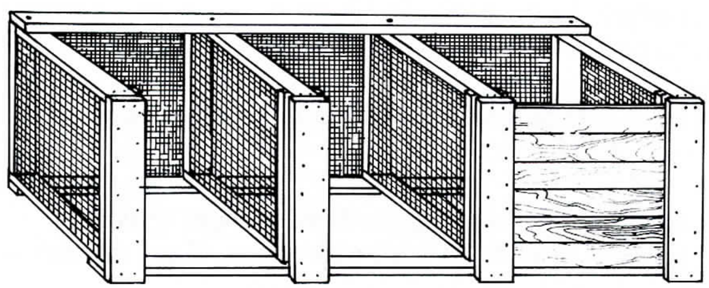
6. The last, and top, layer should have four blocks across the back and three on each side.

7. To make the bin more stable, drive wooden or metal posts through the holes in the blocks.

8. (Optional) If you wish to decrease your composting time, build a second bin next to the first, so that the wastes in one can mature while you add wastes to the other. Use one side wall of the first bin so that you only need to build two additional walls.

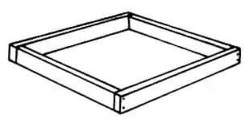
WOOD-AND-WIRE THREE-BIN TURNING UNIT

A wood-and-wire three-bin turning unit can be used to compost large amounts of yard, garden, and kitchen wastes in a short time. Although relatively expensive to build, it is sturdy, attractive, and should last a long time. Construction requires basic carpentry skills and tools.



Building a Wood-and-Wire Three-Bin System

1. Cut two 31 1/2-inch and two 36-inch pieces from a 12-foot length of pressure-treated 2 x 4 lumber. Butt-joint and nail the four pieces into a 35-inch x 36-inch "square." Repeat, building three more frames with the remaining 12-foot lengths of 2 x 4 lumber.



2. Cut four 37-inch lengths of hardware cloth. Fold back the edges of the wire 1 inch. Stretch the pieces of hardware cloth across each frame. Make sure the corners of each frame are square and then staple the screen tightly into place every 4 inches around the edge. The wood-and-wire frames will be dividers in your composter.

3. Set two dividers on end, 9 feet apart and parallel to one another. Position the other two dividers so that they are parallel to and evenly spaced between the end dividers. Place the 36-inch edges on the ground. Measure the position of the centers of the two inside dividers along each 9-foot edge.

Materials

- four 12-foot lengths of pressure-treated 2 x 4 lumber
- two 10-foot lengths of pressure-treated 2 x 4 lumber
- one 10-foot length of construction-grade 2 x 4 lumber
- one 16-foot length of 2 x 6 lumber
- six 8-foot lengths of 1 x 6 lumber
- a 22-foot length of 36-inch-wide 1/2-inch hardware cloth
- 16d galvanized nails (2 pounds)
- poultry wire staples (250)
- twelve 1/2-inch carriage bolts, 4 inches long, with washers and nuts
- one quart wood preservative or stain

Optional materials–for lids

- one 4-x-8-foot sheet of 1/2-inch exterior plywood
- one 4-x-4-foot sheet of 1/2-inch exterior plywood
- six 3-inch zinc-plated hinges
- twenty-four 3/16-inch galvanized steel bolts, with washers and nuts

Tools

- tape measure
- hand saw or circular power saw
- hammer
- tin snips
- carpenter's square
- drill with 3/16-inch and 1/2-inch bits
- screwdriver
- adjustable wrench
- pencil
- safety glasses, ear protection, dust mask, and work gloves

Wood-and-wire three-bin turning unit plan continued on page 36

4. Cut a 9-foot piece from each 10-foot length of pressure-treated 2 x 4 lumber. Place the two treated boards across the tops of the dividers so that each is flush against the outer edges. Measure and mark on the 9-foot boards the center of each inside divider.

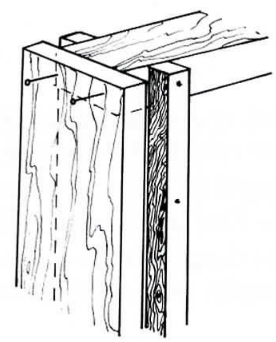
5. Line up the marks, and through each junction of board and divider, drill a 1/2-inch hole centered 1 inch from the edge. Secure the boards with carriage bolts, but do not tighten them yet. Turn the unit so that the treated boards are on the bottom.

6. Cut one 9-foot piece from the 10-foot length of construction-grade 2 x 4 lumber. Attach the board to the back of the top by repeating the process used to attach the base boards. Using the carpenter's square, or measuring between opposing corners, make sure the bin is square. Tighten all the bolts securely.

7. Fasten a 9-foot length of hardware cloth to the back side of the bin, with staples every 4 inches around the frame.

8. Cut four 36-inch-long pieces from the 16-foot length of 2 x 6 lumber for front runners. (Save the remaining 4-foot length.) Rip-cut two of these boards to two 4 3/4-inch-wide strips. (Save the two remaining strips.)

9. Nail the 4 3/4-inch-wide strips to the front of the outside dividers and baseboard so that they are flush on the top and the outside edges. Center the two remaining 6-inch-wide boards on the front of the inside dividers flush with the top edge and nail securely.



10. Cut the remaining 4-foot length of 2 x 6 lumber into a 34-inch-long piece, and then rip-cut this piece into four equal strips. Trim the two strips saved from step number eight to 34 inches. Nail each 34-inch strip to the insides of the dividers so that they are parallel to, and 1 inch away from, the boards attached to the front. This creates a 1-inch vertical slot on the inside of each divider.

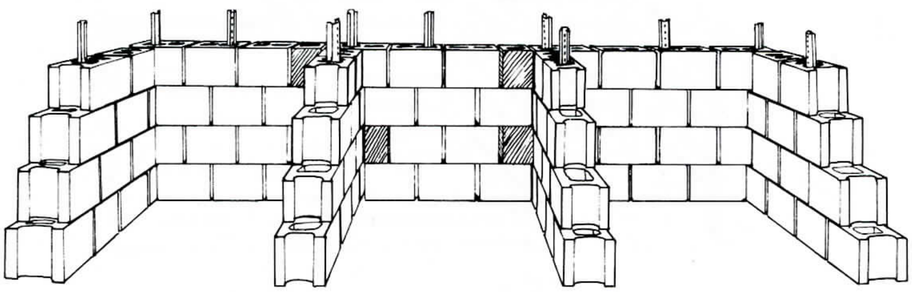
11. Cut the six 8-foot lengths of 1 x 6 lumber into eighteen slats, each 31 1/4 inches long. Insert the horizontal slats, six per bin, between the dividers and into the vertical slots.

12. (Optional) Cut the 4-x-8-foot sheet of exterior plywood into two 3-x-3-foot pieces. Cut the 4-x-4-foot sheet of exterior plywood into one 3-x-3-foot piece on one of the three bins, and attach each to the back, top board with two hinges.

13. Stain all untreated wood.

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 concrete blocks are available, it is inexpensive to build.

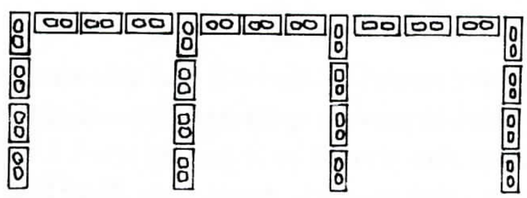


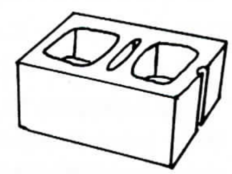
Materials and Tools

- eighty-six concrete blocks
- four concrete half-blocks
- work gloves
- wooden or metal posts to stabilize the bin.

Building a concrete-block turning unit

1. Place twenty-five concrete blocks along the ground at the composting site as shown in the illustration below. Leave about 1/2 inch between each block to let in air.





The illustration above shows a concrete block with a central slit that makes it easy to split into two half blocks. Score each side of the block in the plane of the slit with a chisel. Then use the chisel and a hammer to split the block along the score.

2. Add a second layer of blocks, staggering them to increase stability. Using the turning unit illustration above as a guide, place ten full and two half-blocks along the back wall, and three blocks along each side. Leave about 1/2 inch between each block.

3. Add a third layer of blocks, again staggering them to increase stability. Place twelve blocks across the back of the enclosure and three blocks on each side.

4. The last, and top, layer should have ten full and two half-blocks across the back and two full blocks along each side.

5. To make the unit more stable, drive wooden or metal posts through the holes in the blocks.

WOODEN THREE-BIN TURNING UNIT

This turning unit is a permanent, sturdy structure, but it may be difficult to space the posts to the exact dimensions illustrated. Before cutting the removable slats that slide into the grooves at the front of each bin, cut one slat and check for proper fit in each bin.

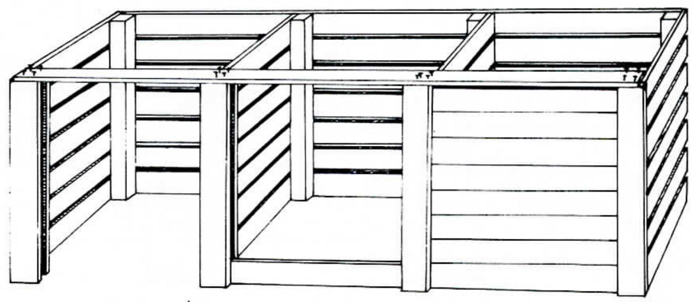
Materials

(All lumber should be pressure-treated)

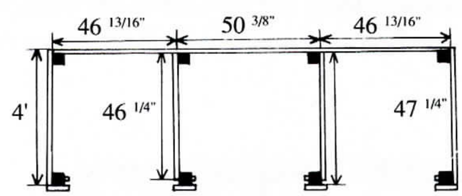
- eight 4-inch x 4-inch x 6-foot posts
- seven 1-inch x 6-inch x 12-foot back slats
- fourteen 1-inch x 6-inch x 4-foot end/side slats
- four 1-inch x 6-inch x 4-foot fronts
- fourteen 1-inch x 6-inch x 46 1/4-inch dividers
- twenty-four 1-inch x 6-inch x 42 13/16-inch (approximate) front slats [Note: before cutting all the front slats, cut one and check for proper fit in each bin.]
- four 1-inch x 1(+)-inch x 4-foot cleats, rip cut from one four-foot 1 x 6 (the cleats are retainers for slats)
- 8d galvanized deck nails or deck screws
- one tube exterior construction adhesive
- (optional) one 1-inch x 6-inch x 12-foot top rail

Tools

- post hole digger
- hammer
- saw
- tape measure
- drill



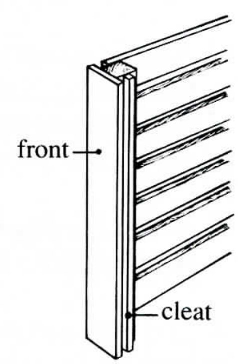
1. On level ground, set the eight posts as shown below using a post hole digger. (The posts are shown as darkened squares.) Embed each post 2 feet into the ground. Be sure all posts are plumb (perpendicular to the ground). The top of each post should be at the same distance above the ground (48 inches).



[Note: Dimensions given for the back are included to assist in post spacing.]

2. Nail (or screw) on the back and side slats and dividers (pre-drill all holes to prevent splitting). Use adhesive on all joints. The bottom slats should be at ground level. Leave 1 1/2-inch (horizontal) spaces between slats. Note that the ends of the dividers should come out to 1 inch behind the front of the front posts, as shown in the illustration above.

3. Install the fronts and cleats, as shown for one of the center divider posts at right.

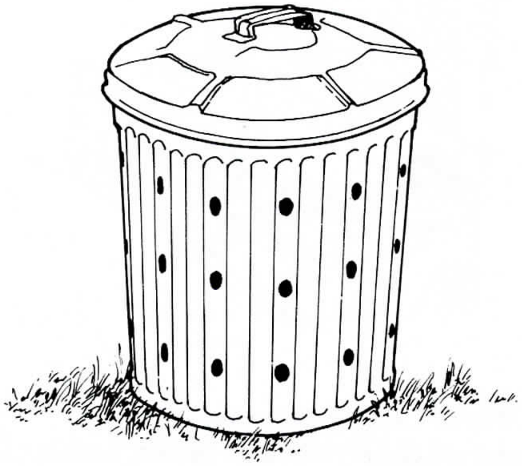


4. After the front slats have been sized and cut, slide them into place between the fronts and cleats as shown in the completed bin illustration above.

5. (Optional) Nail the top rail to each front post, as shown in the completed bin illustration above. Do not use adhesive, and do not drive the nails in fully, as they will be removed to allow access to the slats. The top rail is suggested to prevent the front posts from moving laterally. Another option to discourage this is to use 4-inch x 4-inch x 7-foot posts and embed them one foot deeper.

GARBAGE-CAN COMPOSTER

A garbage-can composter is inexpensive and easy to build. It can be used for food or garden wastes. The wastes do, however, need to be turned.



Materials
- garbage can with cover
- coarse sawdust, straw, or wood chips

Tools
- drill
- pitch fork, shovel, or compost turner
- work gloves

Building a Garbage-Can Composter

1. Drill three rows of holes 4 to 6 inches apart all around the sides of the garbage can. Then drill several holes in the base of the garbage can. The holes allow air movement and the drainage of excess moisture.

2. Place 2 to 3 inches of dry sawdust, straw, or wood chips in the bottom of the can to absorb excess moisture and let the compost drain.

WORM COMPOSTING BIN

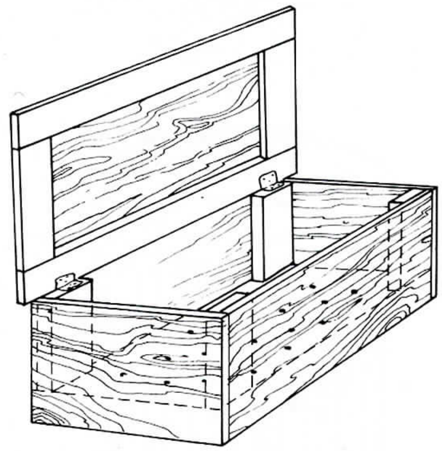
Worm composting is a suitable composting option for apartment buildings or other homes with no yard space. The worms stay in the bin and eat household scraps, and the bin gives off little odor.

Materials

- one 4-x-8-foot sheet of 1/2-inch exterior plywood
- one 12-foot length of 2 x 4 lumber
- one 16-foot length of 2 x 4 lumber
- 16d galvanized nails (1/2 pound)
- 6d galvanized nails (2 pounds)
- two galvanized door hinges
- (optional) one pint of clear varnish
- (optional) plastic sheets for placing under and over the bin
- one pound of worms for every 1/2 pound of food wastes produced per day. (The classified sections of many popular fishing and gardening magazines contain current listings of firms that market red worms.)
- bedding for worms: peat moss, brown leaves, moistened, shredded newspaper or moistened, shredded cardboard

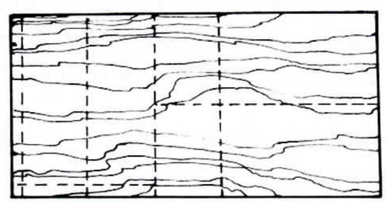
Tools

- tape measure
- skill saw or hand saw
- hammer
- sawhorse
- long straight-edge or chalk snap line
- screwdriver
- drill with 1/2-inch bit
- eye and ear protection
- work gloves
- (optional) paint brush



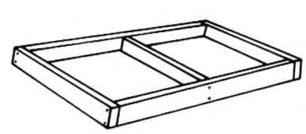
Building a Worm Composting Bin

1. Measure and cut the plywood as shown, so that you have one 24-x-42-inch top, one 24-x-42-inch base, two 16-x-24-inch ends, and two 16-x-42-inch sides.



2. Cut the 12-foot length of 2 x 4 lumber into five pieces: two 39-inch pieces, two 23-inch pieces, and one 20-inch piece.

3. Lay the five pieces on edge on a flat surface to form a rectangle, with the long pieces on the inside and the 20-inch length centered parallel to the ends. Nail the pieces together with two 16d nails at each joint.



4. Nail the 23-x-42-inch piece of plywood onto the frame with 6d nails every 3 inches.

5. Cut four 1-foot lengths from the 16-foot length of 2 x 4 lumber. (Save the remaining 12-foot piece.) Take the two 16-x-42-inch pieces of plywood and place a 1-foot length flat against each short end and flush with the top and side edges. Nail the 2 x 4s in place using 6d nails.

6. Set the plywood sides up against the base frame so that the bottom edges of the 2 x 4s rest on top of the base frame and the bottom edges of the plywood sides overlap the base frame. Nail the plywood sides to the base frame using 6d nails.

7. To complete the bin, nail the 16-x-24-inch pieces of plywood onto the base and sides at each end.

8. To reinforce the bin, stagger nails at least every 3 inches wherever plywood and 2 x 4s meet.

9. Drill twelve 1/2-inch holes through the plywood bottom of the bin for drainage.

10. To build lid frame, cut the 12-foot piece (from the 16-foot length) of 2 x 4 lumber into two 45-inch pieces and two 20-inch pieces. Lay the pieces flat, forming a rectangle with the short pieces inside.

11. Lay the 24-x-42-inch piece of plywood on top of the lid frame so that the plywood is 1 1/2 inches inside all the edges of the frame. Nail the plywood onto the frame with 6d nails.

12. Attach the hinges to the inside of the back of the bin at each end (on the 2 x 4), and the corresponding undersides of the back edge, of the lid frame, so that the lid stands upright when opened.

13. The unfinished bin should last for at least five years; finishing the bin with varnish or polyurethane will protect the wood and prolong the life of the bin. Two coats of varnish with a light sanding between coats should be sufficient. If pressure-treated lumber is used, the bin will last years longer.

14. Find a good location for the bin. It can be placed anywhere, as long as the temperature is more than 50°F (10°C). The most productive temperature is between 55° and 77°F (13°-25°C). Garages, basements, and kitchens are all possibilities, as well as the outdoors in warm weather (not in direct sunlight). Make sure to place the bin where it is convenient for you to use. It is wise to place a plastic sheet under the bin.

Adding the Worms

Moisten the bedding material by placing it in a 5-gallon bucket and adding water to achieve a 75 percent water content, by weight. Weigh the dry material and multiply the weight by three to determine the weight of the water to add. If the material can not be weighed, or if it is already wet, add enough water to dampen all the bedding. Excess moisture will drain off most materials when they are placed into the composting bin; however, peat moss may hold too much water. It is a good idea to put wet bedding material into the bin outdoors and wait until all the water has drained out (one to two hours) before setting the bin up indoors. Add about 8 inches of moistened bedding to the bottom of the bin. Place the worms on top of the bedding, and leave the lid off for a while. The worms will work down into the bedding, away from the light.

Adding Your Wastes

Dig a small hole in the bedding and add your vegetable and fruit scraps. Then cover the hole with bedding. Small amounts of meat scraps can be added in the same way. Do not add any inorganic or potentially hazardous materials, such as chemicals, glass, metal, or plastic.

Maintaining Your Worm Composting Bin

Keep your compost pile moist, but not wet. If flies are a problem, place more bedding material over the wastes, or place a sheet of plastic over the bedding. As an alternative, try placing some flypaper inside the lid. Every three to six months, move the compost to one side of the bin, and add new bedding to the empty half. At these times, add food wastes to the new bedding only. Within one month, the worms will crawl over to the new bedding and the finished compost on the "old" side can be harvested. New bedding can then be added to the "old" side.

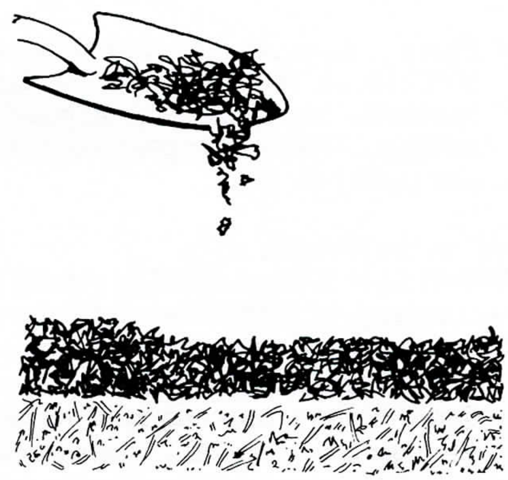
APPENDIX B:
GUIDELINES FOR CONSTRUCTING A COMPOST PILE

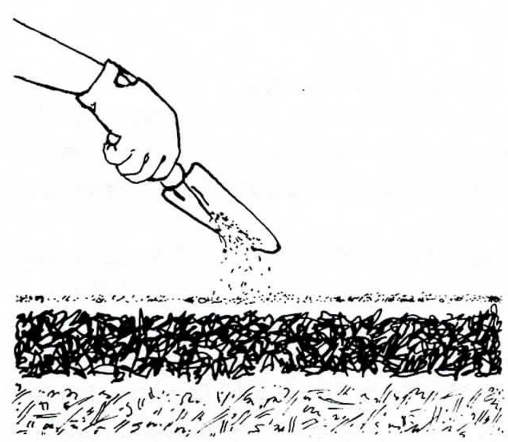
Step 1

- Collect enough material to create a 1-cubic-yard pile. The material should be the right proportions to approximate a 30:1 carbon-to-nitrogen ratio.
- Chop or shred any coarse materials to increase their surface area.
- Start the pile with a 4- to 6-inch layer of high-carbon material (high C:N ratio).

Step 2

- Add a 4- to 6-inch layer of high-nitrogen material (low C:N ratio). Add additional nitrogen if needed. Possible nitrogen sources were discussed in the "Additives" section of Chapter 3. Manure is another source of nitrogen.
- Vegetative kitchen wastes should be added in this layer. If very high-nitrogen materials, such as grass clippings, are used, layers less than 4 inches thick may be appropriate.
- If food wastes are added, an additional thin layer of soil, sawdust, leaves, straw, or compost should be added to absorb odors.





Step 3

- Consider the porosity of the mixture. If dense materials, such as manure or wet leaves, are used, wood chips, straw, or other dry, bulky material should be added to improve the porosity. The thickness of the layers will depend on the C:N ratio of the materials being used.

- Mix the layers.

Step 4

- Conduct a squeeze test to gauge the moisture content of the compost.

- Add water until squeezing a handful will yield one or two drops of water. Adding too much water may leach out nutrients.

Step 5

- Continue alternating and mixing until the pile is 3 or 4 feet high.

APPENDIX C:
TEMPERATURE PROBE DISTRIBUTORS

Atkins
3401 Southwest Fortiers Dr.
Gainesville, FL 32608
(904) 378-5555

Camx Scientific
P.O. Box 747
Rochester, NY 14603-0747
(716) 482-1300
Item No. 5224 x 36; $82.00

Meriden Cooper Corp.
112 Golden St. Park
Box 692
Meriden, CT 06450
(203) 237-8448
Model: Tel-Tru GT 300R; $75.00

Omega Engineering, Inc.
One Omega Dr.
P.O. Box 4047
Stamford, CT 06907
(800) 826-6342
Cat. G-O-200°F-36-PB
or, G-O-100°F-36-PB; $44.00

Reotemp Instrument Corp.
11568 Sorrento Valley Road #10
San Diego, CA 92121
(619) 481-7737
(800) 648-7737
Model: A; $56.00

Tech-Line Instrument
P.O. Box 1236
Fond du Lac, WI 54935
(800) 328-7518

Walden Inst. Supply Co.
910 Main Street
Wakefield, MA 01880
(617) 245-2944
Model: Ashcroft 30 EI50R 360; $57.00

TABLE 6

COMPOST TROUBLESHOOTING GUIDE

Problem	Possible Causes	Solution
Rotten odor	• excess moisture (anaerobic conditions)	• turn pile, or add dry, porous material, such as sawdust, wood chips, or straw
	• compaction (anaerobic conditions)	• turn pile, or make pile smaller
Ammonia odor	• too much nitrogen (lack of carbon)	• add high carbon material, such as sawdust, wood chips, or straw
Low pile temperature	• pile too small	• make pile bigger or insulate sides
	• insufficient moisture	• add water while turning pile
	• poor aeration	• turn pile
	• lack of nitrogen	• mix in nitrogen sources such as grass clippings or manure
	• cold weather	• increase pile size, or insulate pile with an extra layer of material such as straw
High pile temperature (> 140°F)	• pile too large	• reduce pile size
	• insufficient ventilation	• turn pile
Pests rats raccoons insects	• presence of meat scraps or fatty food waste	• remove meat and fatty foods from pile, or cover with a layer of soil or sawdust, or build an animal-proof compost bin, or turn pile to increase temperature

From: **Composting to Reduce the Waste Stream**
Available from the Northeast Regional Agricultural Engineering Service (607) 255-7654

NRAES

NRAES–43

COOPERATIVE EXTENSION