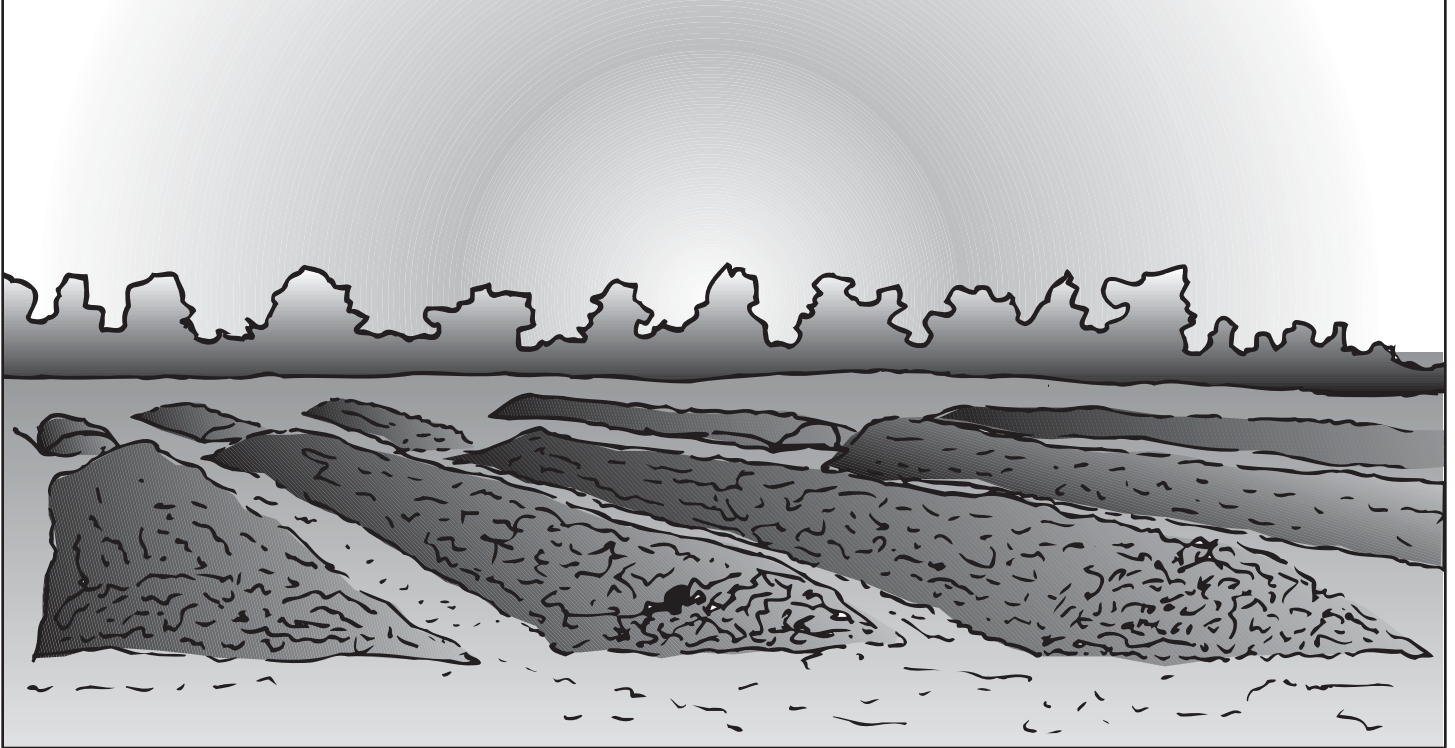


The Virginia Yard-Waste Management Manual

Second Edition



VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

Virginia Cooperative Extension

Knowledge for the Commonwealth



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The Virginia Yard-Waste Management Manual

Second Edition

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The Purpose of this Manual

This manual is designed as a total management manual to guide public- and private-sector composters through the steps necessary to site, design, and operate a yard-waste management program. Information on the principles of composting are presented along with technologies that can assist the composter in making a consistently high-quality product. Establishing a successful statewide composting program is an essential step in building a sustainable future for our state.

Chapter I

Introduction to Yard-Waste Management

Solid-waste management is a critical national issue because of the high cost of landfill construction and operation. The cost of siting and constructing a new landfill in Virginia was approximately \$300,000 per acre in 1990. Today, it costs between \$325,000 and \$475,000 per acre. In addition, it costs about \$215,000 to construct a landfill liner.* The high cost of new landfills has resulted in fewer and larger facilities, as reflected by the reduction in the number of Virginia landfills from 254 in 1993 to 117 in 2001.

Waste managers are promoting source reduction and recycling to increase landfill longevity. The percentage of materials in the waste stream that can be recycled is substantial (Figure 1-1). However, the success of voluntary recycling has been variable, being dependent upon citizen education, convenience, and economic and/or legal incentives. Glass, aluminum, newsprint, and plastic are the most commonly recycled household items. Virginia is currently recycling 32.9 percent of its Municipal Solid Waste (MSW).

Yard waste (i.e., leaves, grass clippings, and shrubbery and tree prunings) comprises an estimated 12 percent (Fig. 1-1) of the MSW being buried in America's landfills. During the peak grass clipping and leaf collection months of the spring and fall, this represents more than 50 percent of the MSW stream in some locales. Local governments in 21 states have enacted yard-waste disposal bans to increase the lifespan of landfills. Yard wastes should not be landfilled because they are relatively clean, biodegradable materials that can be recycled for soil improvement and other agricultural uses. A further advantage of recycling yard wastes is that they are easy to separate from the rest of the MSW stream at their point of origin.

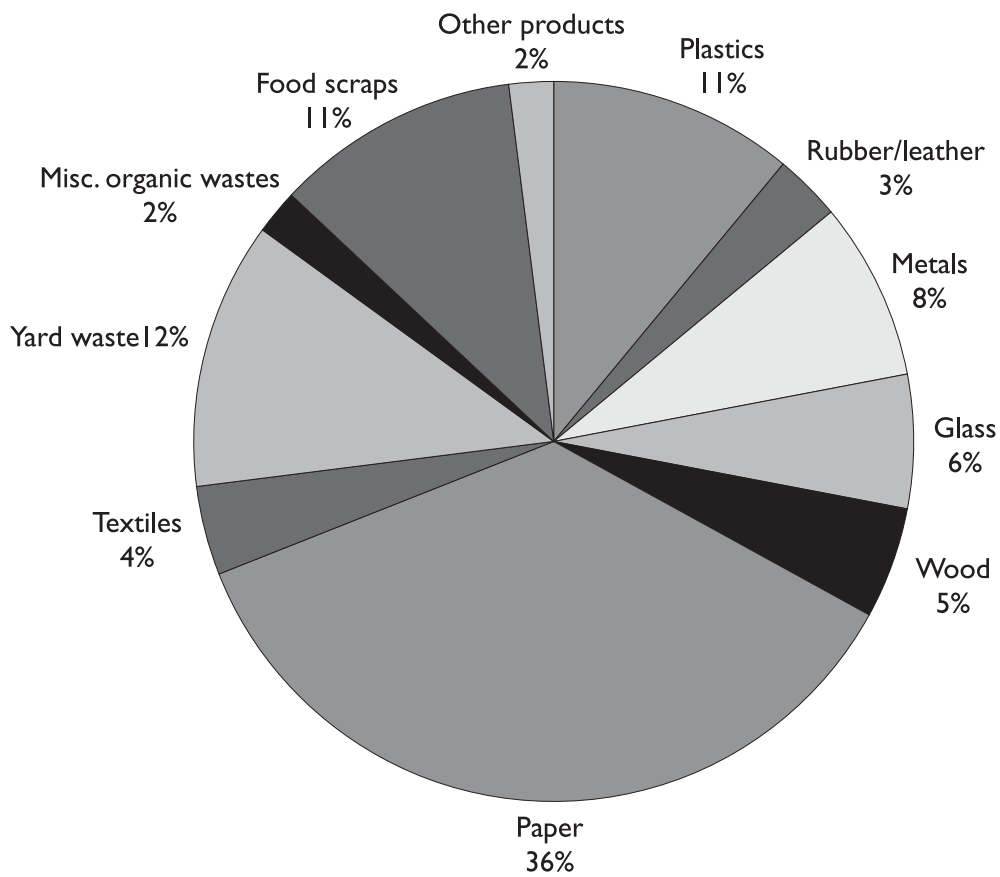


Figure 1-1. Composition of MSW by weight. (EPA, 2002)

*Personal communication with Karen Sismour, director, Virginia Department of Environmental Quality Waste Division.

Composting as an alternative

Composting is the manipulation of the natural aerobic process of biological decomposition of organic materials to increase the decomposition rate. This process is carried out by successive microbial populations that function under increasing temperatures to break down organic materials into carbon dioxide, water, minerals, and stabilized organic matter. Simply piling up leaves and allowing them to slowly decompose is not composting. Composting is a viable alternative to disposing of yard wastes in landfills. An estimated 3,846 yard-waste composting facilities were operating in the United States in 2000.

The primary motivation for composting wastes is the monetary benefit of reduced tipping fees. Average MSW tipping fees in Virginia rose from less than \$20 per ton in 1989 to \$38 in 2000. Composting also can result in a 10 percent to 20 percent reduction in required landfill space, substantially lengthening landfill life. Depending on the level of technology employed, the cost of composting yard wastes may be less than that of landfilling the same materials.

Income from the sale of the finished product and saving the cost of purchased compost are potential financial incentives for setting up a composting operation. Considerable market research is necessary before entering the compost sales business because supply and demand are site specific.

An environmental benefit of composting rather than landfilling yard wastes is the reduction in the amount of methane, a greenhouse gas, released into the atmosphere. When organic materials decompose anaerobically in a landfill, they produce methane. When they decompose aerobically through composting, they do not. EPA estimates that increasing the national recycling rate to 35 percent from its current level of 28 percent would reduce greenhouse gas emissions by another 9.8 million metric tons of carbon equivalent.

On a cautionary note, waste-handling facilities (including yard-waste composting operations) can raise public concerns. Nearby residents should be alerted and educated early in the process of planning a yard waste composting facility. Well-educated and informed citizens often become the most vocal supporters for a composting facility.

Chapter 2

Composting Principles

Overview

Composting is the manipulation or control of the natural decomposition of organic matter. It requires optimizing the conditions favorable to the mixed population of microorganisms (mainly bacteria, fungi, and actinomycetes) responsible for the decomposition. These microbes, normally found on the surface of leaves, grass clippings, and other organic materials, thrive in a warm, moist, aerobic (oxygen rich) environment.

Microorganisms grow rapidly with the proper combination of nutrient and energy sources, such as carbon and nitrogen in the organic material and sufficient moisture and oxygen. During decomposition, the microorganisms multiply and liberate carbon dioxide (CO₂), water, other organic products, and energy. Some of the energy is used by microorganisms and the remainder is given off as heat (Figure 2-1). Eventually, the readily-available food supply is exhausted, microbial growth and heat generation decrease, and a humus-like material remains. This is the material called compost.

The following fundamental principles describe the decomposition of raw materials and illustrate how to optimize that process for efficient composting and the successful production of a valuable end-product.

Composting Fundamentals

The natural process of breakdown can be accelerated by gathering the material into piles. When organic wastes are gathered into piles for composting, the natural insulating effect of the material leads to a conservation of heat given off by the microorganisms and a marked rise in temperature. The temperature rise inside the windrow is due to the difference between the heat generated by the microbes and the heat lost to the surroundings. The dimensions of the pile, particle size of the material, oxygen concentration, and moisture content are critical factors that affect the temperature and, therefore, the microbial population and diversity within the pile.

Microorganisms

The microbes that inhabit a compost pile are so small that a clod of soil the size of a pea may contain millions of them. They break down the complex compounds of the waste material into simpler organic compounds. Bacteria are the most important group of decomposing microorganisms in composting, and they are generally identified by the temperature range in which they are most active (Figure 2-2). At temperatures below 59°F

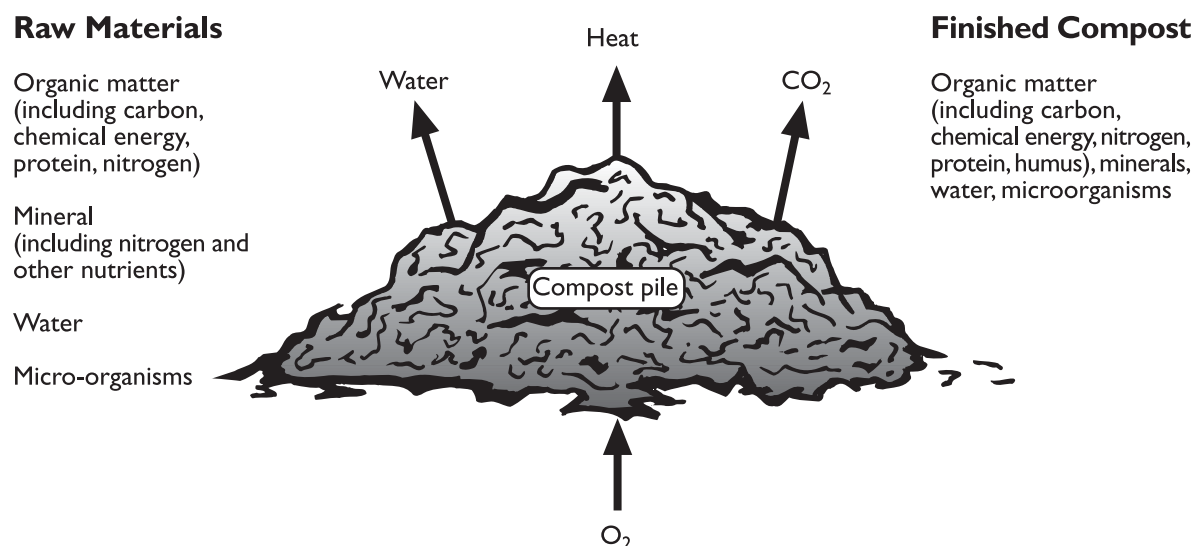


Figure 2-1. The composting process (Source: NRAES, 1992).

(15°C) activity of the primary decomposing bacteria is very limited.

The mesophilic bacteria thrive at temperatures of 77° to 108°F (25° to 42°C), but they can survive at higher temperatures. Mesophilic bacteria feed on the most readily available carbohydrates and proteins during their short life span at the beginning of the composting process. The heat produced during metabolism raises the temperature in the pile beyond their viable range and causes their death.

As the temperature increases, the thermophilic bacteria, which perform best at temperatures ranging from 122° to 140°F (50° to 60°C), become dominant. The most rapid decomposition occurs within this temperature range and the pile heats up very quickly. These bacteria continue to degrade the proteins and non-cellulose carbohydrates. Thermophilic fungi that break down the cellulose portion of leaves also colonize the pile at these temperatures. If the temperature rises much above 150°F (66°C), the majority of the bacterial population and many other living organisms will perish. Thus, an important benefit in maintaining high temperatures in the pile is the destruction of weed seeds, insect eggs and larvae, and possible pathogens.

Excess heat must be released to maintain temperatures conducive to vigorous microbial activity. Mechanically turning the pile or forcing or drawing air through the pile when the temperature reaches 140° to 150°F (60° to 66°C) will maintain the correct temperatures. Monitoring the temperature daily during the early period of decomposition can help determine when it is necessary to aerate. The frequency of compost pile turning depends on moisture level, porosity, and properties of the compost feedstock (incoming organic materials). A pile may initially require turning every day, but that frequency will decline with time. Figure 2-3 illustrates a typical composting pile temperature profile.

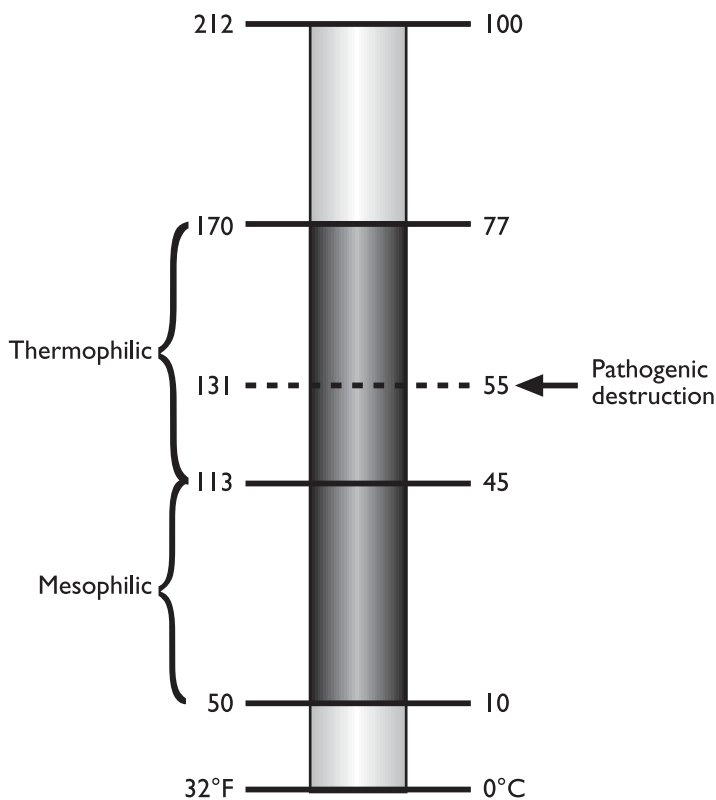


Figure 2-2. Active temperature range of bacteria (Source: Michigan DNR).

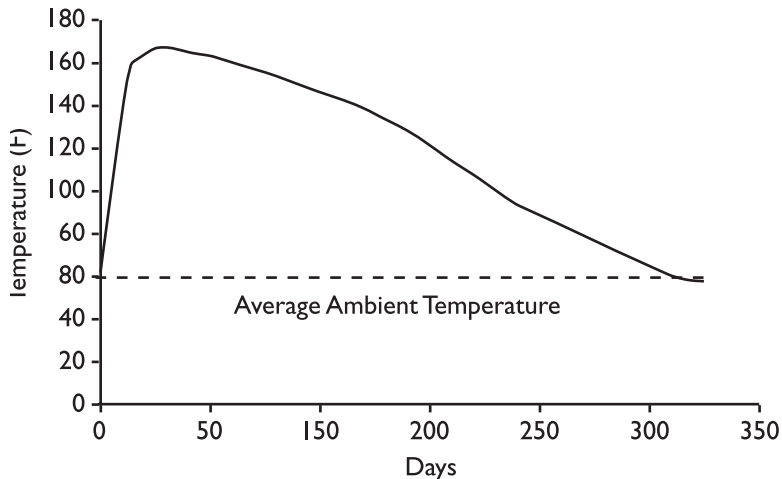


Figure 2-3. Changes in internal temperature of a composting pile over time (Source: Dane County, Wisconsin Department of Public Works 1988).

Macroorganisms

The outer portion of any composting pile provides a cool enough environment for the macroorganisms that also play a part in the decomposition process. Macroorganisms are many-celled organisms ranging in size from microscopic (rotifers and nematodes) to the larger fungi, mites, springtails, sowbugs, beetles, and earthworms. These animals are normally found in the cooler parts of the pile. Their chewing, foraging, and moving through the pile helps to physically break up the materials and create a greater surface area on which bacterial action can occur. Figure 2-4 depicts the food chain for decomposition of organic matter within compost piles.

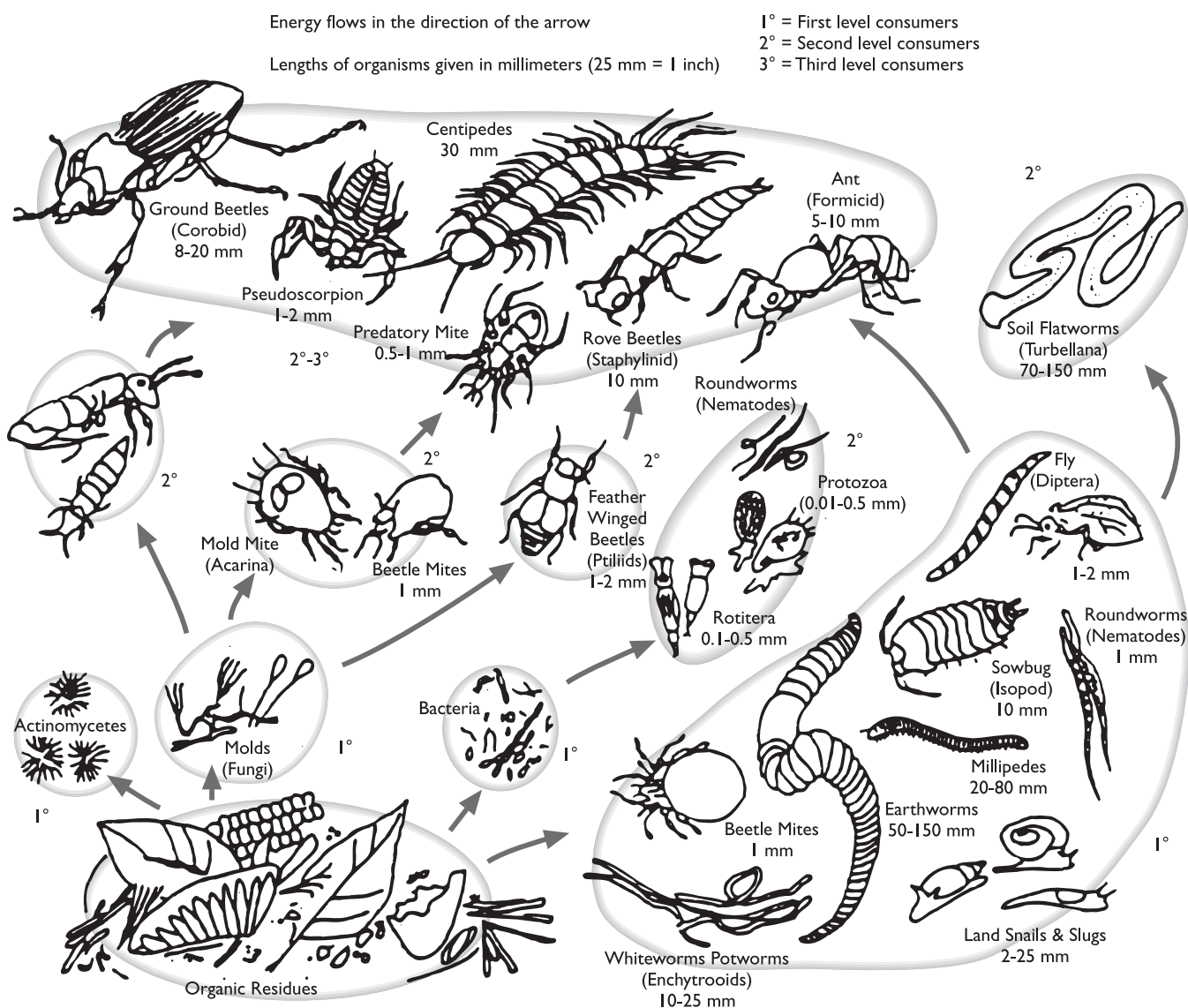


Figure 2-4. Food web of the compost pile (Dindal, 1978).

Moisture and Oxygen

All living things require water, and microbes are no exception. It is important to maintain a moisture content of 45 percent to 65 percent throughout the entire composting process to ensure the survival of the microorganisms. If incoming materials are too dry, water may be added as the piles are formed. However, piles should never be excessively wet. Too much water fills the air spaces, creating undesirable anaerobic (oxygen limiting) conditions. The material may be mechanically mixed and turned to provide oxygen and to facilitate drying if it is too wet. If squeezing a representative handful of the material produces just one or two drops of water, it is sufficiently moist. Although it is not essential, a moisture meter can be used for more precise measurement of water content.

Without adequate oxygen, the aerobic (oxygen requiring) bacterial populations die, anaerobic microbes become prevalent, and fermentation occurs. Anaerobic decomposition (i.e. without oxygen) of organic materials occurs at a much slower rate. This leads to the production of odorous and other undesirable gases, lower temperatures, a slower decomposition rate, and incompletely composted material. The unfinished compost can contain organic acids and other compounds harmful to plants and soil life. Mechanical reoxygenation can restore conditions conducive to efficient composting.

C:N Ratio

Microorganisms use carbon as an energy source and nitrogen to build proteins and other cell components. They use both of these elements in a proportion that averages about 15 parts carbon to one part nitrogen (C:N 15:1), on a mass basis, for energy and growth. However, this ideal C:N ratio is not found in any one organic source, nor is all of the carbon and nitrogen in organic materials readily available to microbes. The carbon is often present in some forms that are much harder for microbes to access than the nitrogen. Various materials are commonly combined to provide a target C:N ratio of 30:1 for composting. Table 2-1 provides a listing of the C:N ratio of some commonly composted yard- and farm-waste materials.

If too little carbon relative to nitrogen is present (C:N < 20:1), the excess nitrogen may evolve as ammonia gas, which results in odor problems and loss of nitrogen. If too much carbon is present (C:N > 40:1), the low level of nitrogen causes the composting rate to be reduced.

The temperature will rise more rapidly as the N concentration of the feedstock increases. For instance, adding a high nitrogen source material, such as grass clippings (C:N = 20:1) or broiler litter (C:N = 14:1), to leaves (C:N = 40:1) increases the rate of composting of the leaves and the nitrogen concentration of the finished compost. A C:N ratio higher than 30:1 is appropriate for mixes containing woodchips and sawdust.

The C:N ratio decreases as decomposition proceeds. The final C:N ratio of the material will vary depending upon the materials used, the technology employed, and how completely the material decomposes. Few composts will have ratios below 15:1.

Table 2-1 C:N Ratio of Selected Organic Materials

Material	C:N ratio
Manure (fresh)	10:1
Manure (rotted)	20:1
Grass clippings	20:1
IDEAL	25:1 to 35:1
Leaves (freshly fallen)	40:1
Leaves (dry)	90:1
Straw	100:1
Sawdust	400:1
Wood chips	800:1

pH

Fresh leaves have a pH that is close to neutral, (i.e., pH 7 on a scale of 1 to 14). Values below 7 represent an acid condition, and values above 7 represent an alkaline (or basic) condition. Some tree species produce leaves that are acidic because of the presence of organic acids; however, composting results in pH neutralization, and finished compost will have a pH in the range of 6.0 to 8.5 (Figure 2-5). If anaerobic conditions exist for an extended period, the pH will remain low, the decomposition rate will slow, and odors will be produced. If low pH conditions persist, reoxygenation of the material will remedy the situation. Acidity should not be neutralized by adding lime because a high pH will promote the production of ammonia gas. Adding lime may also raise the pH of the end product to a level too high for some plants.

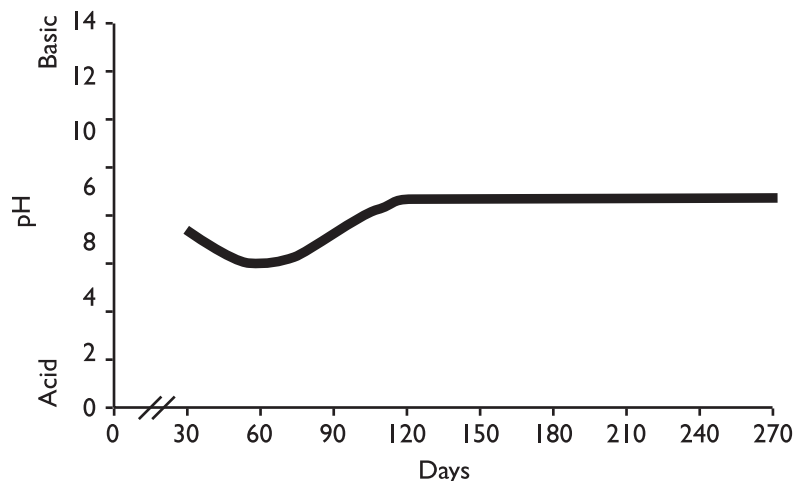


Figure 2-5. Changes in the pH level of composting leaves over time (Source: DPW Dane County, Wisconsin, 1988).

Particle Size, Structure, and Texture

Composting is a surface phenomenon that is affected by the particle size, structure, and texture of the material. Small particle size will provide more exposed surface area to increase the rate of composting. However, very small particles can lead to compaction of the compost pile reducing microbial activity due to poor oxygen availability. It is usually best to construct the compost pile with a variety of material sizes within the range of 1/8 to 2 inches

in diameter. Achieving this mix may require grinding or shredding the raw materials. The action of turning the compost pile may sufficiently reduce the feedstock particle size. Mixing materials with different physical properties, such as grass clippings with leaves or woodchips with wet grass clippings, optimizes the conditions required for efficient composting.

Inoculants and Other Additions

The naturally occurring microbes are capable of degrading organic material without the addition of commercially available inoculants if the requirements of proper C:N ratio, moisture, and oxygen are met. Inoculants are products that contain bacteria and a medium on which the bacteria can grow. There is no scientific evidence that inoculants increase the efficiency of composting. Adding finished compost to a newly formed windrow can provide a concentrated and ready population of bacteria to that windrow. However, an appropriate microbial population will develop readily without such “seeding.” Some compost managers add a small percentage of soil when establishing new piles in order to improve the conservation of nutrients (especially NH_4^+) and to buffer against moisture and temperature fluctuations during the process.

Inorganic nitrogen fertilizer (e.g. urea) generally is not recommended as an additive for low nitrogen materials, such as in the composting of leaves alone. While it can initially create an appropriate C:N ratio, this readily-available nitrogen may quickly transform to ammonia. This gaseous and odorous form of nitrogen is easily lost to the atmosphere and its loss may result in nitrogen deficiency, limiting the process of decomposition. Feedstocks with a combination of organic and inorganic forms of nitrogen are most effective, but inorganic fertilizer N may be used if no other alternatives exist.

Curing

Composts should undergo a maturing or curing period before use to ensure that the most active phase of decomposition is complete. During curing, mesophilic bacteria recolonize the compost, an extensive population of macroorganisms becomes established, nitrate-N forms, and humus develops. Curing also provides protection against using immature material that could harm crops or plants through the phytotoxic effects of high concentrations of organic acids and soil oxygen depletion. The curing stage begins when the temperature plateaus and ceases to rise after pile turning or aeration. Curing is considered complete when internal temperatures decline (under proper moisture and oxygen conditions) to near ambient. It is important to note that compost stability and maturity represent different characteristics of the material. A stable compost does not reheat upon turning/aeration when proper conditions are maintained, while a mature compost will not impair plant growth.

Curing compost for a period of one to several months before use is best. Several piles can be combined for curing to allow more space for incoming raw materials. The compost can be screened later for use at the facility or for the market.

Summary

The following table (Table 2-2) provides a summary of the recommendations for optimum composting.

TABLE 2-2. Recommended Conditions for Rapid Composting (Adapted from NRAES, 1992).

Condition/Characteristic	Reasonable Range	Preferred Range
Initial carbon to nitrogen ratio (C:N)	20:1 to 40:1	25:1 to 30:1
Temperature	110° - 150°F	135° - 145°F
Moisture content	45% - 70%	50% - 60%
Oxygen concentration	> 5%	>>> 5%
Particle size (diameter)	----	1/8" - 2"
Initial bulk density (lb/yd ³)	----	< 1100

Chapter 3

Siting a Compost Facility

Siting a compost facility is extremely important and requires consideration of the land area needed, traffic patterns, water supply, and building and equipment needs. Environmental and safety concerns, such as surface and ground-water protection, erosion control, fire hazards, and proximity to sensitive adjacent land uses must also be addressed. For example, a composting facility should not be established on a floodplain or encroach on a wetland. Yard-waste composting facilities cannot be located atop closed waste disposal units or old landfills. The state yard-waste composting regulations contain requirements for siting, operating, and closing a facility. These regulations are discussed in Chapter 7, Regulation of Yard-Waste Composting Activities.

Determining Land Area Requirements

A yard-waste composting facility should include the following components: (See Figure 3-1)

- Receiving and handling or staging area
- Buffer zones
- Windrow working area
- Equipment storage facilities
- Curing and storage area
- Maintenance facility
- Finished compost loading area
- Runoff, collection, and/or treatment area
- Structure(s) for:
 - a) Administration
 - b) Sales/Distribution

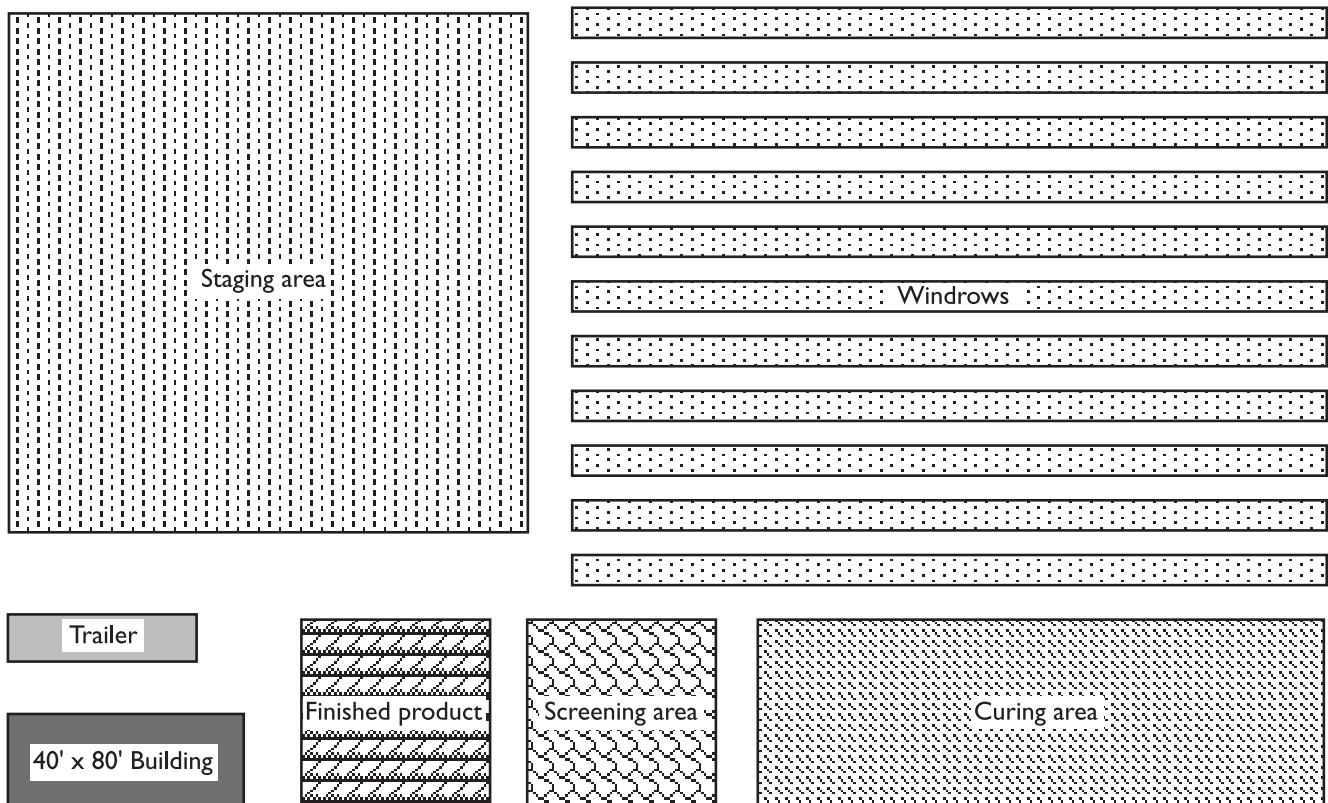


Figure 3-1. Typical compost site layout (Source: Michigan DNR, 1989).

Total Working Area

The land area required depends on the volume of yard waste received and the type of equipment used to process the materials. On average, one acre of land for every 4,000 to 5,000 cubic yards of material will adequately accommodate the receiving, handling, windrowing, and curing activities. Depending on the level of technology used, this can range from 3,000 to 12,000 cubic yards per acre. If no information is available on the volume of yard waste, use a leaf volume estimate of 8 percent of the total annual solid waste volume of the locality for determining land needs. If it is necessary to stockpile material, extra space has to be considered in the site plan.

The handling or staging area is used for unloading trucks and debagging leaves if necessary. This area should be laid out to provide easy access for the public, leaf hauling vehicles, and fire protection equipment. A paved road and pad are recommended to sustain the traffic load in all types of weather conditions. This area needs good traffic flow for turning trucks, and possibly a separate area for private citizens to unload leaves. Waste other than yard waste and non-compostable components in the yard waste must be segregated and stored in containers prior to their disposal at a permitted landfill.

The windrow working area must be properly prepared and maintained for successful composting. The site should be raised or bermed to prevent run-on. The surface should be slightly sloped (approximately 2 percent) to prevent ponding and to control water drainage to prevent excessive run-off. Constructing windrows with the slope rather than across it, will allow runoff to move between the windrows rather than across them.

The windrow working area surface can be established with several different materials. A paved surface is required in Virginia if the composting surface lies within 24 inches of the seasonal high-water table. Pavement can be expensive; therefore, composting facilities have started to use lime-stabilized pads instead. Impervious pads are made by mixing either quicklime or hydrated lime with soil to raise the pH above 11.5, and then water is added. Once these materials react, the chemical structure of the soil becomes very concrete-like. This method is highly dependent on soil type. Soils low in clay, high in organic matter, or high in carbonates tend not to work or need materials such as fly ash added to them.

Unpaved surfaces are allowed, but they require more maintenance. Some possibilities include: a) a 2-inch surface of rock dust over a 6-inch base of mixed crushed rock, laid on compacted clay soil; b) an eight- to ten-inch layer of large woodchips laid over a compacted clay soil surface; c) a six-inch gravel surface over a compacted clay soil; or d) an appropriately sited and sloping area with a well-established turf cover. Options a) and d) are the least desirable because gravel pieces inevitably contaminate windrows, and composting on turf can result in surface deterioration by equipment and difficulty in accessing the windrows when the ground is wet.

To maintain soil permeability when composting on woodchips, gravel, or undisturbed turf, the soil under windrow plots should not be compacted. The runways between the windrows should be compacted to allow runoff and minimize damage by equipment. Initial site preparation usually requires grading. Yearly maintenance of the site should include regrading where necessary.

Curing and storage area

The curing and storage area should be adjacent to the windrow working area to minimize material transport. An area approximately 1/4 the size of the windrow working area is generally adequate. A volume reduction of 50 percent and more occurs during composting, and curing piles can be constructed larger than windrowing piles. Compost that has undergone primary decomposition should be moved to this area to cure for at least a month before screening (See Chapter 2) and to allow regrading or other maintenance of the windrowing area prior to starting the next composting cycle.

Buffer zones

A buffer zone around the perimeter of the working area of 100 to 500 feet should be planned when siting a facility. Virginia regulations require a minimum buffer zone of 100 feet between site activities and facility boundaries

to minimize possible odor, noise, dust, and visual impacts. Specific buffer needs should be determined on a case-by-case basis, depending upon the sensitivity of adjacent land uses. The buffer area may be landscaped or planted with a windbreak to minimize visual impacts. Curing piles may also serve to buffer against noise and dust.

Environmental considerations

It is critical that ground- and surface water quality not be affected by composting activities. Regulations by the Virginia Department of Environmental Quality require appropriate site design and management to protect ground- and surface waters. The facility: 1) must not be located in a flood plain, 2) must be situated at least 24 inches above the seasonal high-water table, 3) cannot be closer than 50 feet to a flowing stream, and 4) must control leachate and runoff to prevent direct discharge into surface waters. Unpaved composting sites generate small amounts of leachate that percolate into the soil and are naturally treated by soil microbes to ameliorate undesirable characteristics. When windrows are exposed to heavy or constant precipitation, more leachate is generated than a natural system can handle.

The predominant approach to treat leachate is to establish a grass filter strip below the windrow area and extending across the full width of that pad. The filter strip must be of sufficient length to accommodate the two-year, 24-hour rainfall event for the location. This length will depend on the slope. The flatter the slope, the greater the retention time of overflow leachate and infiltration, but care must be taken to avoid ponding. Appropriate grass species include fescue and reed canary. The grass should be managed to maintain the proper soil nutrient balance and pH level, and harvested regularly to remove the nutrients it absorbs. Heavy equipment should not travel over the grass filter strip.

A more involved collection and treatment system is necessary at paved sites and when sites with uncovered compost piles receive heavy rainfall. This ensures the protection of nearby streams and ponds. The system can include trenches and stone dams for water collection and direction, grassed waterways for filtration of suspended particles, collection ponds (for those facilities that recirculate leachate/runoff water back onto windrows or that have large uncovered windrow operations), and filter strips. Designing for sufficient collection pond volume may require assistance from Virginia Cooperative Extension (VCE), the Natural Resource Conservation Service (USDA-NRCS), the Virginia Department of Conservation and Recreation (VDCR), or a qualified professional engineer (PE).

Controlling odors, dust, and noise at the composting facility not only protects human health and avoids nuisance problems; it also maintains good neighbor relationships. Chapter 6, Compost Facility Operation, discusses treatment of these potential problems.

Water source

A source of water for adding moisture to the composting material and for potential fire control is necessary. This can be a well, a municipal source, or an on-site pond. A water tank truck may serve smaller facilities, but should not be the main source for large operations. Water needs will vary. Incoming leaves that are to be composted alone can require the addition of 20 to 50 gallons of water per cubic yard to properly wet them. Adding water during mixing will usually be necessary to restore the desired moisture content of approximately 55 percent to 60 percent unless windrows were previously over-watered or uncovered windrows were subjected to heavy precipitation. (See Chapter 2.)

A properly formed, sufficiently moist windrow will not readily burn. However, materials that have been allowed to dry can be combustible. It is, therefore, necessary to have an operable fire protection system.

Security

Personnel should be on-site at all times when the facility is open to monitor incoming yard waste. Access roads should be secured when the site is closed to prevent illegal dumping and vandalism. In some cases the entire site

may have to be fenced, but pre-existing features such as wooded areas, streams, and hills provide some security. Curing piles may also serve in place of a fence in some cases. The Virginia Yard Waste Composting Facility Regulations state “access to a yard waste composting facility shall be permitted only when an attendant is on duty.” (9 VAC 20-101-140.C)

On-site roads

Paved or gravel all-weather roads are necessary to provide access to heavy vehicles making frequent deliveries. A circular traffic-flow pattern at heavily used areas, such as the receiving and handling area, is advantageous. Alternate paved roads or sections of road should be provided for the public to drop off yard waste or pick up finished compost out of the traffic pattern of large vehicles or machinery. At a public drop-off facility, convenience will be a major factor in program utilization.

Safety considerations

Public access should be limited to receiving and pick-up areas. The usual safety precautions should be exercised where heavy equipment is operated.

Chapter 4

Composting Technologies

The composting industry uses three levels of technology to process yard wastes: low-, intermediate-, and high-level technology. All can be employed to create a useable end product. Their differences lie in the degree of sophistication of the monitoring system and processing equipment, the length of time required for compost production, and the space requirements for the operation.

Both low-level and intermediate-level technologies involve the formation of yard wastes into elongated piles, or windrows, generally measuring four to nine feet high, ten to 18 feet wide. The windrow can be as long as necessary to accommodate the volume of material to be composted. Temperature, moisture content, and aeration status are monitored and controlled to varying degrees. In all cases, it is important to establish the proper particle size distribution, C:N ratio, and moisture content for efficient composting.

High-level technology composting includes the aerated static pile method and the in-vessel method. These two methods are not economically practical for yard-waste composting, and are usually used to compost sludge, food wastes and other putrescible solid wastes.

[Note: Stockpiling is not composting. This method of handling yard waste creates strong odors and leachate because the pile quickly becomes anaerobic. Stockpiling requires large parcels of land to house the piles and additional buffer areas to prevent odor complaints. Stockpiled materials can be composted with minimal turning, but it can take up to three years to complete the process. Yard-waste stockpiling is discouraged and, in some localities, prohibited on a large scale. Stockpiling leaves in the fall in order to co-compost them with grass clippings from the next season is popular, but should include some precautions in order to prevent nuisance and environmental problems. (See Chapter 6, Compost Facility Operation.)]

All yard-waste composting operations are required to abide by the Virginia yard waste composting regulations (see Chapter 7), which specify siting activities, stipulate operational restrictions, require runoff control (and possibly treatment), and buffer-zone establishment.

Low-Level Technology

This level of technology is suitable for small to medium sized facilities receiving less than 15,000 cubic yards of yard waste per year. Low-level technology composting is conducted using a front-end loader, skid-loader, or backhoe to construct windrows and to mix them. This type of composting requires between four and 24 months to complete. Odor generation is likely with any of the low-level technology options. Minimizing odor potential is essential for successful facility operation. Windrows can be managed by turning/mixing them according to a particular strategy or simply by constructing them over perforated pipes to allow conductive air flow for aeration and heat release. This latter technique is known as passively aerated windrow composting.

Low-technology compost management uses one of the following windrow-turning schemes.

- a) Infrequent turning: Windrows are turned seasonally for aeration or as the weather conditions, equipment, and labor availability allow. Serious odor problems and leachate generation can develop when the windrows are turned too infrequently. State regulation requires practices that address odor and leachate generation.
- b) Frequent, planned turning: Windrows are turned on a regular schedule that may be as often as every three to four days for several weeks, and once a week thereafter. Odor and leachate problems can also arise with this method.
- c) Temperature-based turning: Internal windrow temperature is monitored daily, and windrows are mixed/turned when the temperature reaches a predetermined level. See Chapter 6, Compost Facility Operation, for a discussion of temperature monitoring and thermometers.

Turning frequency will greatly affect the length of time required to produce finished compost. Frequent turning gives improved temperature control and releases more carbon dioxide from the pile, which supports greater microbial activity. Completely processing yard wastes with frequent turning may take only four to eight months; whereas, processing with infrequent turning can take up to 24 months and require a larger land area.

Compost management using the passively aerated windrow system is conducted as follows:

Three to four foot high windrows are constructed on a six- to nine-inch compost, peat moss, or straw base, onto which has been laid a series of four-inch diameter pipes (drilled with 1/2 inch holes for air flow), and positioned across the windrow plot on 12- to 18-inch centers. The windrow is covered with a six-inch layer of peat moss or finished compost to conserve nitrogen and prevent the infiltration of precipitation. The windrows are aerated by conductive air flow into the pipe ends and then up through the composting mass (Figure 4-1). Thoroughly mixing the materials prior to windrow construction is essential for efficient decomposition because the windrow is not turned. When composting is complete, the pipes are pulled out, and the finished material is mixed with the base material and moved to a curing site.

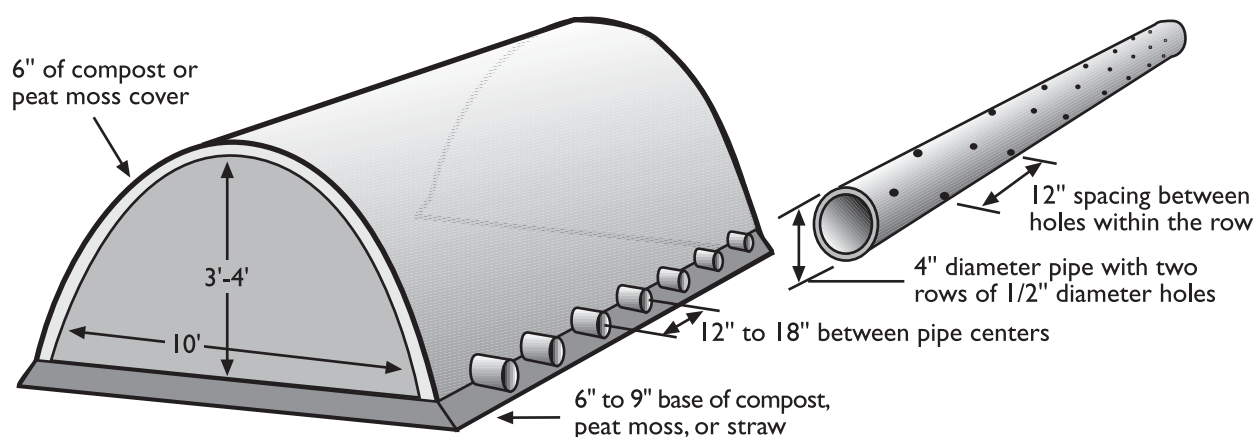


Figure 4-1. Passively aerated windrow method for composting manure (Source: NRAES, 1992).

Intermediate-Level Technology

Intermediate-level technology requires the use of a mechanical windrow turner in conjunction with a temperature-based turning scheme. (Some operators use additional measures, such as carbon dioxide and oxygen concentration, for process management.) The significant advantage to this method of processing is the much shorter time period of three to six months necessary to produce finished compost. Additionally, the physical quality of the final material is higher than that of the low-level technology compost because of the far more efficient mixing and shredding action of the windrow turner. However, in most instances, screening is still necessary to achieve potting-soil-grade compost. The size of the windrows is restricted by the height of the windrow-turning machine, usually not greater than eight feet high by 12 to 18 feet wide. This technology is likely the most appropriate for medium to large-scale operations.

There are several types of windrow turners (Figure 4-2), some straddle the windrow and others turn half of the windrow during each pass. The turning/mixing is usually done by either an elevating face, which lifts and tumbles the material, or a horizontal drum equipped with flails. Windrow turners vary widely in cost, capabilities, and flexibility. Some can be attached to the power-take-off (PTO) drive of a farm tractor, or can be pushed or pulled by a primary mover such as a front-end loader. Others are self-propelled units.

- 1) The smallest size turners are units that can be a) pulled through a windrow attached to a tractor PTO, riding off-set and behind it; or b) pulled or pushed through a windrow by a front-end loader or other prime mover. The latter type usually requires driving down one side of the windrow then up the other, making two passes for each pile. This equipment is available in a variety of sizes and is well suited for lower-budget or smaller operations.

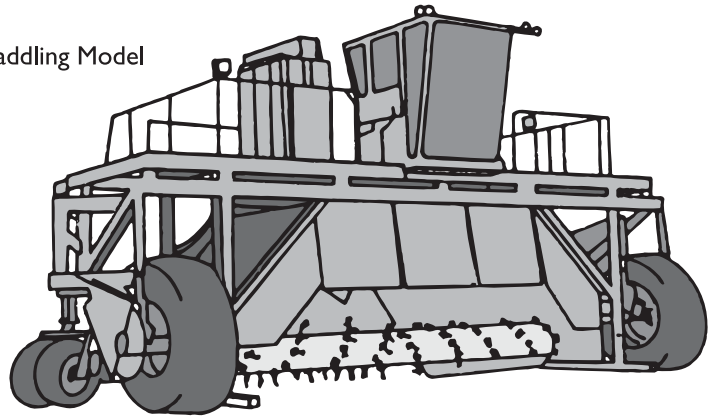
- 2) The large model turners are self-propelled and straddle the windrow. This type of machine has metal teeth on a rotating drum that shred and aerate the compost as the turner moves through the windrow. A skirt or fender reforms the windrows into a pyramidal shape.
- 3) A third type of windrow turner is the “elevating face” machine that lifts the leaves up over a face by a series of teeth and reforms the windrow as the leaves cascade over the rear of the machine. This type of machine is pulled through the windrow by a front-end loader, bulldozer, or other prime mover. Using these machines has advantages: a) processing time is reduced and b) mixing, aerating, and grinding occur in one step, which eliminates the need to shred the compost before sale or use.

The total area required for an intermediate-level operation is less than for a low-level technology one. Piles can be formed closer together because most windrowers actually require less turn-around space than a front-end loader. Some models can be equipped with a water tank or hose attachment and spraying nozzles for adding water during turning/mixing.

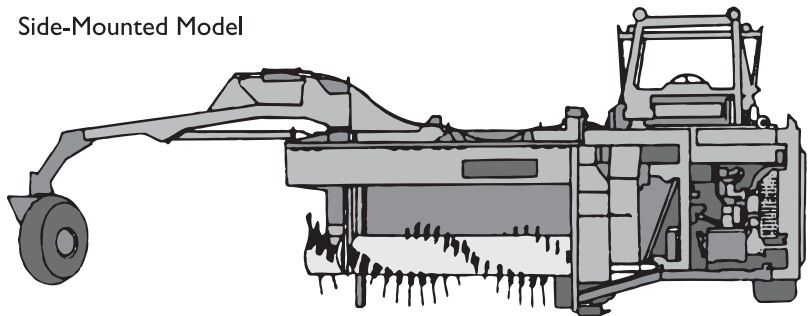
The disadvantage of this technology is the cost of the equipment, which can range from \$12,000 to \$300,000. If the materials being composted are readily chopped and shredded by the turning machine, the cost of the windrow turner can be partially offset by removing the need to purchase or rent a grinder. Additional compensation accrues from time savings, smaller land area requirements, and the sale of a high-quality end-product or the savings and benefits realized from its use.

Observations show that a windrow turner is a necessary piece of equipment for a large compost operation to turn out a very high quality product quickly. The large, self-contained units can process from 2,000 to 4,000 cubic yards per hour and cost from \$100,000 to \$285,000 delivered. The loader/tractor mounted units are designed to turn smaller windrows and can cost from \$10,000 to \$60,000. The elevating face machine ranges in price from \$50,000 to \$150,000, depending on size and options. The major maintenance requirement for turners is regular replacement of the flails or teeth that cost from \$375 to \$500 per set.

Straddling Model



Side-Mounted Model



Elevating Face Model

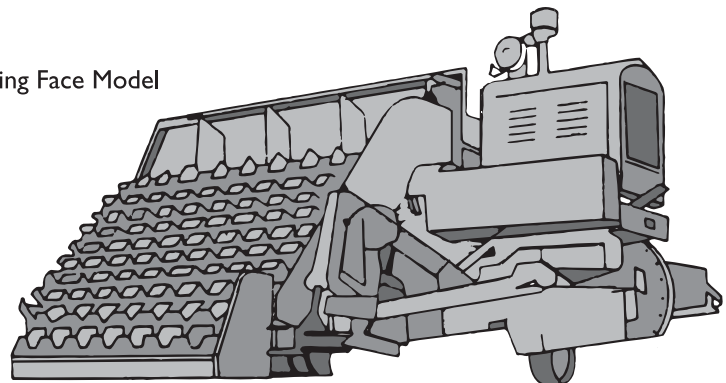


Figure 4-2. Windrow turners

High-Level Technology

Aerated static pile (ASP)

This method uses a system of pipes under the windrows to run forced air up through the piles with a blower controlled by a temperature feedback system. When the temperature inside the pile reaches a preset level, the blower automatically comes on to cool the pile and assure aerated conditions. During the initial start up period, the blowers would come on frequently under control of a thermocouple. After two to ten weeks, the aeration system would be removed and the piles turned periodically.

This type of system is much more expensive to operate, but its advantages include large windrows that save space and the most rapid composting rate of any method. The forced air keeps anaerobic conditions from developing in these large piles. Composting can be completed within a few months because of the rapid decomposition. This level of technology allows for adding higher-nitrogen wastes, such as manures, to the piles to speed up decomposition and raises the nitrogen content of the finished product.

In-vessel composting

In-vessel composting involves a variety of technical steps, including shredding the incoming material, mechanical agitation, mixing with a bulking agent, regular turning in a digester, forced aeration, then windrowing for a final decomposition step. The process takes place in a digester that is housed in a building and can produce finished compost in a few weeks. This technology is used primarily for composting organics from the municipal solid-waste stream. It is not used for yard-waste composting, because simpler, less expensive methods work as well. For certain in-vessel mixes, yard waste may be suitable as a bulking agent. An advantage of ASP and In-vessel composting is they require less labor.

Chapter 5

Compost Feedstock

While yard waste represents 12 percent of the solid-waste stream (Figure 1-1), there are many other organic materials suitable for composting. In many instances, yard wastes may be suitable to use as a bulking agent or carbon source for these other materials. Animal manures, sludges, institutional wastes, and other residuals can be composted. The purpose of this chapter is to provide information on compost feedstocks that can be combined with yard waste.

Leaf Composting

Some compost facilities accept only leaves for composting. Leaves present less of a challenge in both collection and composting than do other organic feedstocks, while representing a major portion of the waste stream. Operators of a new municipal facility may want to begin by composting only leaves until they gain experience. The improper management of leaves and grass clippings by inexperienced composters could result in odor nuisances.

Microorganisms need carbon and nitrogen for energy and growth. The ideal C:N ratio is not found in any one organic source. The C:N ratio of leaves ranges from 40:1 to 80:1. Composting leaves alone has the advantage of producing a very consistent soil amendment year after year, with little change in either the nutrient content or the pH of the material. A consistently high-quality compost will have little difficulty in finding markets.

A disadvantage of composting leaves is the length of time it takes to get a finished product. Depending on the technology used, it can take from five months to three years to compost leaves with no other inputs. This is mainly due to the high C:N ratio. Composting time can be decreased with frequent turning by a mechanical windrow turner.

Composting Other Wastes with Leaves

The practice of mixing other organic wastes with leaves to recycle these materials and create a more desirable end product is gaining attention and acceptance. The addition of a high nitrogen source, such as grass clippings, plant wastes, animal manures, sludges, institutional wastes, or other residuals can increase the decomposition rate and the nitrogen content of the end product. The high nitrogen component must be carefully controlled because adding too much nitrogen can result in the formation of odors from ammonia gas.

Leaves and grass clippings

Grass clippings are a good material to compost with leaves or other coarse, high-carbon compostables. Their relatively high moisture content (82 percent average) and low C:N ratio (9:1 to 25:1) encourage rapid decomposition. Proper management is essential when windrows contain grass clippings. They have a moderate to high potential to generate odor. A mix of 2:1 to 3:1 (volume to volume [v/v]) of leaves to grass clippings is the optimum for rapid and manageable decomposition in composting windrows. Greater amounts of grass clippings promote compaction and the development of anaerobic conditions.

Composting leaves and grass requires planning to accommodate the different collection periods for these two materials through the year. During the early fall, the availability of both leaves and grass allow for ready co-composting. Stockpiled leaves collected in the late fall and winter can be composted with grass clippings collected from the first cuttings through mid-summer. The volume of these stockpiled leaves will decrease substantially over the winter and, in some regions of the state, result in an insufficient quantity to allow co-composting with all of the grass collected.

Grass clippings are often collected in plastic bags. This can result in an odor problem when they arrive at the compost site. Grass must be incorporated into a leaf windrow before the end of the delivery day. Starting out with a high leaf:grass ratio is advisable until some experience is gained. Good mixing is essential and can be done by

working together 20 to 30 loader buckets of material at a time, then forming a windrow with the mixture. The leaves will act as a bulking agent, allowing more oxygen into the windrow to maintain aerobic conditions. The grass clippings are high in nitrogen and moisture, so they will provide needed nitrogen, speed the decomposition, and can restore vigorous composting activity to windrows lacking these essential materials.

Woody materials

Some facility operators may find it more advisable to keep woody wastes separate to be used or sold as a mulch.

Ground or chipped woody wastes are a popular option as a co-composting material for grass clippings. They can be composted with grass alone in the generally recommended ratio of two parts chips to one part grass (v/v), or in combination with leaves and grass clippings in an approximate volume ratio of 1:2:1 (chips: leaves: grass). Wood chips are sometimes preferred to leaves as a co-composting material because they can provide greater structure and porosity. Mixing the three materials together offers a greater range of particle sizes and air spaces than is possible with either of the high-carbon materials plus grass alone. This lessens concerns about developing anaerobic conditions. Woody wastes do decompose slowly. The chips take on a weathered, dark brown color and after they are separated (by screening) from the finished compost, an attractive mulch material is left.

Woody wastes do often require grinding to a size more conducive to microbial attack (< 1/2 inch), necessitating the purchase or rental of additional equipment. Woodchips do not break down entirely during the time required to compost leaves and grass clippings. Following active composting, wood chips can be screened out and re-used in a subsequent compost pile or used or sold as a mulch. The screened material is generally a high-quality compost.

Woody wastes are categorized according to how they are regulated for composting. Facilities subjected to the Vegetative-Waste Management and Composting Regulations (9 VAC 20-101) are restricted to brush and tree prunings coming from general landscape maintenance. There is no restriction on the source of woody waste for facilities operating under the Virginia Solid-Waste Management Regulations (9 VAC 20-80). These other woody materials for chips are wastes such as broken pallets or demolition/construction debris.

Animal manures

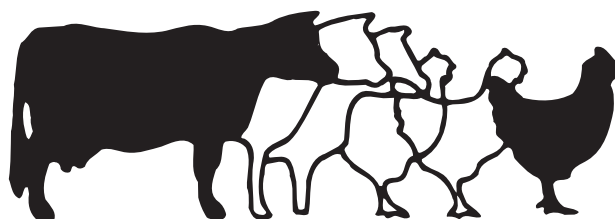
Under current Virginia Vegetative-Waste Management and Yard-Waste Composting regulations, vegetative waste mixed with other yard waste or manure is permitted under the exemptions in Part II (9 VAC 20-101-20 et seq.) or Part III (9 VAC 20-101-60 et seq.). To mix other refuse, sludge, or animal manures (for a facility that does not qualify under the exemptions), a composting permit under Part VI (9 VAC 20-80-330 et seq.) of the Solid-Waste Management regulations would be required.

Manure piles on farms were once a common site and an accepted way of storing manure until it could be spread on fields. Increasingly-regulated livestock and poultry farms are required to manage manure in a more environmentally sound manner. Composting is one alternative to minimize the impact of manure on the environment and the community. Composting allows the farmer to safely store the compost in a state that is stable. In addition, composting manure offers opportunities for additional revenues from the sale of compost or composting services.

Animal manures can be added to leaf compost windrows as a nitrogen source. This will speed up the composting process but it must be carefully monitored to maintain aerobic conditions and prevent odors. The addition of animal manures to the windrows will also increase the nitrogen content of the finished product.

- Poultry litter
- Horse manure/bedding
- Dairy/beef cattle manure

Compost contains less nitrogen than fresh manure because some of the nitrogen is volatilized during the composting process. Most of the remaining nitrogen is incorporated into organic compounds and is released slowly when the compost is applied to the soil.



A suitable mixture of yard-waste compost:poultry litter is about 5:1 if using leaf compost. As with any relatively high nitrogen source, the addition of poultry manure will cause rapid decomposition of the yard waste and has the potential to use up the oxygen in the windrow and begin anaerobic decomposition, causing odors. Therefore, closer monitoring and more frequent turnings of the windrow would be necessary. Horse manure and bedding also have potential as components in a yard-waste compost windrow. This mixture contains more bedding than manure and has a higher C:N ratio than manure by itself. Swine and cattle manures are most often in slurry form and require large amounts of high-carbon yard wastes for co-composting. Woodchips can be utilized in animal manure mixes to improve aeration and particle size variation.

Other compostable solid wastes

The potential exists for mixing many other organic solid-waste components with yard waste for composting. These include items such as waste paper, cardboard, unmarketable old newsprint, vegetative food wastes, fish and other food processing wastes, and paper mill sludge. Considerable planning and proper permitting is necessary to undertake composting with these less common materials, but a high-quality, marketable finished compost can be expected with efficient processing.

Many large-scale facilities presently compost the total organic municipal solid waste stream. This requires a fairly sophisticated materials recovery process as a first step. The practice is very effective for reducing the volume of landfilled waste but produces a compost that has few markets because of foreign material (glass, metal, plastic) contamination. Alternative end-uses are as landfill cover and in some reclamation activities.

Chapter 6

Compost Facility Operation

General

Every composting facility should be customized to the needs and resources of the owner or the authority. While the principles of composting remain the same, collection methods, size and placement of the windrows on the site, turning schedules, length of time required for composting, and quality of the end product can vary greatly.

Incoming yard waste

As yard waste is delivered to the composting site, the material should be unloaded at a separate hard-surface receiving area rather than being deposited directly into windrows. If citizens are allowed to bring yard wastes to the site, a separate drop-off point should be provided for traffic control and safety considerations.

The yard waste will arrive in varying degrees of compaction and with unwanted materials such as plastic, glass, metal, and stones, which are sorted out by hand at smaller-scale operations. In large-scale operations, hand sorting is not efficient and small materials are sorted out in the screening phase. These unwanted materials can damage equipment and will result in a reduced-quality end product. If the yard waste arrives in plastic bags, these should be deposited in a separate portion of the staging area for debagging by laborers. Although debagging is a labor-intensive process, it facilitates inspection and segregation. Operators of facilities with windrow turning equipment can choose to leave the material bagged, relying on the shredding action of a windrow turner to perform the debagging. This tends to be labor intensive because bags wrap around the turner drum and flails and have to be removed manually. Blowing plastic can become a problem and plastic bag shreds will have to be screened from the finished product.

Leaf stockpiling

At facilities that seek to co-compost leaves with grass clippings, the leaves will often need to be stockpiled until the following spring when the collection of grass clippings begins. Under the present regulations, these leaves can be stockpiled up to 12 months. (See Chapter 7.) Only leaves or other high-carbon yard wastes should be stockpiled. When brought to the compost facility staging area, they should be unloaded and sorted to remove trash. They can then be formed into large windrows or piles in order to conserve space. Water should be added to the outside of the piles to prevent the leaves from blowing. Water should not be added to the interior of the piles to inhibit decomposition until grass clippings become available. If these leaf piles are not stored under cover, rain and snow will wet them and an anaerobic condition may develop. In severe cases, odors will be detected and become intensified if the pile is mixed and turned. Even long-standing leaf piles that usually are not odorous will likely emit undesirable gases when turned. Close neighbors must be considered during all phases of a composting operation that can produce odors.

Leachate high in oxygen-robbing characteristics can result from large uncovered piles of leaves and pose a potential threat to nearby small surface-water bodies. Stockpiling areas should be raised or bermed to prevent run on, and leaf piles should be constructed so that leachate can either percolate into the soil, flow onto grassed areas or be collected in a pond for soil treatment. In addition, stockpiling increases the fire risk.

Windrow Composting

High-nitrogen materials should be formed into windrows as soon as a sufficient volume is received at the composting area to avoid problems associated with stockpiling. Initial sorting, homogenizing, and wetting of materials will promote a more uniform porosity, particle size, and moisture content in the windrow. Good mixing can be accomplished by working 20 to 30 loader buckets of material to form the windrow.

Adding water is often necessary to establish the proper moisture content of 50 percent to 60 percent. This may require 20 to 40 gallons of water per cubic yard of leaves. Adding water to the surface of windrows after formation

or between turning activities can be difficult because the water tends to run off the convex structure. Moisture can be achieved by creating a divide in the middle of the pile so that water can permeate into the structure. The squeeze test for moisture should be performed regularly. (See Chapter 2.)

The size of the windrow has a direct effect on the amount of oxygen reaching the pile interior. This affects the temperature and the microbial activity inside the piles. The windrows should be large enough to conserve heat and moisture and to effectively utilize available composting space, but not so large as to promote anaerobic conditions.

With the proper moisture level and oxygen concentration, the windrows will begin to heat up very quickly and will need to be turned every 24 to 48 hours. Thorough mixing while turning will promote shredding and expose more particle surface area. It also allows exterior material to be moved to the interior where the temperature will be higher. An effective method of mixing/turning with a front-end loader or backhoe is to raise the filled bucket or scoop high and release the material slowly so that it tumbles out in a cascading effect.

Properly formed and managed windrows may decrease in size by as much as 50 percent in the first few months. Two moderately sized windrows can be constructed close to each other and combined after their size has decreased to a volume that provides an insufficient insulating effect (Figure 6-1 and Figure 6-2). Moisture content should be checked and adjusted when windrows are combined.

A strategy of turning windrows infrequently can lead to the release of odors. Care must be taken to turn the windrow at a time when odor complaints are least likely and wind direction minimizes neighbor exposure. As on all turning occasions, moisture content should be checked and water added if necessary.

Uncovered windrows receive high amounts of precipitation and may generate considerable leachate. The Vegetative-Waste Management and Yard-Waste Composting Regulations (9 VAC 20-101-130B, 9 VAC 20-101-140H) require protection of ground and surface waters by the collection and treatment of leachates. A high water table or leachate that could run off the site requires collection. Collected leachate can be recirculated to windrows, removed for subsequent chemical treatment, or can be allowed to run over a nearly level, grassed waterway or filter strip. A sufficiently large grassed area will prevent any leachate from exiting the composting site. Properly composted material usually generates little leachate.

When composting is complete, the material should be moved to a curing area at the perimeter of the windrowing area to permit further maturation. (See Chapter 2.) Further active decomposition is unlikely after the material has cured for one to two months. The curing pile may be as large as needed to conserve space because odors are not likely to be produced.

Temperature-based turning

To effectively control the composting process with this method, thermometers should be placed in the windrows approximately every 50 feet and the temperatures recorded daily. Windrows should be turned and thoroughly

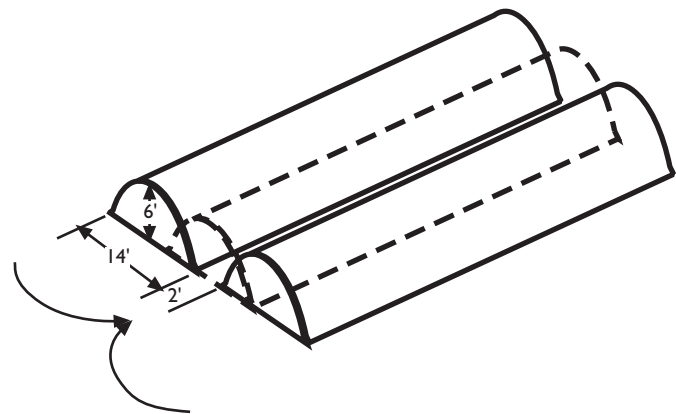


Figure 6-1. Combining composting windrows (Source: Michigan DNR).

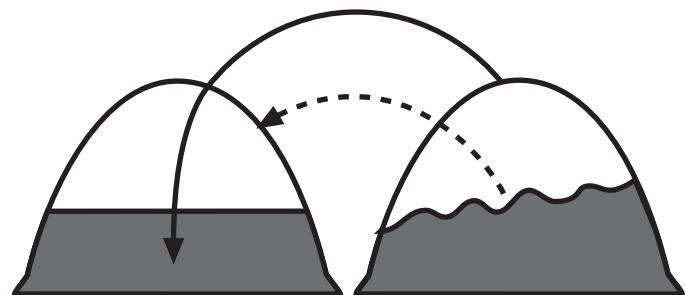


Figure 6-2. The principle of the mixing technique is to move the top of the windrow to the bottom of the windrow being formed, mixing the leaves well during this process. (Source: Connecticut DEP).

mixed when the temperature reaches 140°F (60°C). Composting to this temperature is optimum for destroying most pathogens and weed seeds, while allowing for maximum growth and reproduction of thermophilic bacteria.

Temperature probes are marketed for temperature monitoring, including two types of thermometers: the long-stemmed dial type and the infrared scanner. The most common and least expensive is a dial thermometer with a three- or four-foot stem that can be inserted into the middle of the windrow. (See Appendix C, Equipment Directory.) Several should be inserted into each windrow for daily readings and removed when the windrows are turned. These cost about \$75 to \$120 each. They are also available in a digital read-out model that cost about \$500 each. The infrared scanner contains a sensor module that converts radiant energy to an electrical signal. They are hand-held and can be used to measure the temperature of all sections of a windrow at a distance. Infrared thermometers cost about \$1,200 including the basic accessories.

Measuring temperature on a regular schedule is an excellent way to learn about the process as well as to determine when aeration/mixing is necessary. After some experience, a normal pattern in the temperature profile will be observed over time, and an operator will develop an invaluable sense of the process.

Windrows may require turning as often as every day during the first week. This rate will decrease over time as readily available energy sources (i.e., carbon) are exhausted by the microbial population. After a few weeks, turning may be necessary only every four or five days. When windrow temperatures no longer recover to the set-point, turning should be done when temperatures plateau or when the windrow is too wet or dry. The most appropriate measure to take when the temperatures are outside of the optimum range is to aerate and mix the pile. This is equally true whether the temperature is high and excess heat must be released or it is low due to insufficient oxygen and/or excessive moisture. In some cases, a low temperature can be caused by a C:N ratio that is too high. Adding in a high-nitrogen material is necessary at this point.

Odor Management

The two most important tools for compost process monitoring and management are a thermometer and one's nose. Some facility operators utilize oxygen and/or moisture meters to monitor for anaerobic conditions, the most common causes of odor generation. These tools cost more than long-stemmed dial thermometers and should not be used in place of them. (See Appendix C, Equipment Directory.)

Some odors are a natural by-product of composting; however, a compost pile should not produce strong, foul odors if it is managed properly. The ammonium ion is produced during the process of decomposition of organic wastes, but it is readily transformed and/or utilized by the microbes. Materials with high nitrogen concentrations (e.g., manure) and/or a high pH generate ammonia gas in compost piles. Excess ammonium is often the direct result of too much nitrogen in relation to carbon in the mix (a low C/N ratio). Other odors may be the result of anaerobic conditions that create amines (a reduced nitrogen compound) and various reduced sulfur compounds (hydrogen sulfide, mercaptans.) These odors can be prevented with proper compost management.

Operators may be tempted to reduce windrow-turning frequency to try to contain odors if they begin to become a problem. This usually compounds the problem. Regular turning is the first strategy to reduce odor generation. Thoroughly mixing into the pile highly absorbent materials, or those that can increase the porosity of the mix can alleviate excessive moisture conditions that often lead to odor formation.

To summarize, odor control strategies for prevention and management include: 1) schedule the turning of potentially odorous windrows to minimize neighbor impact; 2) construct properly balanced windrows as soon as is possible after arrival of materials with high odor potential; and 3) utilize windrow covers or composting under-roof to reduce the anaerobic conditions. Table 6-1 provides a comprehensive treatment of the common facility problems including odor.

TABLE 6-1. Troubleshooting

Problem	Causes	Solution
Odors	Anaerobic conditions	
	- windrow too large	Form into smaller windrows
	- excess moisture	Form into smaller windrows
	- leaf compaction	Form into smaller windrows
	- temperature too high	Turn windrow
	Windrow not formed immediately	Form windrows daily
Inadequate composting	Windrow too small	Combine windrows
	Insufficient moisture, material too dry	Add water while forming windrows
	Poor aeration	Turn windrows
	Windrow too large	Turn or reform windrow
Surface ponding	Inadequate slope, ruts formed	Regrade site
Temperature too low	Windrow too small	Combine two windrows
	C/N Ratio out of balance	Add nitrogen source
	Not enough moisture	Reform windrows, adding water
Temperature too high	Actively composting windrow	Monitor temperature daily, turn windrow

Chapter 7

Regulation of Yard-Waste Composting Activities

The regulatory requirements for yard-waste composting and compost distribution and marketing vary from state to state. In Virginia, the 1998 Vegetative-Waste Management and Composting Regulations (9 VAC 20-101, <http://www.deq.state.va.us/waste/wastereg101.html>) apply. Certain provisions of the Virginia Solid Waste Management Regulations (9 VAC 20-80, <http://www.deq.state.va.us/waste/wastereg80.html>) also apply to the stockpiling and handling of leaves and woodchips. The sections in 9 VAC 20-80 that are pertinent are: Exclusions in part II, particularly 9 VAC 20-80-150F and 9 VAC 20-80-330, which cover compost facilities.

Yard-Waste Composting Facility Regulations

The purpose of the yard-waste regulations is to establish appropriate standards and expedited procedures for permitting yard-waste composting facilities. A yard-waste composting facility must conduct its operation using commonly accepted process management practices and, unless the facility is an agricultural operation, must not combine the yard wastes with other wastes. An agricultural operation can mix agricultural wastes, such as animal manures and crop residues, with yard wastes under Virginia's solid-waste management facility standards for compost facilities (9 VAC 20-80-150F). In addition to the above, a yard-waste composting facility must not be situated on top of a partially or fully closed section of a landfill, except under certain conditions (9 VAC 20-101-120.E).

There are five exemptions from the requirement to obtain a permit as long as the composting operation does not pose a "nuisance or present a potential hazard to human health or the environment" and adheres to all local ordinances that govern yard-waste handling, composting, storage, and disposal. These exemptions are:

- 1) On-site exemption: Agricultural operations composting only on-site generated vegetable wastes.
- 2) Agricultural exemption: Certain agricultural operations that annually receive no more than 6,000 cubic yards of off-site yard wastes. In all cases, the owner submits a certification letter and off-site material must be composted and used or sold within 18 months of receipt.
- 3) Small-scale exemption: Property owners or authorized persons composting no more than 500 cubic yards of yard waste annually are exempt as long as no compensation is received by the owner or authorized person from the generators of the material.
- 4) Mulch exemption: Mulch is exempt as long as it is managed to be stored temporarily and does not create an open dump or hazard or nuisance to the public.
- 5) Second agricultural exemption: Agricultural operations which annually receive more than 6,000 cubic yards of vegetable or yard waste must submit a certification letter in compliance with the regulations before any material is received and an annual report describing the volume and type of materials received for the past year. This type of site can maintain (either in process or storage) the material on-site for up to 18 months, must have at least one acre of suitable ground for every 150 cubic yards of compost, must locate the composting area at least 300 feet from property boundaries and 1,000 feet from an occupied dwelling on another piece of property, and must not be sited in an area designated as a flood plain.

All other composting facilities must meet the standards (part IV) and permitting requirements (part V) of the regulations. The regulations were designed to be as simple as possible in order to encourage the development of yard-waste composting facilities, while still providing protection of public health and the environment. In all cases, yard-waste composting operations not exempt from the regulations are subject to applicable provisions of the Financial Assurance Regulations of Solid-Waste Facilities (9 VAC 20 -70-10 et seq.).

Part IV, Facility Standards covers 1) siting, 2) design and construction, 3) operations, and 4) closure. The following is a summary of some of the major components of this part of the regulations. These are abbreviated and not intended to replace the regulations. An operator must have a thorough understanding of the regulations in order to appropriately comply.

Siting

A facility must:

- a) not be located in an area of base floods, closer than 50 feet to a regularly flowing stream;
- b) not be located in a geographically unstable area or heavily dissected topography;
- c) have sufficient area for run-on, runoff, and leachate control;
- d) not be located within 200 feet of any dwelling or public facility; and
- e) not be located atop a closed waste-disposal unit (some exceptions are provided).

Design and Construction

A facility must:

- a) have a handling area and proper containers for temporarily holding non-compostables;
- b) have a hard-surfaced, diked or bermed working area and must collect site water for treatment (this can include recirculation) if the compost facility lies within 24 inches of the seasonal high-water table of the handling areas;
- c) grade the working area for run-on and runoff prevention and provide site water collection for treatment or disposal if the compost facility does not lie within 24 inches of the seasonal high-water table (treatment can include recirculation, grassed waterways and filter strips, or retention ponds with overflow filter strips);
- d) have a minimum buffer zone of 100 feet between facility boundaries and the composting work area; and
- e) have all-weather surfaced roads to service the receiving, handling, composting, and storing areas.

Operations

- a) No other solid waste other than vegetative waste may be composted. Certain exceptions apply for agricultural operations (9 VAC 20-80-150F).
- b) Other solid waste arriving at the compost facility as contaminants of yard waste must be segregated into proper containers for disposal and removed from the site within the specified time.

In addition, a facility must:

- c) have an attendant on duty when the site is accessed;
- d) control dust, odors, and vectors;
- e) implement and enforce a safety program;
- f) not conduct open burning;
- g) minimize fugitive dust and mud deposits on roads;

- h) not allow leachate or runoff to directly drain or discharge into surface waters; and
- i) maintain required buffer zones.

Closure

A closure plan is required for all operations such that little or no further maintenance is necessary, including provisions for removing material. Plans can be amended as stipulated in the regulations.

Part V of the 9 VAC 20-101, Facility Permit-By-Rule, provides for an abbreviated method for permitting yard-waste-only composting operations, contingent upon its meeting the facility standards of Part IV of the regulation. To obtain a permit-by-rule approval, an owner must:

- a) prove legal control of the site;
- b) notify the director of the Department of Environmental Quality (DEQ) of his or her intent to operate;
- c) provide the department with certification from the local government confirming compliance with local ordinances;
- d) submit a certificate that the facility has been designed and constructed in accordance with 9 VAC 20-101-130;
- e) submit an operation plan describing how 9 VAC 20-101-140 will be met;
- f) submit a closure plan describing how standards 9 VAC 20-101-150 will be met; and
- g) submit proof of financial responsibility (if required under the Financial Assurance Regulations for Solid-Waste Facilities 9 VAC 20-70-10 et seq.).

Any non-exempt facility that meets all of the above requirements and accepts only yard wastes for composting shall be deemed to have a solid-waste management facility permit.

Agricultural Facilities

The regulatory exemptions (9 VAC 20-101-60) and the second agricultural exemption (9 VAC 20-101-80) are the statutory exemptions that improve the opportunities for agricultural operations to produce compost from yard wastes, farm manures, and/or other agricultural wastes. The following is a summary of the regulations and the exemptions that govern agricultural operations.

According to the Vegetative-Waste Management and Yard-Waste Composting Regulations (9 VAC 20-101-10), an agricultural operation is any operation devoted to the bona fide production of crops, animals, or fowl, including but not limited to the production of fruits and vegetables of all kinds; meat, dairy, and poultry products; nuts, tobacco, nursery, and floral products; and the production and harvest of products from silviculture activity.

Agricultural operations can compost yard wastes alone or only with agricultural solid-waste materials normally returned to the soil, which are generated by the growing and harvesting of agricultural crops (e.g., spoiled hay, peanut hulls, corn stover) and the raising of animals (e.g., animal manures, spent animal bedding). Farmers can co-compost off-farm manures and yard waste without acquiring a composting permit (9 VAC 20-101-140); however, they must apply for an agricultural exemption. The co-composting of yard wastes with sewage sludge or animal carcasses requires a solid waste composting permit issued in compliance with 9 VAC 20-80-485 or 540 and meeting the requirements of 9 VAC 20-80-330 of the Virginia Solid-Waste Management Regulations.

The following questions must be answered if an owner or operator of an agricultural operation wishes to apply for an exemption from the yard-waste composting permitting requirements:

- Does the facility receive yard waste from off-site?
- Does the farmer intend to sell or otherwise use off-site the compost produced at the facility?
- Does the facility receive more than 6,000 cubic yards of yard waste from off-site per year?

The facility is exempt from all provisions of the regulations if it does not receive any yard waste from off-site. Either a regulatory exemption in accordance with the provisions of subdivision 4 of 9 VAC 20-101-60 may be sought or a second agricultural exemption based on 9 VAC 20-101-80.C may be claimed if the facility receives less than 6,000 cubic yards of yard waste from off-site. Only the second agricultural exemption may be sought if the facility receives more than 6,000 cubic yards of yard waste from off-site or if the finished compost is to be sold or otherwise used off-site.

Certification letters are submitted to the director of the Virginia Department of Environmental Quality in order to obtain an exemption from the Vegetative-Waste Composting Facility Regulations for subdivision 4 of 9 VAC 20-101-60 prior to receiving off-site yard waste. Agricultural operations are then exempt from the siting, design and construction, operations, closure, and permitting requirements of the yard-waste composting regulations if their letter contains:

- a) the name and address of the owner or operator and the agricultural operation and the location and mailing address of the composting site at the operation;
- b) a statement by the owner or operator that only allowed materials will be received from off-site;
- c) a statement by the owner or operator that all yard waste received from off-site will be composted and utilized at the operation address within 18 months;
- d) a statement by the owner or operator that at least one acre of ground will be used for each 150 cubic yards of finished material;
- e) a statement by the owner or operator that the total amount of yard waste received from off-site generators will not exceed 6,000 cubic yards in any 12-month period;
- f) a statement by the owner or operator that the composting site is not within an area subject to base floods and is located at least 300 feet from a property boundary and 1,000 feet from an occupied dwelling (not on the same property);
- g) a signed statement from the owner or operator, as follows: "I certify that I have personally examined and am familiar with the information submitted in this letter and all attached documents, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete."

The owner or operator must notify the director of the Virginia DEQ of his or her intent to operate a yard-waste composting facility and certify that the agricultural operation meets the conditions for exemption in order to be exempt from the second agricultural exemption (9 VAC 20-101-80). To simplify the notification and certification procedures, the DEQ has developed one simple form for the owner or operator to file only once. (Note: One additional annual report sheet is required for operations that accept more than 6,000 cubic yards of yard-waste material per year – see page 29.) The form, DEQ-YW-1, lists the statutory minimum site conditions for exemption, as follows:

- a) the area designated for composting is located greater than 300 feet from the property boundary;
- b) the area designated for composting is located more than 1,000 feet from an occupied dwelling not located on the same property as the composting area;
- c) the area designated for composting is not located within an area designated as a flood plain as defined in section 9 VAC 20-80-10 10.1-600;

- d) the agricultural operation has at least one acre of ground suitable to receive yard waste for each 150 cubic yards of finished compost generated; and
- e) the total time for the composting process and storage of the material that is being composted or has been composted does not exceed 18 months prior to its field application or sale as a horticultural or agricultural product.

For those operations receiving more than 6,000 cubic yards of yard-waste material from off-farm, a certification of compliance with all local ordinances is required (provided on pg 2. of form DEQ-YW-1). In addition, the owner or operator is required to file a simple one-page annual report to the director of the DEQ, indicating the type and volume of yard wastes received (Form DEQ-YW-2).

NOTE: These exemptions do not relieve the operation from compliance with all local ordinances. Individuals interested in establishing a composting operation are advised to fully investigate the local ordinances that may exist governing such operations.

Leaf stockpiling

Facilities receiving off-site yard wastes are required to utilize or dispose of at least 75 percent of the volume within a 12-month period in order for those wastes to not be considered “speculatively accumulated material,” under which designation they would be subject to the Virginia Solid-Waste Management Regulations. Compliance with this requirement is not difficult, even at facilities that use minimum technology, because volume reduction occurs from both the settling of material and its slow decomposition.

Virginia farmers can receive leaves and apply them to agricultural land, but must incorporate them in order to be exempt from solid waste management regulations. Incorporated leaves are considered to have undergone the necessary size reduction, due to the grinding effect of discing or plowing equipment, to meet the definition of mulch in the Virginia Solid-Waste Management Regulations. Mulch is exempted from state regulation. Application rate is restricted to a six-inch maximum depth. Further information on the use of leaves as a soil amendment is available in *On-Farm Mulching: An Option for Farmers and Municipalities*, Virginia Cooperative Extension publication 418-017.

Chapter 8

Compost Use

Marketing Compost

If any of the finished material will be used off-site, marketing becomes part of the composting operation. Markets for the end product must be established if a facility will market as well as produce compost. Two questions should have been answered in the early planning stages of the operation. “What are the end uses for the finished material?” “Who is the customer for the finished material?”

Municipalities may choose to utilize the compost exclusively for public landscaping. However, if the economics of the operation are based even partly on the sale of the finished product, the success of the operation will depend largely on maintaining and expanding markets. Educating the public about the uses and benefits of compost is essential to create demand for the product. Maintaining the demand depends on the production of a consistent material designed to meet specific market needs.

Potential users of mature, stable yard-waste compost may include:

- Nursery/greenhouse operators
- Landscapers
- Homeowners/gardeners
- High-value commodity farmers
- Landfill managers
- County parks and recreation departments
- Golf courses
- Turfgrass producers
- Institutional and commercial grounds managers
- State and local agencies, including Departments of Transportation (DOTs)

End-Product Quality

There is a growing demand in the agricultural, horticultural, and landscaping industries for organic matter that can substitute for existing materials, such as peat moss, and can improve soils and soilless mixes. Consistent quality is critical for meeting and expanding this demand. A well-processed compost is generally dark and crumbly and has a pleasant, earthy odor. It does not contain recognizable leaves, visible pieces of glass, or other foreign materials, nor does it emit foul odors, which would indicate improper composting conditions. It is best to re-process or dispose of a poor-quality product rather than attempt to sell it and, thus, risk negative market impacts.

The quality of the finished compost will largely determine its end use. Screening compost before sale increases its marketability to more user groups. Unscreened compost containing a large percentage of partially decomposed material or trash will likely only be suitable for use as landfill cover. Partially decomposed organic material can be recycled back into the composting process. Wood chips, used in some cases as a bulking agent, can also be recycled to an active windrow, or separated for use as a mulch. The highest economic use of compost is not as mulch; it is in container mixes and incorporation into the soil.

Compost intended for use in container mixes must be well decomposed and properly cured for several months to ensure its maturity and stability. Poorly processed materials can contain phytotoxic compounds and/or immobilize the plant nutrient nitrogen.

Providing accurate information about the product’s quality and use guidelines are important to the marketing of compost. Compost to be sold should be tested by a reputable laboratory for solids content, particle size distribution, water-holding capacity, stability, maturity, nutrient content, pH, soluble salts or electrical conductivity, potentially

toxic trace elements, and certain pesticides (e.g., the persistent herbicide Clopyralid) where source information may indicate potentially phytotoxic concentrations. Recommended values of key variables for finished compost are presented in Table 8-1.

There are currently two organizations that certify compost quality for use. The U.S. Composting Council (<http://tmecc.org/sta/index.html>) administers the Seal of Testing Assurance (STA) program that requires producers to have their compost tested routinely and the analytical results available to consumers. Compost operations certified under the STA program must also provide approved compost use guidelines to the consumer. A program administered by the Woods End Research Laboratory and Rodale, Inc. (<http://www.woodsends.org/>) requires generator testing to ensure high-quality compost, especially for use by organic farmers. Certification of compost quality by these reputable programs enhances customers' confidence in the product. Certification is probably not necessary for smaller operations that have a well-established and satisfied clientele.

Compost Benefits

A mature, stable compost is a valuable soil amendment with a variety of uses. As a soil conditioner, it improves soil tilth; decreases bulk density; increases water infiltration by reducing surface crusting, runoff, and erosion; and increases water-holding capacity. These effects on a soil's physical properties increase water availability to plants and soil pore space, thus creating a healthier environment for plant roots.

Compost increases a soil's pH buffering capacity and its capacity to hold nutrients, termed cation exchange capacity (CEC). The CEC is a measurement of a soil's ability to attract and hold positively charged nutrients, such as nitrogen in the ammonium form (NH₄⁺), potassium (K⁺), calcium (Ca⁺⁺), magnesium (Mg⁺⁺), and others. The

TABLE 8-1. Finished Compost Quality Guidelines.

Characteristic	Potting Media	Top Dressing Grade	Landscaping	Vegetable crops	Soil Amendment
recommended uses	formulating growing media for potted crops	primarily for top dressing turf	establishment/maintenance of landscape plantings and planting beds		improvement of agricultural soils and restoration of disturbed soils
particle size	<1/2 inch	<1/2 inch	<1/2 inch	<1 inch	<1 inch
pH	5.0 - 7.2	5.5 - 8.0	5.5 - 7.2	5.0 - 8.0	5.5 - 8.5
Soluble salts mmhos/cm	<3	<4	<2.5	<6	<20
Moisture content	35 - 55%	35 - 55%	35 - 55%	35 - 55%	35 - 55%
Water holding capacity	100 - 200%	100 - 200%	100 - 200%	100 - 200%	100 - 200%
Bulk density lbs/yd ³	800 - 1000	800 - 1000	800 - 1000	800 - 1000	800 - 1000
O ₂ respiration rate mg/kg/hr	<200	<200	<200	<200	<400
CO ₂ respiration rate mg/g/day	5	5	5	5	10
trace elements/ heavy metals	not to exceed EPA standards for unrestricted use (Part 503 Regulations)	not to exceed EPA standards for unrestricted use (Part 503 Regulations)	not to exceed EPA standards for unrestricted use (Part 503 Regulations)	not to exceed EPA standards for unrestricted use (Part 503 Regulations)	not to exceed EPA standards for unrestricted use (Part 503 Regulations)

Adapted from:

NRAES. 1992. On-Farm Composting Handbook. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY. 186p.

E&A Environmental Consultants, Inc. Cary, N.C. Laboratory Manual (1995).

Alexander, R.A. 1995. Standards and guidelines for compost use. p.68-70. In: Farm Scale Composting, JG Press, Inc., Emmaus, PA.

US Composting Council. 1996. Field Guide to Compost Use. E&A Environmental Consultants, Inc. and The US Composting Council. 128p.

quantity of the negatively charged organic matter sites in compost that attracts these cations is several orders of magnitude greater than in a normal soil; therefore, more nutrients can be held in available forms for plants and fewer will be leached out with irrigation or precipitation. Nitrogen (N) and phosphorus (P) are two essential plant macronutrients that can be supplied in significant quantities by high compost application rates. Nearly all of the N in compost is in an organic (or slowly available) form, which must mineralize (or be transformed into plant-available N) before it can be used by a plant. The available portion of organic N in compost is approximately 10 percent during the year of application. Much of the P in compost will become available for plant uptake during the year of application.

Recent research has highlighted the biochemical and microbial advantages of using compost. U.S. Environmental Protection Agency regulations banning soil sterilants, such as methyl bromide, have increased the interest in the use of compost to control soil-borne pathogens. Research has demonstrated that compost suppresses some soil pathogens by either “general suppression” and/or “specific suppression.” General suppression is attributed to high microbial biomass activity in mature compost that suppresses, but does not kill, the disease-causing organism. Such suppression has been shown to be effective against organisms such as *Phytophthora* and *Pythium* spp.

“Specific suppression” occurs only when certain varieties of organisms are present in the compost. Specific suppression has been found to be effective against diseases such as damping off (*Rhizoctonia solani*). Not all composts contain the organisms that elicit specific suppression. Mature compost, whose extended curing period permits extensive colonization by beneficial microorganisms, exhibits the greatest protection against soil-borne diseases. Yard-waste compost has been shown to be particularly effective against brown patch, dollar spot, and red thread on turfgrasses and against *Pythium ultimum* on other plant species. The use of compost as a plant disease suppressant is not routinely practiced because the factors that elicit the effect are not understood well enough to impart consistent responses.

The presence of plant growth regulators (PGRs) in compost provides another potential plant health benefit. Plant growth regulators are natural or synthetic compounds applied to or found in soil that can alter plant physiological processes to increase resistance to stress and improve yield and quality. Microorganisms that live in compost produce some PGRs, but additional research is necessary to determine the extent of the value of these substances in compost.

End Users

Table 8-2 provides a summary of the potential markets and relevant compost characteristics. Table 8-3 provides application rate guidelines for end users. The guidelines described in Table 8-3 are only general. Specific application rates must account for the build-up and potential loss to groundwater and surface water of nitrogen and phosphorus in the added compost. These nutrients, if over-applied, can impair water via eutrophication and nitrate contamination.

Nurseries and greenhouses

Nursery and greenhouse operators can utilize yard-waste compost as a partial substitute for peat or other materials in potting mixes and as a soil amendment in the production of field-grown or container nursery crops. Sixty-seven percent of the respondents to a 1989 survey of registered nursery operators in Virginia expressed an interest in using compost if it were available at competitive prices. Over half (56 percent) of the respondents believed that compost could substitute for peat in potting soil mixes.

Landscape contractors

Landscape contractors can use yard-waste compost as a soil amendment in planting beds or as a top dressing for lawn establishment or renovation. Contractors who grow their own woody ornamentals will find compost very suitable as a growth medium. Compost can also be used as a mulch, especially if the compost contains a high proportion of coarse, woody materials. Fine, screened compost is better suited for container mixes because such uses replace higher-value materials.

TABLE 8-2. Potential Markets and Compost Characteristics.

Potential User	Use	Concerns and Limitations	Comments
Homeowners	Soil amendment, mulch	Aesthetics, contaminants (glass, etc.)	Only highest quality compost can be marketed
Groundskeepers	Soil amendment, mulch	Aesthetics, handling, contaminants	Need high quality
Golf Courses	Soil amendment, topsoil replacer	Aesthetics	Need to educate this somewhat reluctant market
Nurseries/ Greenhouses	Peat replacer in soilless potting mixes	pH, soluble salts, ammonium	Potentially high paying market but stringent specs
Nurseries (Field stock)	Soil amendment	Varies with species	less specific requirements than for media
Landscapers	Soil amendment	Handling	Less expensive than top soil
Parks	Soil amendment	Aesthetics	Many have own source of compost
Agriculture	Soil amendment, possible liming	Handling, availability, nutrient content low	Uses large volumes at one site
Reclamation projects	Soil extender, soil amendment	Perhaps least demanding product specs	Uses large volumes at one site
DOT	Soil amendment, erosion control	Costs	Need high quantity, mainly for seeding grasses, not yet in specifications

(Adapted from Minnesota Pollution Control Agency)

Many landscapers have difficulty finding a consistently reliable source of inexpensive, fertile topsoil. The cost of high-quality topsoil typically ranges from \$0.97 to \$3.95 per 40-pound bag. By comparison, yard-waste compost, which can be used as a partial topsoil replacement in lawn establishment or renovation, typically costs about \$12 per cubic yard in the southeastern United States. Generally recommended application rates for compost range from two to six cubic yards per 1,000 square feet incorporated into the top four to six inches of soil.

Homeowners

Homeowners constitute a large potential market for yard-waste compost because it is an excellent high-organic-matter amendment for vegetable and flower garden soils. Gardeners find it especially desirable for forming raised beds. When incorporated into the garden, compost improves water holding capacity and soil tilth. Other homeowner uses for compost are as a top-dressing or partial topsoil replacement for establishing and renovating lawns and in planting or transplanting shrubs and ornamentals.

The homeowner market is accessible to any compost producer, if a high-quality, screened compost is offered. Large facilities may consider selling compost to homeowners bagged or in bulk. Nurseries and garden centers can sell bagged or baled compost. Some communities have established programs that provide compost to citizens in exchange for unprocessed yard wastes.

An increasing number of citizens practice backyard composting, and many communities actively encourage it as an alternative to burning or landfilling. In Seattle, Washington, a Master Composter program was established to train participants as instructors in backyard composting. Over 300 Master Composters now teach the public how to build a compost bin, layer and mix the materials, and manage the process to prevent odors and produce a valuable end product. (See the section on backyard composting in Chapter 11 for more information.)

Organic and high-value commodity farmers

An increasing demand for compost is also occurring in the farming sector. Certified Organic and traditional farming operations are seeking organic fertilizers and effective ways to increase the organic matter content of their soils.

TABLE 8-3. General Uses and Application Rates for Compost.

Market	Applications	Approximate Usage Rates (by volume)
Retailers/Homeowners	common landscape or garden amendment	1" application or 20% of planting mix
	mulching	2-3" around all landscape plants
Sports turf	construction mixes for new golf courses	5-20% depending on application needs
	topdressing mixes	5-20% of mix or up to 100% compost for athletic fields after aeration
	new turf establishment	1-2" tilled to a 5" depth depending on soil type
	turf renovation	1/8-1/2" topdressed after aeration
Landscapers	new turf establishment	1-2" tilled to a 5" depth depending on soil type
	turf renovation	1/8-1/2" topdressed after aeration
	planting bed preparation	1-2" tilled into raised beds
	mulching	2-3" around all landscape plants
	backfill for tree planting	30% of planting hole volume
	outdoor planter mix	20-40% by volume
Nurseries	field application as a soil amendment	1-2" incorporated 5" depth
	band application for shade trees	applied in 2-foot wide band
	liner beds – incorporated	1-2" incorporated pre-plant to 5" depth
	liner beds – mulched	1-2" mulched post-plant
	container mixes	5-40% of vol. depending on plants
Topsoil blenders	soil amendment for many beds	10-50% for blends depending on plant family and specifications
Roadside	new seedlings/ upgrading of soil	1" disked to 4" depth
	erosion control	1-2" as coarse mulch
	mulch for tree plantings	2-3" evenly applied
	planting beds at rest stops/ interchanges	1-2" tilled into raised beds 5" deep
Silviculture	new seedling establishment	1-2" disked where possible
	mulch	1-2" evenly applied
Agriculture	general field soil amendment	1-2" incorporated to 5-8" depth
	specialty crop production	1-2" incorporated to 5-8" depth

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Annual applications of one to two inches (135 to 270 cubic yards per acre) will usually provide all the required essential plant nutrients and organic matter for a growing season. Annual applications will lead to long-term improvements in soil quality.

Yard wastes must be pesticide-free in order for compost from this source to be used on a certified organic farm. Some farmers can produce their own compost, but the investment in equipment and labor makes composting unfeasible for most farmers.

Golf course operators and turfgrass producers

Turf managers of golf courses, cemeteries, and other sizable turf areas can use incorporated or top-dressed compost in establishment and renovation projects. Aerating the soil, top-dressing with one-half to one cubic yard of compost per 1,000 square feet of turf, and dragging the area are especially effective practices.

Turf or sod producers will find yard-waste compost to be an ideal growth medium for turfgrasses. Kentucky bluegrass and other mixtures can be seeded into a two to six inch layer of compost to produce a sod that is 30 percent to 40 percent lighter than with conventional techniques. Compost can also be used to replace lost topsoil for reseeding after sod harvest.

State and local governments

Grounds departments can use yard-waste compost as a soil amendment for planting beds, for top-dressing lawns and athletic fields, for erosion prevention, as a mulch around trees and shrubbery, and as a partial topsoil replacement for lawn establishment and renovation. State and local governments can utilize compost on highway re-vegetation projects, as a growth medium for constructed wetlands, and as a mulch for erosion-prone hillsides.

Several states have incorporated the use of compost into state department of transportation (DOT) specifications. This can potentially increase the demand of compost dramatically. Within Virginia, the DOT is presently conducting tests to see if it wants to include compost in its specifications, but up to this point has not.

Private building contractors and land managers

Compost has demonstrated environmental benefits when used to improve soil degraded from land disturbance activities (e.g., mining), as a mulch for marginal land, and in a berm as a silt fence replacement in building construction.

Landfill managers

Yard-waste compost is suitable for use as a daily cover, for a cover over a cap, and for other landscaping and re-vegetation projects.

Chapter 9

Yard-Waste Collection

Collection of yard waste is typically the most expensive component of any program designed to divert organic wastes from the rest of the municipal solid-waste stream. Many communities provide separate yard-waste collections during the fall for leaf pickup. Whether or not community waste managers can provide a separate pickup in the spring and summer for grass clippings depends on labor availability and the cost of collection. Encouraging the backyard composting of yard wastes and the practice of leaving grass clippings on the lawn as waste reduction techniques can be effective in reducing yard-waste collection and processing costs.

Materials

Leaves can present a large burden on a waste collection system because large volumes are generated in a short time period. The mass of yard waste comprises approximately 12 percent of the total municipal solid-waste stream, with fall leaves representing nearly half of that; however, leaves can amount to 30 percent or more of the waste stream during the fall collection period. Communities that collect leaves probably have estimates of the quantity collected. If no records are available, an estimate of 200 pounds of leaves per household per year can be used for planning purposes. Leaves can be collected by vacuum, claw, front-end loader, sweeper, and in bags.

Grass clipping volumes vary widely by season and are affected by watering and fertilization schedules and the use of lawn care services. The moisture content of grass clippings increases their weight and makes them difficult to pick up with vacuum systems or sweepers; therefore, most grass is collected in plastic bags.

Woody materials such as brush and prunings can be included in a municipal or other large-scale yard waste composting system. The largest volumes of woody wastes will be generated in the spring and fall and should be collected separately from leaves and grass clippings because these materials require size reduction (e.g., chipping). Woody chips do not readily decompose and will require screening from finished compost. The chips may be recycled into newly established windrows or used as mulch. Some communities have established successful programs for Christmas tree collection and chipping for mulch production. Equipment needs for chipping, grinding, and screening must be addressed when woody materials are collected for composting. (See Chapter 10.)

Collection Systems and Equipment

Yard-waste collection usually is done through one of two systems, curbside or drop-off, each of which includes a variety of options. A system that combines both curbside and drop-off collection may actually be the most efficient for many communities.

Curbside collection

Yard wastes are either collected in bulk after the material is raked to the curb or in bags or containers placed at the curb. For bulk collection, woody wastes may be bundled or picked up in piles by a front-end loader or claw. Residents must be well informed about collection methods in order to facilitate the process. Newspaper articles, TV and radio public service announcements, and leaflets will all increase participation. The distribution system must be well advertised if homeowners are expected to use special bags for yard wastes.

Equipment options for bulk collection systems include:

- **Mechanical claw.** Yard wastes are placed in loose piles at the curb and picked up with a pincer bucket or mechanical claw attached to a small front-end loader. The material is then placed in a dump truck, roll-off container, or a packer truck to be taken to the compost site. The use of a packer truck to reduce the volume of the leaves collected can save many trips to the composting site. A claw is a versatile type of equipment that can pick up any sort of yard waste, including wet material. This method is convenient, fast, and requires only a small crew of

generally one raker and two drivers. The disadvantage to this method is that the capture rate of material is only about 90 percent.

- Vacuum leaf collector. Vacuum leaf collectors are designed to collect leaves that have been raked into the street or along the curb. Tag-along units are towed behind a truck, into which the leaves are blown. Self-powered units, some with compaction capacity up to 32 cubic yards per load, are also available. Most have manually operated intake hoses that range from 7 to 18 inches in diameter. Some models include an internal shredding system. The self-contained units are expensive and must sit idle much of the year, making it difficult to justify their cost. The portable or tow-behind units are less expensive and can be used with existing trucks. This equipment functions more effectively when collecting only dry leaves because wet leaves or grass clippings may clog the hose. Operational problems due to clogging are common. A crew of two rakers and a driver is required for this type of collection.

- Front-end loader (Figure 9-1). Yard wastes that have been raked to the curb may be picked up with a front-end loader and placed in a dump truck or roll-off container. Transportation costs are expensive because yard wastes are not compacted using this system and two or more trucks are often necessary. This arrangement allows additional trucks to be loaded while the first truck transports the waste to the compost facility. The capture rate is about 90 percent with a front-end loader collection system, which requires one loader operator, two rakers, and two or more truck drivers.

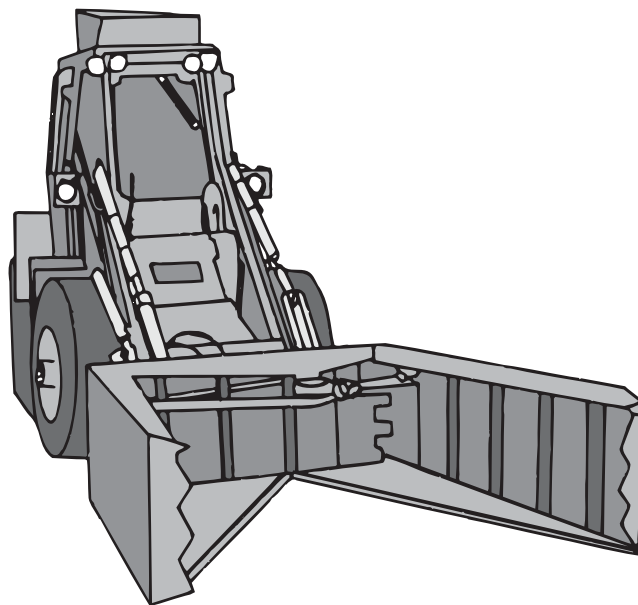


Figure 9-1. Front-end loader with mechanical claw attachment.

- Leaf-loader. This type of equipment, which is towed behind a dump or packer truck, sweeps yard waste off the street and into the truck. The material is ground or chopped as it is collected to reduce the volume. As the truck becomes full, it is detached and another truck is connected.
- Bag collection. Bag collection can be very efficient because it requires a pickup crew of only one or two laborers and a driver. Field data indicate that bag collection is the most cost-effective method for yard waste systems as long as debagging is not required. Some form of labor investment to handle bags is required at some point in the process unless the bags are compostable. There are three types of bags that can be used in yard waste collection/composting systems: compostable, degradable, and plastic. (See Appendix C for manufacturers.)

Table 9-1 concisely describes the pros and cons of each piece of equipment described.

Compostable has been defined by the American Society for Testing and Materials as “capable of undergoing biological decomposition in a compost site as part of an available program, such that the material (which is feedstock) is not visually distinguishable and breaks down to carbon dioxide, water, inorganic compounds and biomass, at a rate consistent with known compostable materials” (ASTM D-5488-94d). The compostable bag most commonly used for yard waste and food residuals is the kraft-paper bag with cellulose lining. Paper bags are difficult to handle if they get wet.

Degradable bags include those that are biodegradable, photodegradable, and physically/chemically degradable. Biodegradable bags are manufactured from: (a) a combination of polyethylene and starch; (b) a blend of synthetic and natural polymers; or (c) kraft-paper bags with a synthetic biodegradable plastic lining. These bags often consist of materials that require longer periods of decomposition than that used by a managed composting process.

Bags that use polyethylene in combination with corn or other starch for binders will not degrade completely because the polyethylene is non-biodegradable. Their use can result in many small pieces of plastic remaining following composting. Photodegradable bags are even less desirable in a composting system because their shreds will not always be exposed to light for sufficient periods of time. Plastic bags are made from polyethylene, which will not biodegrade, even though they will deteriorate to very small pieces over time. A new generation of compostable bags consists of biodegradable carbon-based polymers (e.g., poly lactic acid or PLA) that degrade readily. These are more expensive but becoming more widely used.

The type of bag used in a yard-waste collection system will depend on the structure of the collection and composting system, economics, and proposed compost end-use. Biodegradable bags range in price from \$0.18 to \$0.85 per bag (depending on bag volume); uncoated paper bags are generally about \$0.30 each; and plastic bags average less than \$0.08 each. Labor costs often determine the choice for bag and bag treatment.

If debagging is not to be a component of the collection/composting system, then either a fully compostable bag must be used or laborers hired to remove bags and their shreds during and/or following composting. Debagging before composting may be preferable for smaller operations utilizing a front-end loader for mixing and turning. Ask citizens to not tie the bags closed if employees debag yard wastes at the point of collection. This allows more yard waste per bag and makes emptying them easier.

Bags and shreds can become a blowing trash problem where yard wastes are not debagged prior to composting, and their presence in the finished compost will increase the amount of screening necessary to achieve high-quality material. Waste management entities often choose to provide special yard waste collection bags to the public at no or some charge. Arrangements can be made to distribute the bags through a variety of channels. Special instructions for bagging yard waste can be printed on the bags and provided through the media and printed materials.

Scheduling a separate collection for bagged yard wastes is an important consideration. Collecting bagged yard waste on the same day as the regular waste collection has the advantage of requiring the public to remember only one day for trash pick-up. A disadvantage is that it requires a separate truck and crew. A Monday pickup is desirable because most yard work is done on weekends and the time that materials remain in bags is minimized. This is especially important for grass clippings, which quickly become odorous. If collection is on the same day as other refuse, a system using specially colored bags to differentiate the yard waste is helpful. Using transparent bags in conjunction with a collection policy to not pick up bags containing contaminants is becoming increasingly popular because it helps reduce the amount of foreign materials placed in the bags.

- Container collection. Special containers such as 20-gallon plastic bins or 90-gallon rolling bins can be an attractive alternative to bags. Such bins are sturdy and will last for many years. Leasing these containers can be a less expensive option for waste managers than purchasing, and cost is competitive with biodegradable bags.

Problems encountered in a curbside collection program can include vehicles parked on the street on collection day, automobile catalytic converters igniting leaves, vandalism, and contamination with sticks, rocks, glass, plastic, and cans. Regardless of collection method, the yard waste must be relatively free of these extraneous materials in order to avoid problems in the composting process and to minimize the degree of post-composting handling/screening necessary to produce a high-quality compost. All materials must be monitored and foreign substances removed both at the collection point and the composting site.

Drop-off

Under a drop-off system, residents are responsible for delivering materials to a collection or compost site at which a supervised compactor truck, roll-off, or other container is stationed. Multiple yard waste drop-off sites may be effective for servicing larger areas or municipalities. Operators must be present at the site during drop-off hours to monitor the content of the incoming loads and to control traffic flow. Locations and schedules must be appropriate to encourage high rates of citizen participation. A centrally located site with weekend hours will encourage public participation.

Low participation rates have been a problem for drop-off programs. The success of this type of system depends on public awareness of the location of drop-off site(s), hours of operation, drop-off procedures, and, sometimes, incentives. Newspaper and radio ads and leaflets that include a map with drop-off site(s) will improve public awareness of a new program. Citizens can be given free bags and/or free finished compost as an incentive for participation. They also can be encouraged to empty the bags themselves and take them home for reuse as a further contribution to the community waste-reduction effort. Local governments are permitted by the Commonwealth of Virginia to enact ordinances prohibiting yard-waste disposal in landfills if a composting facility is available. Such an ordinance can increase citizen participation in a drop-off system. Although a drop-off system will not attract as high a rate of public participation as a curbside collection program, its utilization in place of curbside collection during times of low yard-waste generation should be considered.

TABLE 9-1. Collection Options Summary

Procedure and/or Equipment	Collection Options	
	Advantages	Disadvantages
A. Bagged leaves	Keeps leaves out of street and prevents blowing leaves; pick-up not sensitive to weather; low-cost collection; no specialized equipment required; instructions can be imprinted on bags	Cost of bags; time required for debagging; plastic must be screened out of finished compost
1. Bag type:		
(a) non-biodegradable plastic	Lower bag cost; debris can be removed when bag is emptied	Costs and possible shortage of debagging labor; possible blowing of plastic; screening of finished product required for certain markets (without debagging)
(b) partially biodegradable, photo degradable plastic	Good choice for labor restricted operations with non stringent quality requirements for compost end use	Same as for non-biodegradable plastic; high bag cost
(c) compostable	No need to debag; no concern for bags or pieces in finished compost; greater compaction than with plastic containing bags	High bag cost; extra effort in distribution of special bags; shredding possibly necessary; bag deterioration when wet
2. Equipment and procedure:		
(a) compactor truck	Large quantity per load possible	High equipment costs for single purpose use
i. empty bag at pick-up	Maximum opportunity for debris removal; efficient discharge at compost site; no debagging at compost site required	
ii. empty bag at compost site	Shorter collection time	Delays windrow forming when debagging prior to composting
(b) Dump truck	No specialized equipment required	Smaller quantity per load than compacted

continued on next page

TABLE 9-1. Collection Options Summary (continued)

Procedure and/or Equipment	Collection Options	
	Advantages	Disadvantages
B. Loose Leaves		
1. Location of piles:		
(a) curbside	Avoid problems encountered with in-street piling	Collection crew must rake leaves; more raking necessary when collection is with front-end loader; more extraneous material in piles
(b) in street	Most convenient for collection in absence of parked cars	Danger to children playing in leaves; danger of fire from catalytic converters igniting yard wastes; raking or repeated collection necessary if cars are parked on street; more extraneous material in piles
2. Vacuum leaf collector with discharge into wire or mesh-covered box on dump truck or trailer	Some shredding and compaction, especially when materials are somewhat moist	Ineffective when material is excessively wet or frozen; dusty when dry; noisy activity; some specialized equipment and accompanying cost necessary
(a) Mounting options:		
i. on trailer, discharge into truck	Can load one truck while other is in transit	Potential danger to operator; rear-of-truck operation poses inconvenience
ii. on front of truck (plow hoist)	Driver can see operator	Not generally available with belt drive
iii. on trailer of leaf box	Can be pulled with any type of truck, including one equipped for snow-plowing and sanding	Potential danger to operator; rear-of-truck operation and backing trailer to unload pose inconvenience
(b) Drive options:		
i. belt	Belt drive reduces vibration from impeller to engine, reducing maintenance costs and increasing service life	Higher initial cost
ii. on engine crankshaft	Lower initial cost	Vibration from impeller increases
iii. power take-off	Intermediate cost relative to other options	Intermediate cost relative to other options
3. Catch basin cleaner	Large units (12" suction hose) are fast and effective with sufficient suction for collection of wet leaves	Small units (6-8" suction hose) are slow and clog in excessively wet or freezing conditions; very high initial costs; high maintenance costs; noisy
4. Front-end loader and dump truck	Specialized equipment is optional; effective with wet and/or slightly frozen leaves; efficiency can be increased if front-end loader works with a small snow plow and street sweeper conducts final clean-up	Leaves must be raked into the street (tractor-pulled rake can be used only in suburban areas); inefficient with dry leaves
5. Front-end-loader and compactor truck with chute	Same as in number 4, except that effective capacity is much greater with a compactor	Same as in number 4

Adapted from Connecticut Department of Environmental Protection.

Chapter 10

Yard-Waste Material Handling and Composting Equipment

Equipment requirements for handling materials prior to, during, and after composting will vary substantially with the type and size of the operation. The minimum equipment required for any type of facility is a front-end loader or a tractor with a bucket. A grinder and screen also are needed in order to produce a high-quality end product. This chapter briefly discusses the major types of desirable handling equipment and provides cost estimates. A list of equipment vendors is included in the Appendix C, Equipment Directory. Any mention of brand name does not constitute endorsement of that product.

Front-end Loaders, Tractors, Windrow-forming Equipment

Loaders

Both track loaders and wheel loaders may be used in composting operations. The track loader operates better in loose or muddy soil, and may be required if the loader is to be used as a prime mover of larger-scale windrow turners. It is less easily transported to additional sites than a wheel loader. The wheel loader is more versatile (Figure 10-1), more easily maneuvered, and causes less site compaction and damage to road and ground surfaces. Both types of loaders are available in a range of sizes and with optional accessories. They are usually equipped with diesel engines, but models using gasoline and other fuels are available. Bucket sizes range from three-fourths to four cubic yards. The larger buckets are best for turning windrows. Other attachments, such as a claw, are optional.

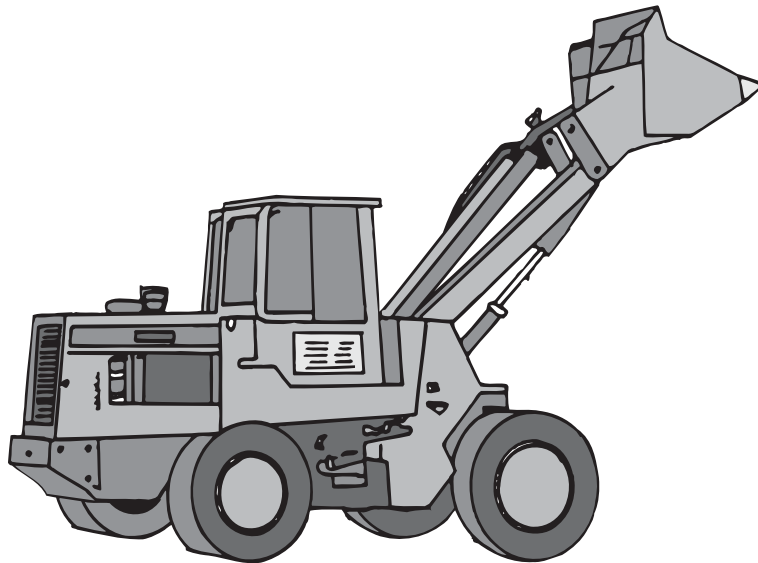


Figure 10-1. Front-end loader.

Tractors

Windrows can also be constructed using a tractor with a bucket attachment. Most farm-based composting operations use this equipment, which can perform the same tasks as a front end-loader. In addition, loaders and bucket-equipped tractors can be used to turn windrows.

Other equipment

A backhoe may be used for windrow construction and turning/mixing. A skid loader also can be used for materials handling; however, it is best suited for small operations because of its small bucket size (one cubic yard, maximum).

Grinders

Tub grinders

Tub grinders are characterized by a rotating tub-type drum intake system. Material is dumped into the tub with a front-end loader or tractor with bucket. Standard tubs are equipped with a fixed bar of hammermills. These shear the material as it moves across the floor of the rotating tub. As the material is reduced in size, it is forced through a screen and onto an elevator belt that discharges it into standing piles or onto a transfer vehicle. Different screen sizes are available, depending on the desired dimensions of the ground material.

Tub grinders are available in several models with significantly different capabilities. Large, heavy-duty grinders (Figure 10-2) are designed to grind large amounts of dry wood and brush. These machines can process 50 to 125 cubic yards (10 to 25 tons) per hour, depending on factors such as type of plant waste, screen size used, and waste moisture content. The larger units can grind pieces of wood up to twelve inches in diameter. Grinders can jam if overloaded, but jamming can be limited by properly mixing wastes and using varying screen sizes. Forage grinders are designed for grinding crop wastes such as straw, corn stalks, etc. and are suitable for grinding leaves. A non-farm operation wishing to grind only leaves may be able to rent this type of grinder from a farmer during non-harvesting periods of the year.

Tub grinders require regular maintenance, including rotation and replacement of the hammers. Generally, hammers should be rotated after 50 hours of use and replaced after 140 to 240 hours of use.

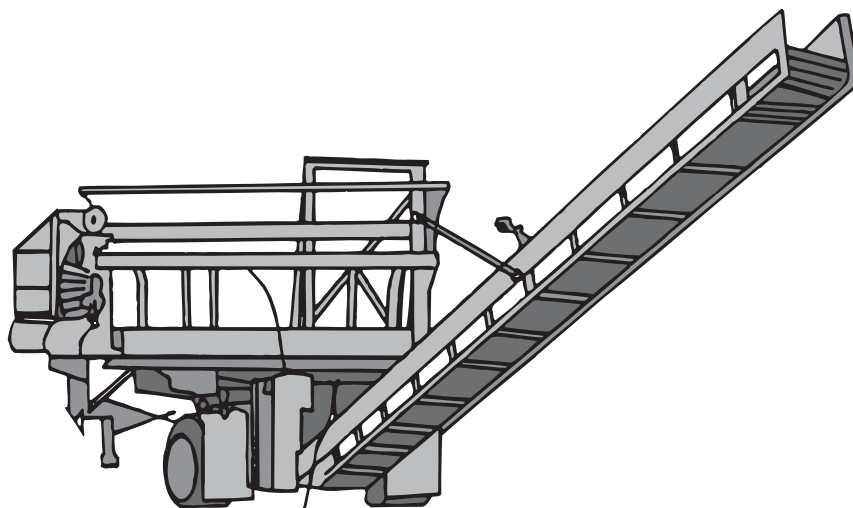


Figure 10-2. Tub grinder.

Special design grinders and shredders

Special design grinders and shredders are similar to tub grinders but are special purpose machines. Several manufacturers offer woody-waste grinders that will accept logs and stumps several feet in diameter. Smaller, portable machines can process material up to six inches in diameter. The large models are powered by diesel engines up to 350 horsepower. One such shredder has a set of free turning rollers with teeth and blades to impale and hold the wood. The wood is rubbed against the rollers and quickly reduced to small pieces. The shredded material is then moved by conveyers to sizing and screening equipment.

Chippers

Chipping machines are designed to chip brush, limbs, and other woody debris up to six inches in diameter. They are typically hand-fed and have blades that range in size from 12 to 16 inches in diameter. Some models are equipped with heavy-duty blades that can handle an occasional can or rock without damage to the machine. Chippers are powered with gasoline or diesel engines or from a power take-off shaft and produce large chips suitable for mulch.

Finishing Equipment, Shredders and Screeners

Shredders and screeners are frequently used to refine or finish the compost. The material is loaded into a receiving hopper where it is carried to the top of a conveyor. The conveyor drops the material onto a belt and, by a system of adjustable, variable sweep fingers, the material undergoes a continuous raking action to shred and aerate the load. Oversized pieces undergo further shredding, while items such as sticks, stones, metal, and glass are rejected and discharged through a trash chute. Shredders can process from 25 to 250 cubic yards per hour, depending on size and options.

A variety of screening devices, including grizzly screens (scalpers), trommels (rotating screens) (Figure 10-4), and shaking/vibrating screens (Figure 10-3), can be used in compost operations. Grizzly screens are used primarily for crude screening at two inches or more, and trommels and shaking screens are used to separate material greater than one-half inch in diameter. Vibrating screens can be used for coarse or fine screening.

Vibrating screens and trommels come in a wide range of models, sizes, and prices. Units, including screens, feed hoppers, and conveyers, are capable of processing from 25 to 50 cubic yards per hour.

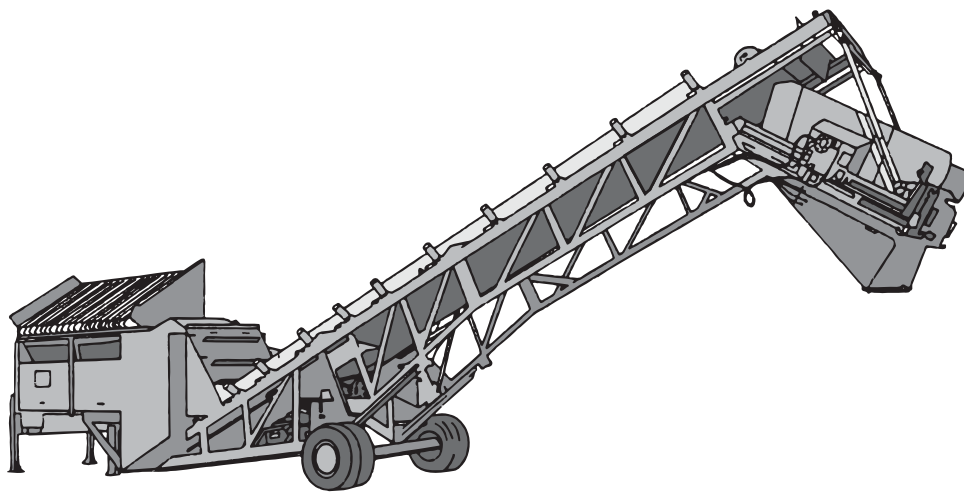


Figure 10-3. Shaking/vibrating screener.

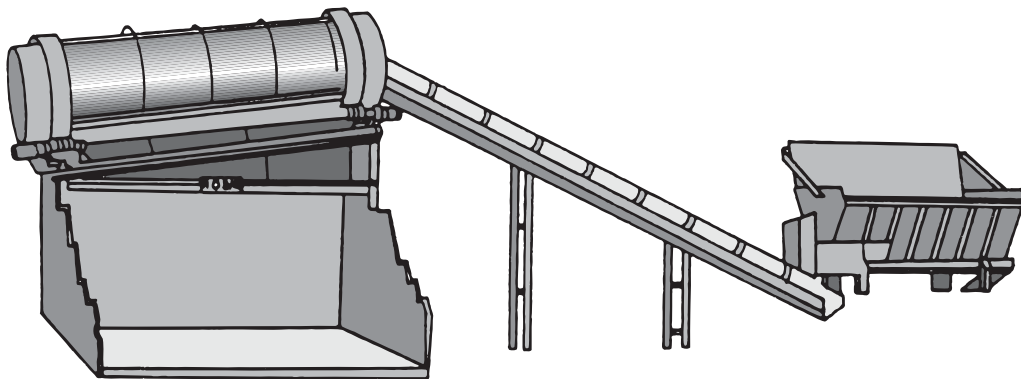


Figure 10-4. Trommel screen.

Compost Turners

Compost turners are designed especially for windrow turning and aerations. There are three basic types of machines.

The large models are self-propelled and straddle the windrow. A compost facility can turn 100,000+ cubic yards per year with this type of model. This machine has metal teeth on a rotating drum and as it moves over the

windrows, the teeth shred, break up, and aerate the compost. A skirt or fender reforms the windrows into a pyramidal shape.

A smaller unit that is side mounted can either run off of a tractor PTO or be pushed through the windrow by a front-end loader or other prime mover. This type drives down one side of the windrow then up the other, requiring two passes for each pile. These also come in a variety of sizes and are well suited for lower-budget or smaller operations.

A third type is the “elevating face” machine that lifts the leaves up over a face by a series of teeth and reforms the windrow as the leaves cascade over the rear of the machine. This type of machine is pulled through the windrow by a front-end loader, bulldozer, or other prime mover.

Chapter 11

Options for Reducing Yard-Waste Volumes

Backyard Composting

Backyard composting is a key to reducing the flow of yard wastes to landfills. Processing yard wastes by backyard composting reduces the costs of collecting, transporting, and processing waste and marketing compost.

Construction of a simple compost bin out of wire or snow fencing, wooden slats, or old shipping pallets will provide the backyard composter with a suitable container (Fig. 11-1). Compost can be made in open piles; however, bin systems are more appropriate for most suburban situations because they keep piles neat and prevent raiding by animals. The bin should be large enough to contain a pile capable of holding heat and small enough to allow air to reach the center of the pile by natural convection. Generally, the minimum dimension should be 3' x 3' x 3' to hold heat. If the bin is too large, air flow into the center of the pile will be restricted and turning/mixing will be difficult. Turning the pile is the most important and, often, most ignored step in home composting.

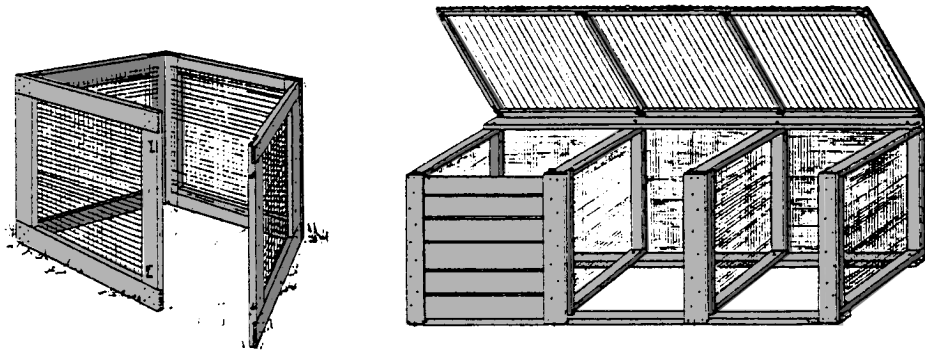


Figure 11-1. Portable wood and wire bin and wood and wire stationary bin (Artwork Courtesy of Seattle Tilth).

Backyard composting involves the same process and requires the same control of variables as do municipal-scale systems. Backyard composting piles should be assembled by layering the raw materials. This practice allows one to keep track of how much of each type of organic material is being contributed to optimize the carbon to nitrogen (C:N) ratio. (See Chapter 2.) Although an initial C:N ratio of approximately 30:1 is optimum for efficient decomposition, a higher ratio will slow but not prevent the process. Grass clippings can be composted successfully if enough oxygen can get into the pile. Composting the grass clippings with bulking agents such as leaves or chipped woody wastes improves air flow through the pile. The high C:N ratio of leaves and woody wastes can help optimize the C:N ratio of the grass mix. Moisture should be added to the pile during its construction if the material being layered is not already sufficiently moist. Ideally, the pile should be covered. Rain may provide enough moisture for uncovered piles but can also promote anaerobic conditions if the pile becomes saturated with water.

There are unlimited types of materials that can be added to a compost pile. Any type of yard waste, such as leaves, grass clippings, immature weeds, and shredded woody waste, can be successfully composted. Meat, bones, fish, and fatty food wastes, such as cheese and oils, may attract animals if piles are not constructed to provide an adequately deep barrier of well-decomposed materials to cover such food wastes. Dog and cat excrement and diseased plants should only be composted in backyard systems if temperatures of 131°F can be maintained for at least three consecutive days throughout the pile because these high temperatures are required to destroy animal and plant pathogens. The seeds, rhizomes, and stolons of perennial weeds require a composting temperature of 140°F for at least three to five consecutive days to assure destruction of these plant parts. Meat and animal products, animal manures, and reproductive parts of weeds and diseased plants should be composted in backyard systems with caution.

Gardeners' use of home-made compost to improve their soil is a well-established practice. The addition of compost rich in organic matter provides the following benefits:

- Increases soil's water-holding capacity and reduces erosion;
- Improves soil tilth, which allows better root penetration;
- Prevents soil crusting, which aids seedling emergence and increase water infiltration;
- Provides a food source for earthworms and other soil macroorganisms;
- Increases the cation exchange capacity (CEC) of the soil, which increases the nutrients available to the plants;
- Provides some nutrients for plant growth; and
- Suppresses plant disease and reduces the need for fungicides.

Municipal waste managers can encourage backyard composting as a part of their overall yard-waste management program. Approximately 11 percent of Virginians currently participate in backyard composting, according to a 1989 survey of Virginia Cooperative Extension field agents. A campaign to educate the public on the benefits of composting can encourage more people to compost considerable amounts of their yard and food wastes. Publications available from Virginia Cooperative Extension that provide specific information on backyard composting include *Composting*, VCE publication 426-325; *Mulches For The Home Garden*, VCE publication 426-326; and *Soil Preparation*, VCE publication 426-313.

Local ordinances may discourage or prohibit backyard composting. Properly constructed and maintained compost bins should not produce objectionable odors or attract unwanted animals, but poorly managed systems can become a nuisance.

Grass Clippings Management

Collecting grass clippings can pose a problem for municipal waste collectors. The high moisture content and weight of grass when wet make them unsuitable for vacuum pick up. Plastic-bagged grass clippings may aggravate odor problems at landfills; thus, an important goal for waste managers with minimal composting capabilities may be to reduce the volume of collected grass clippings by promoting backyard composting. Localities may restrict the collection of grass clippings, and citizens can be educated to leave clippings on the lawn.

Leaving clippings on the lawn

It is not necessary to remove clippings from lawns if they are mowed slightly more frequently than is the general practice. Grass clippings often contain over 4 percent nitrogen, 0.5 percent phosphorus, 2 percent potassium, and smaller concentrations of other essential nutrients. Grass clippings will decompose rapidly and return nitrogen and other nutrients to the soil, thus, reducing the need to apply additional fertilizer.

Homeowners can mow their lawns to a height of three to four inches tall. This height helps to decrease plant stress. This may require mowing more often than usual during the rapid growth period in the spring. Clippings decompose rapidly and nearly completely within a few days. Many manufacturers market mulching mowers that chop the clippings finer than standard mowers and distribute them evenly under the mower.

A few additional tips for the public are:

- Use a sharp mower blade to create finer clippings that will decompose quickly.
- Avoid over-fertilizing the lawn. Dense growth hinders clippings from reaching the soil surface where they more readily decompose.
- Only apply lawn chemicals when problems have been correctly diagnosed. Microbes are essential for clipping decomposition and a healthy lawn is characterized by a thriving community of soil life. Standard insecticides often kill beneficial soil organisms as well as undesirable ones.

Thatch

The perceived need to remove grass clippings has become an issue because it was once believed that grass clippings left on the lawn would contribute to thatch build-up. Recent research has demonstrated that thatch build-up does not result from leaving grass clippings on a properly managed lawn. Thatch results from the abnormally fast growth of tissues high in lignin (an organic polymer that provides strength to cell walls), such as roots, rhizomes, stolons and crowns. The dry matter in grass clippings are comprised mostly of cellulose, which breaks down rapidly. Thatch accumulation is largely due to incorrect mowing height and improper timing of fertilizer application.

Mulching

Another option is to use yard-waste components as mulching material.

- Grass clippings can be spread in thin layers over vegetable and flower beds or around the base of trees. Avoid heavy mulching, which can limit soil air exchange. Trees should not be mulched too close to the trunk.
- Leaves can be spread around shrubbery in the fall and even mixed with grass clippings to be used as a mulch. Applying leaves in the fall allows for some decomposition to occur before spring.
- Wood chips can be used around trees and shrubs or used to make an attractive, long-lasting path.

Appendix A

Planning Checklist

Advanced planning is essential to properly establish a composting facility. Several key decisions must be made regarding yard-waste collection, processing, and end use. Of primary importance in planning any facility is a thorough understanding of the process and of the regulatory requirements to which it is subject.

A. Determine the volume of yard wastes to be composted.

B. Determine the collection method (Chapter 9).

Three common methods are:

- 1) Collecting at curbside, either in bags and/or containers;
- 2) Collecting in bulk utilizing a vacuum, sweeper, or claw; or
- 3) A drop-off system where the wastes are brought to a local drop-off site or transfer station by private individuals.

C. Management Options:

- 1) Publicly owned and managed.
- 2) Publicly owned, privately managed. A private company operates the facility, and a public entity (e.g. municipality, regional waste authority) provides the site and equipment. The operator is generally responsible for assuring that the facility meets operating standards and regulations set by the local and state agencies. In most cases, the private operator is also responsible for marketing the end product. This arrangement typically involves a multi-year contract agreement.
- 3) Privately owned and managed.

Advantages of the private sector over the public sector in operating a compost facility include avoiding:

- a. new staff hires;
- b. contracting with trainers; and
- c. incurring equipment, processing and market development/servicing costs. Increasingly, the private sector is recognizing an opportunity to provide yard-waste processing services to public sector waste management entities.

D. Options for private-sector compost operation management include:

- 1) Nurseries and landscapers

Often they already have the land available and much of the finished product could be used in-house for potting soil mixes, field nursery crops, container crops, soil amendments for bedding plants, and lawn establishment/renovation.

- 2) Specialized companies

These companies may own the necessary composting equipment, or they may simply provide administrative and/or labor services for a fully-equipped publicly-owned facility. In the latter case, a private company may

provide technical expertise, supervise the site(s), and market the compost.

3) Farmer composters

In Virginia, agricultural operations can utilize regulatory and statutory exemptions to streamline facility permitting. Farmers often already have equipment, such as tractors with buckets, that can be utilized for composting.

4) Private waste-management companies

Waste management companies are also diversifying into yard-waste composting, as a means to reduce the tipping fees they pay or as a way to expand services.

E. Determine the uses of the end product: Chapter 8.

F. Site selection: Chapter 3.

Other criteria include:

- relatively flat or gently sloping land;
- for non-paved surface operations, a moderately drained soil which is not affected by a seasonally high water table;
- a water source for wetting windrows;
- a central location with good traffic flow;
- a means of securing the site to prevent illegal dumping; and
- an adequate buffer zone to protect neighbors from noise and odors.

G. Assess equipment needs: Chapters 4 and 10.

H. Determine the level of technology required: Chapter 4.

I. Public Participation

The public should be informed about the proposed facility early in the planning process. Public meetings and the distribution of literature to explain the economic and environmental benefits of composting will alleviate some of the concerns citizens have about a nearby compost facility. Anticipating opposition and responding neutrally with support from local leaders, regulatory agencies, and the scientific community will help build trust and confidence. An on-going public education program involving citizens will promote and maintain long-term interest and participation.

J. Secure regulatory approval and required permits: Chapter 7.

K. Establish a monitoring system for compost operations: Chapters 2 and 6.

Appendix B

Worksheet for Estimating Municipal Costs of Collection

Annual Operating Costs

\$/Year

I.

A. Cash Expenses for Equipment (operating and maintenance costs and/or rental costs)

1. Compactor trucks:

$$(\text{_____ units}) \times (\text{_____ hr/wk}) \times (\text{_____ wks/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

2. Vacuum leaf collectors:

$$(\text{_____ units}) \times (\text{_____ hr/wk}) \times (\text{_____ wks/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

3. Catch-basin cleaners:

$$(\text{_____ units}) \times (\text{_____ hr/wk}) \times (\text{_____ wks/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

4. Front-end loaders:

$$(\text{_____ units}) \times (\text{_____ hr/wk}) \times (\text{_____ wks/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

5. Dump trucks:

$$(\text{_____ units}) \times (\text{_____ hr/wk}) \times (\text{_____ wks/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

6. Other equipment:

$$(\text{_____ units}) \times (\text{_____ hr/wk}) \times (\text{_____ wks/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

Total cash expenses for equipment

= _____

B. Labor

1. Truck drivers:

$$(\text{_____ workers}) \times (\text{_____ hrs/wk}) \times (\text{_____ wk/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

2. Equipment operators:

$$(\text{_____ workers}) \times (\text{_____ hrs/wk}) \times (\text{_____ wk/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

3. Other workers:

$$(\text{_____ workers}) \times (\text{_____ hrs/wk}) \times (\text{_____ wk/yr}) \times (\text{\$_____ /hr}) = \text{_____}$$

Total of hourly wages

= _____

Costs of fringe benefits (\\$_____ Total of hourly wages) x (_____ %)

= _____

Total labor costs (total of hourly wages plus costs of fringe benefits)

= _____

Total Annual Operating Costs (sum of parts A and B)

= _____

Worksheet for Estimating Municipal Costs of Collection (continued)

Annual Operating Costs

\$/Year

II. Annual Capital Costs (In each case start with the initial capital cost of the particular item and convert to an annual basis with a capital recovery factor (CRF) that includes an allowance for annual depreciation over the service life and annual interest on investment; see Appendix G. Let C/T stand for the ratio of usage in leaf collection to total usage).

A. Compactor trucks:

$$(\text{_____ units}) \times (\$ \text{_____}) \times (\text{_____ C/T}) \times (\text{_____ CRF}) = \text{_____}$$

B. Vacuum leaf collectors:

$$(\text{_____ units}) \times (\$ \text{_____}) \times (\text{_____ C/T}) \times (\text{_____ CRF}) = \text{_____}$$

C. Catch-basin cleaners:

$$(\text{_____ units}) \times (\$ \text{_____}) \times (\text{_____ C/T}) \times (\text{_____ CRF}) = \text{_____}$$

D. Front-end loaders:

$$(\text{_____ units}) \times (\$ \text{_____}) \times (\text{_____ C/T}) \times (\text{_____ CRF}) = \text{_____}$$

E. Dump trucks:

$$(\text{_____ units}) \times (\$ \text{_____}) \times (\text{_____ C/T}) \times (\text{_____ CRF}) = \text{_____}$$

F. Other equipment:

$$(\text{_____ units}) \times (\$ \text{_____}) \times (\text{_____ C/T}) \times (\text{_____ CRF}) = \text{_____}$$

Total Annual Capital Costs

= _____

Annual Costs of Leaf Collection (sum of parts I and II)

= _____

Worksheet for Estimating the Increase in Leaf-Collection Costs Associated with a Shift from Disposal to Composting

Collection Costs	\$/Year	
	Municipal	Non-Municipal
A. Costs of Leaf Collection if leaves are to be composted		
1. Bags	= _____	_____
2. Independent hauling by:		
(a) Residents	= _____	_____
(b) Groundskeepers	= _____	_____
(c) Privately hired haulers	= _____	_____
3. Municipal contractors	= _____	
4. Municipal crews (from Table 4)	= _____	
5. Other	= _____	_____
Subtotal for A	= _____	_____
B. Costs of Leaf Collection if leaves are not to be composted		
1. Bags	= _____	_____
2. Independent hauling by:		
(a) Residents	= _____	_____
(b) Groundskeepers	= _____	_____
(c) Privately hired haulers	= _____	_____
3. Municipal contractors	= _____	_____
4. Municipal crews	= _____	_____
5. Other	= _____	_____
Subtotal for B	= _____	_____
C. Change in Leaf-Collection Costs		
(Subtotal A minus Subtotal B)	= _____	_____

Worksheet for Estimating Municipal Costs of Leaf Composting

I. Annual Operating Costs

\$/Year

A. Labor

1. Site monitoring and directing of trucks while leaves are being received:¹
 (_____ hrs./wk) x (_____ wks/yr) x (\$_____/hr) = _____
2. Emptying of bags:
 (_____ hrs/cu yd) x (_____ cu yd/yr) x (\$_____/hr) = _____
3. Equipment operator during windrow formation:
 (_____ hrs./wk) x (_____ wks/yr) x (\$_____/hr) = _____
4. Truck driver if needed during windrow formation:
 (_____ hrs./wk) x (_____ wks/yr) x (\$_____/hr) = _____
5. Compost process monitoring:
 (_____ hrs/visit) x (_____ visits/wk) x
 (_____ wks monitored /yr) x (\$_____/hr) = _____
6. Equipment operator for turning windrows:
 (_____ hr/turn) x (_____ turns/yr) x (\$_____/hr) = _____
7. Wetting of leaves:
 (_____ hr/wetting) x (_____ wettings/yr) x (\$_____/hr) = _____
8. Other (shredding, loading, bagging, etc. as applicable):
 (\$_____) = _____
9. Site monitoring while compost is being sold or given away:¹
 (_____ hrs./wk) x (_____ wks/yr) x (\$_____/hr) = _____

Total of hourly wages = _____
 Costs of fringe benefits (\$_____) x (_____%) = _____
Total Labor Costs (total hourly wages plus costs of fringe benefits). = _____

B. Cash Expenses for Equipment (operating and maintenance costs and/or rental costs)

1. Front-end loader during windrow formation:
 (_____ hrs./wk) x (_____ wks/yr) x (\$_____/hr) = _____
2. Dump truck for moving leaves at the site:
 (_____ hrs./wk) x (_____ wks/yr) x (\$_____/hr) = _____
3. Front-end loader or other equipment for turning windrows:
 (_____ hrs./wk) x (_____ wks/yr) x (\$_____/hr) = _____
4. Water truck (if needed):
 (_____ hr/wetting) x (_____ wettings/yr) x (\$_____/hr) = _____
5. Maintenance of roads, fences, drainage and water systems, and buildings = _____
6. Other equipment for shredding, loading, bagging, etc. as applicable = _____

Total Cash Expenses for Equipment = _____

¹If one person monitors more than one activity include only the time associated with or allocated to leaf composting.

Worksheet for Estimating Municipal Costs of Leaf Composting (continued)

C. Supplies and Other Expenses

\$/Year

- | | | |
|-----------------------------------|---|-------|
| 1. Training personnel | = | _____ |
| 2. Replacement thermometers | = | _____ |
| 3. Laboratory analyses of compost | = | _____ |
| 4. Electricity | = | _____ |
| 5. Water | = | _____ |
| 6. Other | = | _____ |

Total for Supplies and Other Expenses = _____

Total for Annual Operating Costs (sum of parts A, B, and C) = _____

II. Annual Capital Costs (In each case start with the initial capital cost of the particular item and convert to an annual basis with a capital recovery factor (CRF) that includes an allowance for annual depreciation over the service life and annual interest on investment; see Appendix G. Since land does not depreciate, the CRF for land is the annual rate of interest).

A. Land (\$ _____) x (_____ CRF) = _____

B. Site Improvements

- | | | |
|--|---|-------|
| 1. Site grading, drainage and roads: (\$ _____) x (_____ CRF) | = | _____ |
| 2. Fencing, gate, signs, and buffers: (\$ _____) x (_____ CRF) | = | _____ |
| 3. Water system: (\$ _____) x (_____ CRF) | = | _____ |
| 4. Gate house and storage shed: (\$ _____) x (_____ CRF) | = | _____ |
| 5. Other | = | _____ |

Annual Capital Costs for Site Improvements = _____

C. Equipment

 (Let C/T stand for the ratio of composting usage to total usage)

- | | | |
|--|---|-------|
| 1. Front-end loader:
(\$ _____) x (_____ C/T) x (_____ CRF) | = | _____ |
| 2. Dump truck: (\$ _____) x (_____ C/T) x (_____ CRF) | = | _____ |
| 3. Water truck: (\$ _____) x (_____ C/T) x (_____ CRF) | = | _____ |
| 4. Other equipment for turning windrows, shredding, bagging, etc.:
(\$ _____) x (_____ C/T) x (_____ CRF) | = | _____ |
| (\$ _____) x (_____ C/T) x (_____ CRF) | = | _____ |

Annual Capital Costs for Equipment = _____

Total Annual Capital Costs (sum of parts A, B, and C) = _____

Annual Costs of Composting (sum of parts I and II) = _____

Worksheet for Summarizing Annual Economic Benefits and Costs from Leaf Composting

Item of Function	\$/Year	
	Municipal	Non-Municipal
A. Benefits		
1. Avoided cost of incinerating or landfilling leaves	= _____	_____
2. Value of compost used by the municipality	= _____	_____
3. Revenue from the sale of compost	= _____	_____
4. Value of compost used by residents and businesses in excess of payments to the municipality	= _____	_____
5. Other revenues or benefits	= _____	_____
Total Economic Benefit	= _____	_____
B. Costs		
1. Change in collection costs (from Table 5)	= _____	_____
2. Municipal costs of composting (from Table 6)	= _____	_____
3. Other costs	= _____	_____
Total Economic Cost	= _____	_____
Net Economic Benefit (Total Economic Benefits minus Total Economic Costs)	= _____	_____

Capital Recovery Factor Values¹

Interest Rates

Years	7%	8%	9%	10%
2	.5531	.5608	.5685	.5762
3	.3811	.3880	.3951	.4021
4	.2952	.3019	.3087	.3155
5	.2439	.2505	.2571	.2638
6	.2098	.2163	.2229	.2296
7	.1855	.1921	.1987	.2054
8	.1675	.1740	.1807	.1874
9	.1535	.1601	.1668	.1736
10	.1424	.1490	.1558	.1627

¹The formula for computing capital recovery factors not presented here is as follows:

$$CRF = \frac{d(1+d)^n}{(1+d)^n - 1}$$

where: d = discount or interest rate

n = number of years

Source: Derr, Donn A. *The Economics of Leaf Composting*
 Department of Agricultural Economics and Marketing,
 Cook College, Rutgers University, Research Report Series
 No. P-02550-2-85

Note: This is only one of many methods of calculating annual depreciation and interest on investment. If an allowance is to be made for salvage, value straight line depreciation and average annual interest on investment can be calculated as follows:

$$\begin{aligned} \text{Annual depreciation} &= (c - s)/n \\ \text{Annual interest} &= d(c + s)/2 \\ \text{Where: } c &= \text{initial cost} \\ s &= \text{salvage value} \\ n &= \text{service life in years} \\ d &= \text{annual interest or discount rate} \end{aligned}$$

Appendix C

Equipment Directory

Resources

Recycler's World; www.recycle.net

Analytical laboratories

Control Laboratories
42 Hanger Way
Watsonville, CA 95076
(831) 724-5422
fax (831) 724-3188
frank@compostlab.com

Woods End Research Laboratory
PO Box 297
Mt. Vernon, ME 04532
(207) 293-2457
fax (207) 293-2488
www.woodsend.org
info@woodsend.org

Equipment

Shredders, grinders, and screeners

Aggregates Equipment Inc.
(screens)
PO Box 39
Leola, PA 17540-0039
(717) 656-2131
fax (717) 656-6686

Amadas Industries (screens)
PO Box 1833
Suffolk, VA 23434
(804) 539-0231
fax (804) 934-3264
www.amadas.com

Bandit Industries (shredders/
grinders/used equipment)
6750 Mill Brook Rd.
Remus, MI 49340
(989) 561-2270
(989) 561-2273
fax www.banditchippers.com

Banner Environmental Recycling
and Equipment (screens, shredders)
N. 117 W. 18299 Fulton Dr.
Germantown, WI 53022
(262) 253-2900
fax (262) 253-2919
www.bannerweld.com

Construction Steel Inc.(screens)
1772 Corn Rd.
Smyrna, GA 30080
(770) 433-2440

Diamond Z Manufacturing (shred-
ders/grinders)
11299 Bass Lane
Caldwell, ID 83605
(800) 949-2383
fax (208) 585-2112
www.diamondz.com
diamondz@diamondz.com

Excel Recycling & Manufacturing
Inc. (screens, shredders/grinders)
PO Box 31118
Amarillo, TX 79120
(800) 858-4002

EXTEC of North America (screens,
crushers/grinders)
Mailstop 32, Tincum Industrial
Park, No. 10 Industrial Highway
Lefter, PA 19113
(610) 521-6344
fax (610) 521-5782
www.extescreens.com

Farmhand Inc. (shredders/grinders)
Box 1500
Excelsior, MN 55331
(515) 236-6571

Fecon Inc. (shredders/grinders)
10350 Evendale Dr.
Evendale, OH 45241
(513) 956-570
fax (513) 956-5701
(800) 528-3113
www.fecon.com
fecon@fuse.net

Fuel Harvesters Equipment (shred-
ders/grinders)
PO Box 7908
Midland, TX 79708
800) 622-7111
(915) 694-9988
fax (915) 694-9985

General Kinematics Corp., (screener)
777 Lake Zurich Rd.
Barrington, IL 60010
(847) 381-2240
fax (847) 381-1376
www.generalkinematics.com,
mail@generalkinematics.com

Haybuster Manufacturing Inc.
(DuraTech Industries International Inc.) (grinders)
PO BOX 1940
Jamestown, ND 58402-1940
(701) 252-4601
fax (701) 252-0502
www.haybuster.com
info@duratechindustries.net

Heil Engineered Systems (shredders/grinders)
205 Bishops Way Suite 201
Brookfield, WI 53003
(262) 789-5530
fax (262) 789-5508
www.heil-engsys.com

Iggesund Recycling
(shredders/grinders)
PO Box 387
Aitkin, MN 56431
(218) 927-6922
fax (218) 927-6779
(218) 963-4343

Jacobson Inc. (shredders/grinders)
2445 Nevada Ave. N.
Minneapolis, MN 55427
(612) 544-8781

Jones Manufacturing Co. (tub grinder)
PO Box 38
Beemer, NE 68716
(402) 528-3861
fax (402) 528-3239
www.mightygiant.com

Knight Industrial Division
PO Box 167
Brodhead, WI 53520
(608) 897-2131
fax (608) 897-2561

Lindemann Recycling (screens)
500 Fifth Ave. Suite 1234
New York, NY 10110
(212) 382-0630

Lindig Manufacturing
PO Box 106
St. Paul, MN 55113
(612) 633-3072

MAC Corporation/Salem Shredders
(shredders/grinders)
201 East Shady Grove Rd.
Grand Prairie, TX 75050
(214) 790-7800
fax (214) 790-8733

MI-JACK, (shredder)
3111 West 167th St.
Hazel Crest, IL 60429
(708) 596-5200
fax (708) 225-2312
fax www.mi-jack.com

Morbark Inc. (tub grinders, chippers, screens)
PO Box 1000
Winn, MI
(800) 831-0042
www.morbark.com

Multitek
PO Box 170
Prentice, WI 54556-0170
(715) 428-2000
fax (715) 428-2700
(800) 243-5438;
www.multitekinc.com

Norcia (shredders/grinders)
RD No 4, Box 451
North Brunswick, NJ 08902
(201) 297-1101

Northeast Implement Corp., West Salem Machinery Co.
PO Box 5288
Salem, OR 97304
(607) 589-6160
www.northeastimplement.com
valby@baka.com

Olathe Manufacturing Inc. (wood chippers)
100 Industrial Parkway
Industrial Airport, KS 66031
(913) 782-4396

Old Dominion Brush Co. (ODB)
(shredders/grinders)
5118 Glen Alden Dr.
Richmond, VA 23231-4305
(800) 446-9823

Parker Manufacturing Inc.
18012 Bothell Highway SE
Bothell, WA 98012
(206) 486-3547

Powerscreen of America (screens),
11300 Electron Dr.
Louisville, KY 40299
(502) 267-2314
fax (502) 267-2317

Processing & Recycling Machinery
(screener)
PO Box 26439
Eugene, OR 97402
(541) 689-1052
fax (541) 689-1052

Promark Products Inc.
330 9th Ave.
Industry, CA 91746
(818) 961-9783

PST, 1335 NW Northrup St.
Portland, OR 97209
(800) 417-4733

Radar Companies, (screen)
Resource Recovery Group
PO Box 181048
Memphis, TN zip
(901) 365-8855

Rawson Manufacturing Inc.
99 Canal St.
Putnam, CT 06260
(860) 928-4458
(860) 928-0366 fax
www.rawsonscreens.com

Re-Tech (screens) 341 King St. Myerstown, PA 17067 (717) 866-2357 fax (717) 866-4710	Satellite Screens PO Box 366 DeWitt, IA 52742 (800) 922-2493 faxes (319) 659-8387	Universal Engineering Division, Pettibone Corp. (shredders/grinders) 800 First Ave. NW Cedar Rapids, IA 52405 (319) 365-0441
Recomp Inc. 1500 East 79th St. Suite 102 Bloomington, MN 55420 (612) 854-6211	Screening and Shredding Systems Winston-Salem, NC (910) 766-6461	Universal Refiner Distributors Corp. (shredders/grinders) PO Box 125 Parlin, NJ 08859 (201) 525-1100
Read Corp. (screens) 25 Wareham St. Middleboro, MA 02346 (800) 992-0145	Screening Systems of Virginia Inc. PO Box 729 Lebanon, VA 24266 (540) 889-1400	Valby Woodchippers (shredders/grinders) PO Box 402 Spencer, NY 14883 (607) 589-6160 fax (607) 589-4026 valby@baka.com
Recycling Systems PO Box 364 Winn, MI 48896 (517) 866-2800	Shredding Systems Inc. (shredders/grinders) PO Box 869 Wilsonville, OR 97070 (503) 682-3633 (800) 23-SHRED	West Salem Machinery Co. (screens, shredders/grinders) PO Box 5288 Salem, OR 97304 (503) 364-2213 (503) 364-1398 (800) 722-3530
Resource Recovery Systems Inc. (screens) PO Box 32035 Detroit, MI 48232 (519) 977-9852	Stumpmaster Inc. (shredders/ grinders) PO Box 103 Rising Fawn, GA 30738 404) 462-2445	
Rexworks Inc., (shredders/grinders) 445 W. Oklahoma Ave. Milwaukee, WI 53207 (800) 292-6294 (414) 747-7200	Sundance (shredders/grinders) PO Box 2437 Greeley, CO 80632 (970) 339-9322 fax (970) 339-5856	Wildcat Manufacturing Co. Inc., (trommel screen) PO Box 1100 Freeman, SD 57029 (800) 627-3954 fax (605) 925-7536
Royer Industries, (shredder/screener) PO Box 1232 Kingston, PA 18704 (800) 44SHRED (717) 287-9624 (804) 226-4433 in Virginia	Triple/S Dynamics Inc. (shredders/grinders) PO Box 151027 Dallas, TX 75315-1027 (214) 828-8600 fax (214) 828-8688 (800) 527-2116 www.sssdynamics.com sales@sssdynamics.com	

Compost turners

Autrusa Compost Consulting (Sandberger) PO Box 1133 Blue Bell, PA 19422 (215) 825-2973	Brown Bear Corp. PO Box 29 Corning, IA 50841 (515) 322-4220 www.brownbearcorp.com brnbear@mddc.com	Eagle Crusher Co. Inc. (Cobey) PO Box 537 Galion, OH 44833 (800) 253-2453 fax (419) 468-4840 www.eaglecrusher.com
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Fecon (Willibald)
9281 Le Saint Dr.
Farifield, OH 45014
(800) 528-3113
fax (513) 874-2914
www.fecon.com

Frontier Manufacturing Co.
192 Young St.
Woodburn, OR 97305
(503) 982-2907
(503) 982-5449

Kolman/Athey
PO Box 806
Sioux Falls, SD 57101
(605) 336-2610

Midwest Bio-Systems (Sandberger)
28933-35 E St.
Tampico, IL 61283
(800) 335-8501
fax (815) 438-7028

Resource Recovery Systems of
Nebraska Inc. (King of Windrow)
Rt. 4
Sterling, CO 80751
(970) 522-0663
fax (970) 552-3387
www.rrskw.com
rrskw@kci.net

Scarab Manufacturing
PO Box 1047
White Deer, TX 79097
(806) 883-7621
fax (806) 883-6804
www.scarabmfg.com
scarab@arn.net

Scat Engineering
202 Locust
PO Box 237
Hopkinton, IA 52237
(800) 843-7228
fax (563) 926-9098
www.scat.com
sales@scat.com

Valoraction Inc. (Sittler)
855, rue Pépin, Bureau 100
Sherbrooke, Quebec J1L2P8,
Canada
(819) 829-2818
fax (819) 829-2717

Wildcat Manufacturing Co.
PO Box 1100
Freeman, SD 57029
(800) 627-3954
fax (605) 925-7536

Thermometers

Commonwealth Industrial
Specialists
2817 N. Parham Road
Richmond, VA
(804) 270-5018

Omega Engineering Inc.
1 Omega Drive
Stamford, CT 06907
(203) 359-1660
www.omega.com

Trend Instrument Inc.
887 S. Matlock Street
PO Box 2047
West Chester, PA 19380
(215) 431-2000

Meriden Cooper Corp.
112 Golden State Park
Meriden, CT 06450
(203) 237-8448
www.meridencooper.com

Reotemp Instrument Corp.
11568 Roselle Street #10
Box 692
San Diego, CA 92121
(619) 481-7737
(800) 648-7737

Walden Instrument Supply Co.
910 Main Street
Wakefield, MA 01880
(617) 245-2944

Collection Equipment

Loose Collection
Ag-Bag Corporation
2320 SE Ag-Bag Lane
Warrenton, OR 97146
(800) 334-7432
fax (503) 861-2527

American Road Machinery Inc.
401 Bridge St.
Minerva, OH 44657
(330) 868-7724
fax (330) 868-3386 fax

Athey Products Corporation
1839 S. Main St.
Wake Forest, NC 27587
(919) 556-5171
fax (919) 556-9503

Ford - New Holland 500 Diller Ave. New Holland, PA 17557 (717) 355-1121	Colonial Bag Co. 205 East Fullerton Carol Stream, IL 60188 (630) 690-3999	Rollpak 1413 Eisenhower Dr., South Goshen, IN 46526 (574) 533-0541 (574) 533-0546 www.rollpak.com
Giant-Vac Manufacturing Inc. South Windham, CT 06266 (203) 423-7741	Dano Enterprises Inc. (Stone Container) 75 Commercial St. Plainview, NY 11803 (516) 349-7300	Set Point (Union Camp Corp) 69 Elm St. Foxboro, MA 02035 (508) 543-3800
Gledhill Road Machinery Co. 411-A N. State St. Painesville, OH 44077 (440) 357-8789	Guardian Poly Industries Inc. 238B Ste-Rose Boulevard Ste-Rose, Laval, Quebec H7L 1L6 Canada (514) 663-9943	Webster Industries 58 Pulaski St. Peabody, MA 01960 (978) 532-2000 www.websterindustries.com
Haul-All Equipment Systems 4115-18 Ave. North Lethbridge, Alberta T1H 5G1 Canada (800) 661-1162 www.haulall.com solutions@haulall.com	Home Plastics 5250 N.E. 17th Des Moines, IA 50313 (515) 265-2562	Containerized collection, bins Bonar Plastics 6111 S. 6th Way Ridgefield, WA 98642 (800) 927-5252 (416) 475-6980
Tink Inc. 2361 Durham-Dayton Hwy. Durham, CA 95938 530-895-0897 800) 824-4163 fax 530-895-0751	International Paper 400 Atlantic Street Stamford, CT 06921 (203) 541-8000 (800) 223-1268 info hotline comm@ipaper.com	Greif Bros. Corp. PO Box 796 Hebron, OH 43025 (614) 928-0070 www.grief.com
Vac-All Div., Leach Co. PO Box 2608 Oshkosh, WI 54903 (920) 231-2770 (920) 231-2770	Manchester Packing 2000 East James Blvd. St. James, MO 65559 (314) 265-3569	Heil Rotomold PO Box 8676 Chattanooga, TN 37411 (615) 899-9100
Walluski Western Ltd. PO Box 642 Astoria, OR 97103 (503) 325-5187 fax (503) 325-0397 www.haulall.com solutions@haulall.com	North American Plastics 921 Industrial Dr. Aurora, IL 60506 (630) 896-6200	Kirk Manufacturing Inc. 4052 Highway 56 Houma, LA 70363 (504) 868-9975
Containerized Collection, Bags Commercial Plastics Co. 2322 East 13 St. Ames, IA 50010 (515) 233-2268	Petoskey Plastics Inc. U.S. 31 Petoskey, MI 49770 (800) 999-6556 (231) 347-2878 fax www.petoskeyplastics.com	Master Cart PO Box 12543 Fresno, CA 93778 (209) 233-3277
	Poly-Tech Inc. 6578 Christmas Tree Rd. Campbellsburg, IN (812) 883-2106 (812) 528-1853	Otto Industries PO Box 410251 Charlotte, NC 28241 (601) 922-0331 www.otto-usa.com

Pawnee Products
PO Box 751
Goddard, KS 67052
(316) 794-2213

Refuse Removal Systems
PO Box 2258
Fair Oaks, CA 95628
(800) 231-2212

Reuter Inc.
410 11th Ave. South
Hopkins, MN 55343
(952) 935-6921
fax (952) 933-5803

Rotational Molding
17038 South Figueroa St.
Gardena, CA 90248
(213) 327-5401

Rubbermaid
3124 Valley Ave.
Winchester, VA 22601
(703) 667-8700
www.rubbermaid.com

Snyder Industries
PO Box 4583
Lincoln, NE 68504
(402) 467-5221
fax (402) 465-1220
www.snydernet.com

SSI Shaeffer
666 Dundee Rd. Suite 1501
Northbrook, IL 60062
(847) 498-4004

Sulo of America Inc.
700 Larkspur LDG Cr. Suite 199
Lakespur, CA 94939
(415) 461-8528

TEG Enviromental
RKB Enterprises
625 Maury Avenue
Norfolk, VA 23517
(757) 622-0692
fax (757) 640-0239
rbroom@aol.com

Zarn Inc.
P.O. Box 1350
Reidsville, NC 27320
(910) 349-3323
fax (910) 342-4101
www.zarn.com

Appendix D

Glossary

Aerobic - oxygen present or oxygen demanding. Aerobic composting is desirable due to the fact that it is a rapid decomposition that minimizes odors.

Anaerobic - oxygen absent. Anaerobic composting can lead to production of undesirable products such as methane and ammonia, leading to odor problems.

Bio-trash - a term for compostables other than yard waste, manures, sludges, etc. Includes institutional waste such as restaurant wastes, paper, and kitchen wastes.

Buffer zone - the area between the composting operation and neighboring land uses.

Compost - the end product of the composting process that is thoroughly decomposed, cured and ready for application to the soil.

Composting - the manipulation or control by humans of the natural aerobic process of biological decomposition of organic materials under proper moisture conditions. This process is carried out by successive microbial populations that function at increasing temperatures to break down the organic materials into carbon dioxide, water, minerals, and stabilized organic matter. The final product (compost) is sufficiently stable for storage or application to the soil.

Cubic yard - a standard measure of volume containing 27 cubic feet. One ton of incoming yard waste contains four to five cubic yards of material. Due to the volume reduction during the composting process, one ton of finished compost is approximately two cubic yards.

Curing - a late stage of composting after most of the readily metabolizable material has been decomposed to the point necessary to ensure stabilization. It is essential to cure compost before marketing.

Decomposition - the biological degradation or breaking down of organic materials, such as leaves, by microorganisms. Different from composting in that it is not controlled and does not result in thermophilic temperatures.

Heavy metals - metallic elements with high molecular weights and a specific gravity of five or more. Some of these elements can be poisonous to humans, animals, and/or can adversely affect plant growth.

Leachate - the liquid that results from groundwater or surface water that has been in contact with solid waste or compost and has extracted material, either dissolved or suspended, from the solid waste.

Mesophilic - bacteria that thrive at temperatures of 70° to 90°F (21° to 32°C) that feed on the most readily available carbohydrates and proteins. Their metabolic activity raises the temperature of the windrow sufficiently to allow the takeover by the thermophilic, or heat loving, bacteria.

Microorganisms - microscopic organisms that feed on waste material, breaking down complex compounds into simpler organic compounds. The microorganisms that inhabit a compost pile or windrow consist mainly of bacteria, actinomycetes, and fungi.

Municipal solid waste (MSW) - garbage, refuse, trash, and other solid waste from residential, commercial, and community activities. Approximately 15 percent to 20 percent of this MSW is yard waste.

Pathogens - organisms capable of producing infections or disease, often found in waste materials. The high temperatures in a compost pile kills many pathogens.

pH - a measurement of acidity/alkalinity that is measured on a scale from 1 to 14, with 7 being neutral. Values below 7 represent acid conditions, above 7 are alkaline.

Runoff - flowing water and associated contaminants originating from any part of the compost facility that drains over the land. Windrows should run up and down the slope so that runoff does not collect between the windrows.

Run on - any rainwater, wastewater, leachate, or other liquid that drains over land onto any part of the compost facility.

Screening - a process in which the finished compost is run through a series of screens, each with different size openings, to remove trash such as plastic, metal, and glass. This can improve the quality of the end product and increase marketability.

Shredder - a mechanical device used to break up waste materials into smaller pieces to increase the surface area. Can be used on woody waste to produce mulch. Not always a necessary piece of equipment for all types of yard waste. Types of shredders include hammermills, shears, tub grinders, and rasp mills.

Soil amendment/Soil conditioner - an organic matter source that when added to the soil improves the general physical, chemical, and biological properties of the soil, but doesn't necessarily add nutrients.

Stabilization - the decomposition of compost to the point where the temperature of the windrow equals the ambient temperature and it does not reheat when turned. Also see curing.

Staging area - the area of the compost site where the material is received. Manual removal of trash can be performed here. This area needs good traffic flow to accommodate private as well as commercial vehicles.

Static pile composting - a method of composting in which the oxygen and temperature levels are mechanically controlled by a system of air forced through the windrows. Due to costs, this is not practical for yard-waste composting, but is used in sludge composting.

Thermophilic - heat loving. Thermophilic bacteria and fungi perform best at temperatures ranging from 113° to 160°F (45° to 71°C). These microorganisms are responsible for the fastest decomposition and rapid heating of the pile.

Windrow - an elongated pile in which the yard wastes are placed. The piles are typically six to eight feet high by 12 to 18 feet wide and as long as needed to accommodate the yard waste.

Yard waste - material such as leaves, grass clippings, and brush and tree prunings. This material may all be recycled either by composting or chipping to make mulch.

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