Compost Operator Guidebook

Best Management Practices for Commercial Scale Composting Operations

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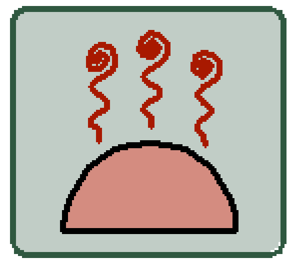

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1 Introduction to Composting

About your Guidebook

This manual presents a series of Best Management Practices for Composting which provide technical information and assistance on the operation and management of compost sites, especially those that process yard trimmings and "diminimus" (5% or less) amounts of other organic residuals. Each module in the series is designed to provide information to improve the success and viability of a composting operation with an overall goal of minimizing odor and water quality impacts while producing quality compost products. The industry continues to evolve and improve through trial and error, research, innovation, and technological development. This Best Management Practices Series and the corresponding training offer the best approaches to the current challenges of composting.

Composting Defined

Composting is a managed, aerobic (requiring oxygen) process in which microorganisms decompose organic materials (for example; leaves, grass, brush, wood, manure, agricultural residues, food scraps, etc.) yielding carbon dioxide gas (CO2), heat, water, and a stable, soil-like product called humus or compost. Understanding the biological principles of composting enables the site manager to make sound operational decisions to control and optimize the process to produce a quality product.

The Environmental and Economic Benefit of Composting

Composting is a way to manage organic discards to the benefit of the environment.

- Composting reduces the production of greenhouse gases in landfills that contribute to climate change,
- Composting diverts yard clippings and food residuals from taking up valuable space in highly engineered landfills, and
- Compost replenishes the organic matter and nutrient value of soil.
- Compost can be used to effectively reduce or eliminate soil erosion and filter stormwater discharge
- Composting provides local jobs and enhances the local economy.

Impact on Climate Change

According to the U.S. Environmental Protection Agency's 2008 Facts and Figures on Municipal Solid Waste, yard trimmings and food scraps make up the second and third largest portions of the MSW stream, 13.2% and 12.7% respectively (by weight). In a landfill these materials undergo anaerobic decomposition and produce methane. Methane (CH4) is a greenhouse gas that remains in the atmosphere for about 9-15 years and is over 20 times more effective at trapping heat in the atmosphere than carbon dioxide (CO2) over a 100-year period. Some landfills are equipped to capture, presently, up to 80% of the gases produced. Most landfills are not equipped to capture landfill gases. According to the U.S. EPA, landfills are the second largest source of methane emissions in the U.S.

As a fundamentally aerobic process, well-operated composts sites do not produce significant amounts of methane and contribute considerably less to the production and release of climate changing greenhouse gases. Additionally, experimental studies have shown that carbon sequestration in soil was increased by 6 to 40 tons of carbon per hectare from the application of compost.

Impact on Waste Management

Continuing pressures have focused attention on diverting yard trimmings from landfills and many states have responded by implementing yard trimmings composting programs or even bans on the disposal of yard trimmings in landfills. Increasingly in the United States, composting is used to handle a variety of municipal solid wastes, agricultural residues (old hay/straw, animal bedding, and manure etc.), biosolids, food scraps, and more. Smaller scale backyard composting is promoted as a means of reducing the total amount of yard trimmings that require collection and transportation to central composting facilities.

Composting contributes to local economies by employing people, transforming a locally produced "waste" into a locally produced resource. In a still-relevant study conducted and recently reaffirmed by the Institute of Local Self-Reliance, for every 10,000 tons of material per year managed, if landfilled creates one job but if composted creates four jobs. (Waste to Wealth, 2006) Tax revenue from composting businesses also add to the community bottom-line.

Providing a lower cost option for the management of organic wastes makes composting even more valuable to a community. Because composting is less resource intensive than landfilling, compost can be managed and produced locally in most communities.

Impact on Soil

The worldwide deterioration of agricultural soils has made composting and soil rehabilitation a necessity. Much research is taking place on the benefits of compost as a soil amendment. The widespread dependence on fertilizers and pesticides temporarily improves soil productivity but does nothing to maintain soil structure and ultimately leaves the soil lifeless. The successful diversion of organic waste to compost and back into the soil rebuilds healthy soil ecosystems that control and reduce soil erosion, suppress disease in crops, restore and rehabilitate wetlands and brownfield sites by breaking down pollutants, and reduce the need for artificial agricultural chemicals. The application of compost can reduce the need for irrigation by 30-70% and also reduce the overall agricultural demand for energy.

History

The origins of composting practices in human history date back thousands of years. Archeological evidence suggests that animal manure was used to increase food production shortly after people began cultivating food. Manure was mixed with straw in what eventually became a fertile soil-like material. There are numerous references in the Bible and the Talmud to the cultivation of the soil and the use of animal manure as fertilizer. One of the earliest documented agricultural uses of manure was discovered on a set of clay tablets dated to the Akkadian Empire which flourished in the Mesopotamian Valley 1,000 years before Moses was born.

The first groups of European settlers came to America with the knowledge of spreading manure to fertilize soils but lacked sufficient numbers of farm animals to impact crop production. In the early 17th century, Pilgrims were taught by members of the Abanaki tribe to add a fish to each hill of corn, a practice which many American colonial farmers continued until the early 18th century. As the number of farm and farm animals grew, farmers soon discovered (or rediscovered) that mixing barnyard manure with muck soils produced a much higher quality fertilizer.

Sir Albert Howard, a government agronomist in India, developed the modern concept of composting. The Indore method called for the mixing of three parts garden clippings to one part manure or kitchen waste. Howard published his ideas in a 1940 book, *An Agricultural Testament*. The first advocate of Howard's method was J.I. Rodale, founder of Organic Gardening Magazine. This technique quickly became the standard for gardeners who prefer not to use synthetic chemicals. The use of compost in agriculture, however, declined with the growing prevalence of chemical fertilizers following World War II.

Historically, most composting methods are based on practical experience rather than scientific knowledge. There has been little application of scientific principles to composting practices, but current interest in the science of composting has grown due to increasing complexities in dealing with large amounts of organic residues in a short period of time, lack of landfill space, and increasing concern about the environment.

2 The Biology and Core Principles of Composting

This part of the Best Management Practices Guidebook provides technical assistance in the operation and management of compost sites, specifically those that process yard waste. Each chapter of Best Management Practices (BMP's) is designed to improve the success and viability of composting operations, with an overall goal of minimizing odor and water quality impacts during the production of quality compost products. While the industry will continue to improve through research and development, innovation, equipment developments and trial and error, BMP's offer the best approach to the challenges of composing.

Introduction

This chapter reviews the biological aspects of composting and their role in management of the process. Topics include definition and description of the composting process; historical aspects, microbiology of composting monitoring and controlling the composting process; and characterization of finished (marketable) compost. A terminology section has been appended, as well as, journal articles related to biological aspects of composting.

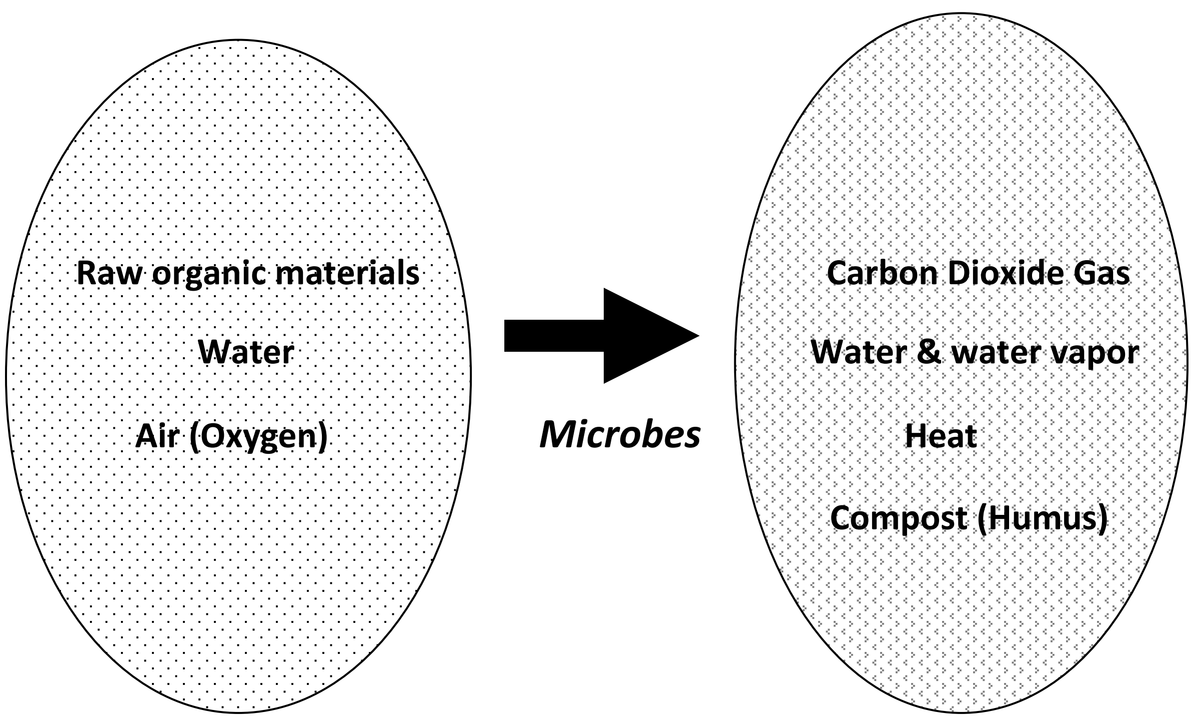
The composting process

In a managed environment, composting is a process that produces a valuable, quality product (compost), and minimizes odor.

In nature, dead plant and animal matter is decomposed slowly into humus primarily by microorganisms. These organisms are distributed widely throughout every environment on the planet. The rate at which these microorganisms decompose organic material aerobically into humus depends upon the relative amounts of carbon and nitrogen in the material mix, the availability of oxygen and moisture, other environmental factors such as temperature, and physical factors such as particle size of the materials being consumed.

The overall objective in managing the composting process is to create and maintain communities of microorganisms that work together to decompose the organic matter. Management of the composting process initially requires the proper mixture of ingredients based on the ration of carbon to nitrogen (C: N ratio) in the input materials, periodic monitoring and adjustment of factors such as compost, moisture, O_2 and/or CO_2 levels and temperature. These are some of the factors directly associated with the activity of microorganisms doing the work (figure 1).

Figure 1: The composting process.



Microbiology of composting

Composting is a process carried out primarily by microorganisms that decompose organic materials. The major groups of microorganisms that are active during composting are bacteria, actinomycetes, and fungi. Other organisms that complete the diversity of decomposers include nematodes, protozoa, and micro-arthropods. In the visible spectrum are earthworms, arthropods, larger nematodes, beetles, and other detritus eating insects. Each group is diverse, with many family members that function under a variety of environmental conditions. We refer to all of these organisms collectively as the "soil food web."

Compost typically contains large amounts of carbon-based materials. Fungi and actinomycetes help to break the complex chemical bonds releasing the nutrients necessary for other microorganisms such as bacterial to thrive. Their microfilaments transport nutrients across distances. Bacteria, actinomycetes, and fungi are able to access a larger surface area of organic material after other larger microorganisms have broken it into smaller particles.

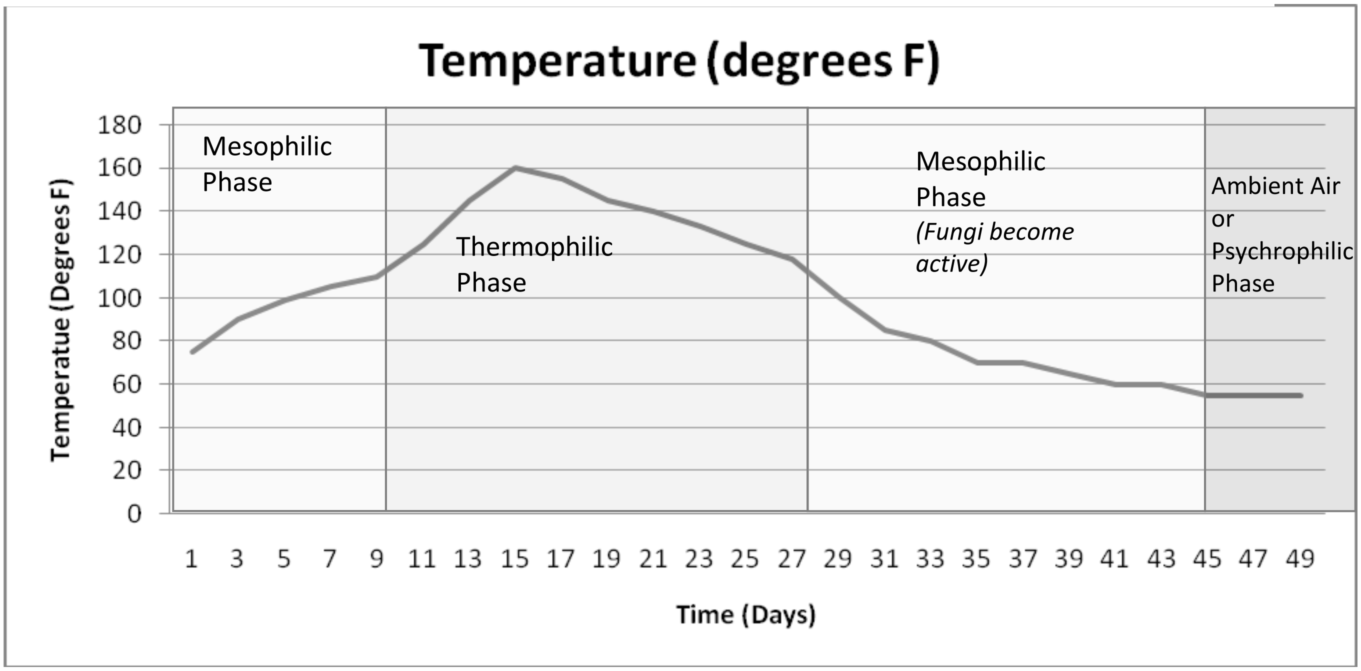
Bacteria groups are classified based on the temperature ranges in which they are active, shown in Table 1. These are divided into three groups: Psychrophilic bacteria that are active between 0°F - 55°F; Mesophilic bacteria that are active from 50°F -120°F (10 - 50°C), and the Thermophilic bacteria that are active from 110° - 160°F (45°- 70°C).

Table 1: Microbial Groups

Microbial Group	Description
Bacteria ***Psychrophilic*** ***Mesophilic*** ***Thermophilic***	Microscopic organisms that are very simplistic and can exist in a variety of forms and environmental conditions. Most numerous group of microbes active during composting and generally considered the fastest decomposer.
Actinomycetes	Similar in structure to fungi, but more closely related to bacteria. Primarily aerobic, more pronounced after easily degraded compounds are gone and when moisture and temperature is low. Generates the "earthy smell" that is familiar to healthy soil and compost.
Fungi (Molds)	Larger than bacteria and actinomycetes, more tolerant of low-moisture and low pH conditions, but less tolerant of low oxygen conditions. Decompose woody substances and other decay-resistant materials better than bacteria through breaking enzyme chemical bonds.

Temperature is one of the primary indicators of microbial activity. Figure 2 shows the typical temperature trend observed in a well managed compost windrow over the first 50 days of composting. Ranged in which the different classes of microbes thrive are indicated.

Figure 2: Idealized Temperature Profile of a Windrow Compost Pile



As shown above, bacteria flourish in the early stages of composting consuming the easily degraded materials. Bacteria will dominate composting as long as conditions are favorable. Fungi and actinomycetes become most active near the end of composting, feeding on materials that are more difficult to break down. Fungi gains advantage at low pH, while low-moisture favors both fungi and actinomycetes. Low oxygen reduces fungi populations and aerobic bacteria populations and increases anaerobic bacteria populations generating gasses that produce offensive odors.

Many chemical changes are occurring during the decomposition process. As sugars, starches, and proteins and other compounds are oxidized they produce heat, carbon dioxide, water and compounds that are resistant to further decomposition. Many of these are in the form of nutrients necessary for plant growth. Others are "glued" together by microbes to form organic chains and polymers such as Glycine and humic acid.

Table 2: Microbial Requirements

Requirement	Benefit to Microbes
Carbon (C)	Provides carbohydrates (energy) and builds microbial biomass
Nitrogen (N)	Provides proteins, nitrate, ammonia
Oxygen (O_2)	Respiration (aerobic microbes), facilitates metabolism
Moisture	Critical for promoting and maintaining activity
pH	Percent Hydrogen (H), optimal near neutrality (pH 7), normally finishes higher (pH 8).

Aerobic vs. anaerobic conditions

Composting will occur through aerobic decomposition if enough oxygen is present throughout the pile to support the reproduction of aerobic microorganisms. If the percent oxygen in part or all of the pile is insufficient, then the process will become anaerobic and an entirely different community of microbes will flourish taking over the process. Anaerobic microbes do not require oxygen to survive.

You can easily identify when your compost has gone anaerobic from the number of neighbors calling to complain about the smell.

Aerobic decomposition converts organic matter into carbon dioxide gas, water, and heat, while nitrogen complexes are converted into nitrates. This will smell like fresh soil or woodland. That is a byproduct of actinomycetes activity. Anaerobic decomposition converts organic matter into carbon dioxide gas, methane gas, various alcohols, and volatile fatty acids (VFA's). The nitrogen complexes are converted to ammonia (gas) and sulfur compounds are converted to hydrogen sulfide gas.

Compost piles can reduce by half in both weight and size within the first couple of weeks of decomposition.

To minimize odors, the composting process must be managed to promote aerobic decomposition, unless you are composting in-vessel. In-vessel is a compost method that will be discussed in later chapters. A septic tank is one example of in-vessel composting.

Each compound has its own unmistakable odor. For example, NH_4 based ammonia smells sharp like ammonia or fertilizer; sulfur smells like rotten eggs; and VFA's smell like "rotting garbage" or "dead animal." Aerobic composting can be accomplished by maintaining control of a variety of factors which affect the composting process. Specifics on how to control these factors are discussed in more detail in the chapter on operations.

As aerobic decomposition occurs, carbon is lost as CO_2 gas, and nitrogen tends to be conserved. The higher rate of carbon loss results in a decrease of C:N ratio of the mixture. The pH tends to rise to 8.0 to 8.5 and the volume of the composting material is reduced by 50 to 60%; while the weight is reduced by 40 to 80%.

Composting methods affect biology

A variety of methods are used for large scale composting (>100 yards) of organic materials. The most common and effective methods are heap and windrow composting, on which this guidebook focuses. In windrow composting a mixture of raw organic material is placed in elongated trapezoidal piles called windrows.

Finished compost curing in windrows

Windrows with dimensions relative to their contents aerate naturally by chimney effect or convection (figure 3): rising heat generated inside the pile draws in cooler air from the bottom and sides of the windrow. Turning windrows blends the composting materials, decreases particle size, releases CO2, and homogenizes ingredients to promote uniform decomposition increasing temperatures to help kill pathogens and weed seeds.

There are other effective large-scale composting methods such as passive systems, static pile systems, and in-vessel systems that will be discussed in more detail later in this guidebook. Smaller scale composting (i.e. backyard composting) rarely achieves high enough temperatures to effectively kill weed seeds and pathogens.

Figure 3: Schematic of the Chimney Effect

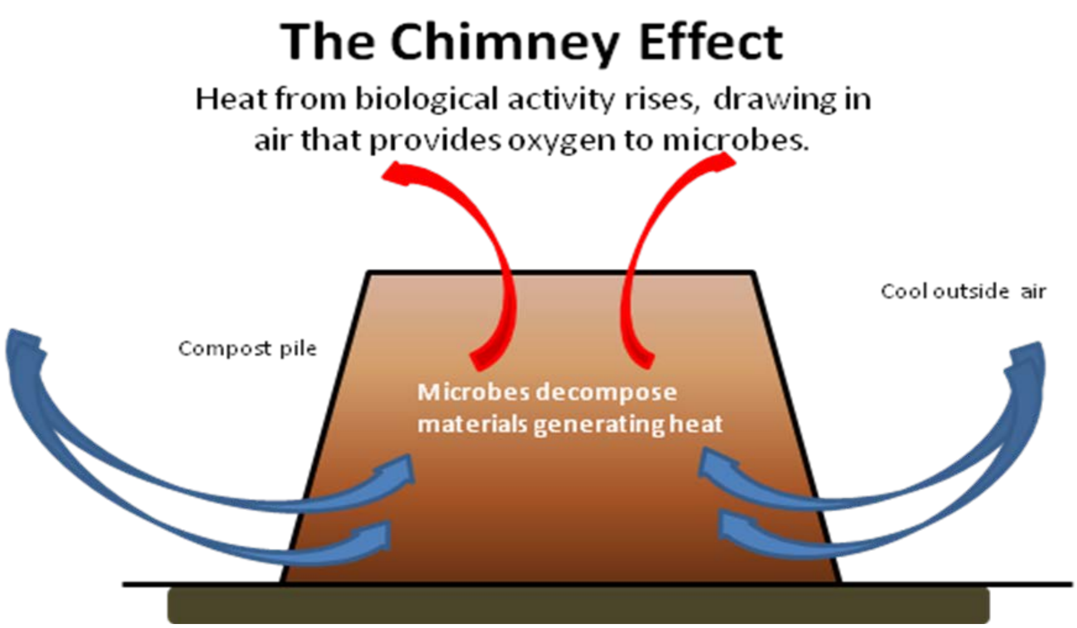


Table 4: Critical Factors Overview

Factor	Significance
C:N ratio (recipe)	A carbon to nitrogen (C:N) balance of 25:1 to 30:1 helps ensure rapid decomposition. C:N ratios below 20:1 tend to generate foul odors. C:N ratios above 40:1 increase composting times.
Moisture	The right balance nourishes microbial organisms. Target range is 50 – 60% by weight. Excess moisture tends to limit oxygen availability and can leach out.
Oxygen and carbon dioxide	Microorganisms need O_2 to oxidize carbon which is released as CO_2. The aerobes die, and the anaerobes flourish, resulting in offensive odors. O_2 concentrations in the compost air greater than 5% are recommended for rapid composting.
Temperature	Heat is the result of vigorous microbial activity. 110-140°F indicate an active pile. Most weed seeds and pathogens are killed at 145°F. Temperatures above 160°F effectively stop the composting process.
Time	The time to reach a stable compost is affected by C:N ratio, O_2 availability, moisture, particle size, mixing, and temperature.

3 Characterization and Collection of Organics

Now that you know the science behind composting this chapter moves you into collecting and handling your feedstock materials. You will also learn how to handle food wastes safely. Finally, you are presented with an overview of site management of these materials to help ensure the creation of a quality compost product with few problems.

Introduction

Leaves, grass, and brush are the organic components of the waste stream most often considered for composting. These and other organic materials such as food waste, wood waste, non-recyclable or soiled paper, and biosolids (waste water residuals or sludge) make up almost two-thirds of the waste that must be handled every day in every community. Managers who are interested in reducing and diverting as much material as possible from disposal must consider the characteristics of organic wastes and pursue cost-effective, technically and environmentally sound management.

Considerations

Volume: how much organic material is in the municipal waste stream?

Diversion potential: how much of that organic material can feasibly be composted?

Material characteristics: how do moisture, nutrient content, and particle size affect handling?

How much organic waste is there?

- ✓ The average household in Michigan generates yard clippings at the rate of 4.4 cubic yards per household per year, or about 1500 pounds annually. This amounts to between two and five paper bags per week (3-4 during peak grass growing season; 1-2 in mid-summer; and as many as 25 in a week in the late fall).

- ✓ Up to 60% of all yard clippings are grass and weeds generated in the growing season from May through September, but may only result in 30% of the total actually collected due to increasing mulching or “grasscycling” at the site of generation.
- ✓ Yard clippings are estimated to comprise between 18-25% of the residential waste stream; an additional 10-17% consists of other organics, such as food, wood, and soiled paper.
- ✓ Biosolids are generated at a rate that ranges from 100 to 150 dry pounds per capita annually.

Characteristics of Organic Materials

Management activities including source reduction, source separation, collection, preprocessing, and ultimately composting; final product uses are affected by the mix and volume of the materials composted. This table summarizes key material characteristics.

	Volume	Characteristics
Leaves	160 lbs/ household /yr *0.8 cubic yards, loose*	C:N ratio: 80:1 Moisture content: 10-50% Density: 150-700 lbs/cy High carbon & mineral content Composts alone, but slowly, with little odor
Grass	1,040 lbs/ household /yr *2.6 cubic yards, loose*	C:N ratio: 15:1 Percent moisture: 60-80% Density: 400-800 lbs/cy Decomposes quickly Good nitrogen source Strong potential for odor
Brush and Tree Trimmings	300 lbs/household/yr *1 cubic yard, loose*	C:N ratio: 200-500:1 Percent moisture: 40-50% Density:250-500 lbs/cy Very slow to break down
Food	255 lbs/household/year 1.64 tons/employee/yr (food service, markets) 0.71 tons/employee/yr (restaurants) 19.29 tons/employee/yr (food processors)	C:N ratio: variable, typical 15:1 Percent moisture: variable Density: 800-1000 lbs/cy
Biosolids	120 dry pounds/per capita/per year	C:N ratio: High nitrogen Percent moisture: variable Quality of sludge variable

Urban wood waste	300-5,000 lbs/employee/yr (manufacturers) *Generation rates vary tremendously depending on the type of manufacturing. Highest rates occur in the wood processing industry.*	C:N ratio: 300:1; high in lignin Percent moisture: 5-20% Density: 300-600 lbs/cy Slow to compost. Requires grinding to reduce particle size
Industrial sludge	Variable, depending on industry (paper mills, leather, pharmaceuticals)	C:N ratio: 6:1 Nutrient value can be high. Concern about contaminants varies by industry

Collection Options for Yard Clippings

An effective yard trimmings collection system includes many components, all of which must function smoothly together. The physical components of an effective collection system are the method used to set yard trimmings out at the curb (in bags or carts, or loose) and the type of collection vehicle. Equipment for processing yard trimmings after they arrive at their destination for composting must be planned in conjunction with collection equipment. Factors affecting equipment choices include the quantity, composition, and timing of yard trimmings generation, the structure and route allocation of the existing hauling infrastructure, and market specifications for the final compost product.

Key Collection Issues

- ♦ Degree of source separation (i.e., woody materials separated from soft materials such as grass, leaves, and garden trimmings).
- ♦ Type of container used, if any, affects collection vehicle choice as well as processing components.
- ♦ Reducing the number of trucks passing down each street for organics, recyclables, and trash. Co-collection systems are gaining attention as a method to increase efficiency while adding materials such as food scraps to the recovery stream.
- ♦ Managing a low odor operation within the confines of your site.

Once a service has been provided to residents, it is very difficult to repeal, or stop, no matter how costly to taxpayers. When designing collection programs for brush and other yard trimmings, it is advisable to start with minimal frequency and convenience, from which the community can later add or build additional services. For example, on-call brush collection is great for the resident, but costly to administer for a reasonable cost.

Key Collection Considerations	
Self-Haul to Drop-Off Site	• Limits collection costs • Quality control is a problem at unattended drop-off sites • Provides incentive to home compost • Negative impact on seniors, or physically challenged individuals

	• Some residents expect curbside service • Provides some level of services in sub-rural areas
Curbside Collection	• What material is set-out? • Is material loose or contained (i.e. bags, carts, mesh fabric)? • Which materials can be commingled?
Equipment Issues	• Labor (seasonal staffing, lifting, safety, etc.) • Automated trucks versus loaders versus vacuums • Impact of grasscycling and home yard care practices

	• Costs (capital and O&M) • Service availability from private sector
Funding	• Charge through taxes versus user-based, with bags, tags or subscription

Best Collection Practices

Best collection practices can be affected by time of year and how they are collected. Contracting with a city for their leaf collection using vacuum trucks for municipal leaf collections is both cost effective and practical. However, not all residents may be able to get their leaves raked to the curbside in a timely fashion, so multiple passes may be required.

Leaves	❖ Collect source separated; Fall 6-8 weeks; Spring 1-2 weeks Loose → vacuum truck or loader Carts → Automated packer truck Paper bagged → Packer truck
Grass Clippings	❖ Collect at curb source separated, April – September, or provide drop-off site ❖ Carts or paper bags → Packer truck ❖ *No plastic bags!* ❖ Encourage on-site handling by generator through pricing, education incentives ❖
Brush and Tree Trimmings	❖ Curb chip ❖ Bulk collect
Food	❖ Collection from commercial sector e.g. restaurants, produce markets, grocers in curb carts or wet-strength compostable bags ❖ Food processing waste composted or transported to farmers for feed.
Waste wood	❖ Separate collection at C&D sites ❖ Source-separated collection from businesses and contractors (pallets, clean dimensional wood, other)

Material separation

The three primary residential yard trimmings materials (leaves, grass, brush) may be completely segregated for curbside set-out, or commingled. Alternatively, two of the materials (typically grass and leaves) may be mixed, with brush segregated. The level of separate collection of materials is dependent on key factors including:

1. The seasonality of generation of the respective materials,
2. Available equipment to mix or grind material
3. Compost market specifications, and
4. Potential end use.

In locations where leaf drop is substantial in the fall, a separate collection of leaves is very common.

Segregation of woody materials from soft, wet materials generally increases processing efficiency. However, commingling is generally easier for residents, thereby increasing participation while reducing the costs for educating residents on proper set-out methods. Commingling materials also requires fewer specialized collection vehicles, thereby reducing capital and labor costs.

Segregation of brush by residents is necessary where curbside chipping is the handling method for woody waste. This benefits site processing by eliminating the need to grind soft materials along with woody materials due to commingling.

Commingled materials

Under a commingled materials collection program, grass clippings, leaves, brush and other woody items such as vines, are placed in a single container, bag or pile.

Advantages	Disadvantages
• Convenience = high participation • One collection truck can be used • Carts and automated loading mechanism can be used • Potentially, less collection labor is required than for separated materials • Lower overall cost of collection	• Where plastic bags are used for collection, extra labor is required to debag • If higher product grades are required, brush separation may be required • Commingled “hard” & “soft” wastes must all be ground at processing site • Equipment to separate brush from leaves/grass at the site can be purchased

Separated materials

Under this system, brush and wood are set out separately from leaves and grass. Brush and wood can be piled loose, placed in bags or bins, or bundled with twine. Brush collection can typically occur less frequently (quarterly, monthly) while grass collection would require weekly service to avoid odor problems.

Grass clippings and leaves can be commingled (although they occur mostly in different season, with some spring and fall overlap), while wood wastes are generally bundled separately for chipping or collecting in bulk.

Advantages	Disadvantages
• Increased processing efficiency • Reduced site processing costs • Faster decomposition of soft-only wastes • Pruning practices are substantially different from mowing practices • At the processing site, wood chips can be added as needed to balance C:N	• Increases promotion and education costs • Requires specialized trucks (e.g., compartmentalized) or 2 trucks or chipper • Potentially more collection labor than for a commingled method • May require separate collection routes for trucks

Loose material collection

The greatest advantage of collecting loose yard trimmings, leaves simply raked to the curb, is the avoidance of purchasing any containers. Also, plastic bag fragments, if used in the collection process, a are avoided in the finished compost.

Advantages	Disadvantages
• Convenient – conducive to participation • Amount of material set-out is unrestricted • Contaminants are more visible • No container costs • No bags to remove in processing	• Potentially greater contamination than for contained material • Requires specialized equipment to move materials from curb to truck • Wet material is difficult to handle, and may cause odors; materials may clog street drains • Material in street is litter-prone through disruption by traffic, rain and wind • Street sweepings may impact the quality of the end product.

Contained material collection

Some communities allow residents to place yard trimmings at the curb in *any* labeled container. A second option is to designate a specific type of container. Containers include paper bags, reusable mesh bags, cans, carts, and semi-automatic carts.

Advantages	Disadvantages
• Less equipment and potentially less labor than for loose material • Potentially less contamination than for loose material • Material is not litter-prone or problematic for traffic, parking, sewers • Promotes participation	• Initial capital costs for containers may be high • May require specialized trucks (automated or semi-automated lifters) • Amount of material set-out may be limited to container capacity • May require more residential storage space • May need separate leaf collection program to handle the large volume of leaves in the fall

Plastic bags

The use of plastic bags for yard trimmings pick-up is no longer a popular option because of the anaerobic odor that develops in the bags during the collection and because of the plastic fragments that remain in the finished compost. Plastic bags were initially used by some communities because little behavior change was required of residents and because plastic bags are cheaper than paper. However, the problems created by the use of plastic bags, even compostable plastic bags often outweigh their benefit.

Non-compostable plastic bags	
Advantages	Disadvantages
• Lowest cost among bag options • Residents are familiar with this container (i.e. the standard household garbage bag) • Availability (i.e., special purchase and distribution of bags are not required)	• Private sector operating costs are passed along to generator in the form of higher tip fees. Site closure is often threatened due to odors. • Added processing costs from acceptance of plastic bags (including *compostable*) are initial debagging, control of blowing plastic bits, and removal of plastic contaminants from final product • Cost effective debagging systems have not been demonstrated; laborers for manual debagging are nearly impossible to find and keep • Once separated from the yard trimmings and compost, plastic bags must be disposed of at an additional cost • Plastic fragments in compost reduce quality and marketability
Compostable plastic bags	
• Lower cost than paper or mesh bags • Possible degradation of the bags which, if true, would eliminate plastic fragments in the finished compost	• Impedes processing operations unless effort is made to remove the contents • Plastic fragments in compost reduce quality and marketability • Little data on the environmental effects – including the effects on compost – of degradation products • May have reduced strength when wet • Breakdown does not occur in composting time frame, or with some bags, may break down too quickly (i.e. before collection at the curb) • Odor remains an issue if materials are in bag for too long

Paper "kraft" yard waste collection bags decompose completely.

Paper bags

Biodegradable paper "kraft" bags are an increasingly popular method of containing yard trimmings material for collection. In many municipal programs, these bags are sold in local retail stores at a price that covers the cost of the bag, or the bag plus the costs of collecting and composting. The ability of the paper bag to decompose along with the bag contents is its most obvious advantage. One disadvantage is the higher price per bag versus traditional plastic (25¢-

39¢ per bag, bulk pricing for paper versus 9¢/bag for plastic), but an advantage is the lower price per bag versus a compostable plastic bag ($1 per bag).

Advantages	Disadvantages
• Less expensive than compostable plastic bags • Bag can be shredded by windrow turners along with contents reducing pre-processing costs • Allows airflow during collection process, preventing pre-composting odors • Most models stand upright, making loading easier • Less potential for puncture or tear than plastic • May hold more material than plastic, which tears more easily	• More expensive than traditional plastic bags • Heavier than plastic bags • May lose strength under prolonged wet conditions, making handling difficult • Non-degradable items (such as glass bottles, bricks, cans) cannot be seen through the paper

Carts and bins

Advantages	Disadvantages
• Fewer vehicles and workers required for collection • Carts are durable • Easy for residents to load and transport to curb • Eliminates problems with plastic bags which can in turn lower tip fee costs and processing site • Sticker system can be used to allow homeowners to use their own container (supplemental kraft bags could also be used)	• Initial investment is high if municipality or hauler provide carts • Automated tipping equipment may be needed for curb carts and possibly bins • Smaller bins have limited capacity, especially for fall leaves

Collection Equipment Options

Different methods of material set-out require different types of collection equipment. For material that is set-out loose in the street, equipment is needed for gathering the material and loading it into a transport vehicle. Contained material may be loaded directly into a transport truck, such as an existing garbage truck, or a truck with an automated loading mechanism.

Some collection vehicles may be specifically designed for handling particular materials. For example, leaf vacuum trucks are often used to collect leaves from the streets in fall. Mobile chipping units are used to handle tree trimmings and other wood wastes.

Following is a summary list of the various types of equipment used for the collection of yard trimmings.

General gathering	Material-specific	Transport
• Front-end loader • Mechanical claw truck	• Leaf vacuum truck • Mobile chipping unit for wood waste	• Dump truck • Rear-loading packer truck • Semi-automated rear-loading truck • Automated or semi-automated side-loading truck

Loose material is typically set in the street for collection. If the material is a mix of yard trimmings types, a front-end loader or mechanical claw truck may be required to load the material into a transport truck. Loose material such as brush may be set on the curb, in which case it would be handled separately from material set in the street (e.g., leaves and grass).

Material contained in bags can generally be manually loaded into packer trucks, but carts are commonly too large for manual loading. Semi-automated rear-loading trucks or fully automated side-loading trucks are required to handle carts with capacities typically need for yard trimmings collection (i.e., 60 or more gallons).

General Gathering Equipment

Front-end loader

For efficient yard trimmings collection, the front-end loader is usually adapted with an oversized bucket (i.e., greater than 4.5 cubic yards). It is particularly efficient for collecting leaves where leaf fall is heavy. This type of operation typically involves one loader operator, one or two laborers as rakers, and two or more dump trucks for transport.

Advantages	Disadvantages
• Efficient for collection of leaves • May utilize existing municipal equipment	• Relatively time consuming • Potentially high contamination • Dump trucks may fill fast because leaves are not compacted • Not as thorough as vacuum truck for leaf collection

Front-end loader with a bucket is an efficient tool.

Mechanical claw truck

The claw is a pincer loading bucket attached to the front-end lift assembly of a tractor. It is used for grabbing loose yard trimmings in the street. As with the conventional front-end loader, material is hoisted into a transport vehicle–commonly a rear packer or dump truck.

Advantages	Disadvantages
• Efficient for loose material collection – either leaves or only mixed yard trimmings materials • More adaptability to different materials and conditions than conventional front-end loader • Material is compacted to some extent, saving space in the transport vehicle	• As with front-end loader, relatively time-consuming • Potential contamination from street debris • Can interfere with street parking during collection season

Material-Specific Equipment

Leaf vacuum trucks

Vacuum trucks are often used to clean gutters and storm drains. They also efficiently collect leaves that are set-out loose on the street. They work by sucking leaves into a shredder, then blowing them into a transport vehicle. In some cases, leaves are also compacted.

Advantages	Disadvantages
• Thorough collection of material • Faster than front-end loaders when leaves are dry • Leaves can be compacted	• High operating and maintenance costs • Potentially high contamination • Relatively slow operation • Does not perform well with wet leaves • Requires several laborers

Leaf loader

A newer type of collection attachment called a leaf loader is pulled along behind a truck, and picks up leaves with a five-foot-wide sweeper. Like vacuums, it reduces leaf volume through some shredding.

Advantages	Disadvantages
• Labor costs are less than a vacuum system • Shreds leaves as it loads • Can be towed in a variety of positions • Creates less leaf dust; eliminates need for special box on truck	• Must be used on curbed-street • Potential for high contamination

Mobile chipper

Mobile chipping units are typically used by public works crews and private firms involved in tree trimming. They are also useful for collection of special materials (e.g., Christmas trees).

Advantages	Disadvantages
• Efficient for collection of woody materials that may be difficult to handle using other methods • Useful for Christmas tree collection • Processes material at the point of collection • Chips may be marketed as mulch	• Extremely time consuming when used as a regular collection method • High labor, operation and maintenance costs • High potential for operator injury

Transport Equipment

Dump truck

This utility truck is typically part of municipal service vehicle fleets. It can serve many functions, including the transport of yard trimmings gathered by front loaders or claw trucks.

Advantages	Disadvantages
• Relatively low cost transport vehicle option • Useful for receiving loose material gathered with either the front-end loader or the claw • May be used for collection of material contained in bags • Commonly part of existing municipal fleet of service vehicles; cost of vehicle may be shared with other public works	• Does not compact material and has relatively low capacity, so transport is relatively inefficient and costly due to labor involved • Must be covered to prevent blowing material back onto street

Rear-loading packer truck

This truck is commonly used to collect garbage, and generally ranges from 16 to 25 cubic yard capacity. It is also efficient for collecting yard trimmings materials in bags, largely because it compacts the material.

Advantages	Disadvantages
• Efficient for a system that uses bags for set-out material • May be used as transport vehicle in collection system involving collection of loose material with front-end loader or claw truck • Compaction minimizes transport costs • May take advantage of existing equipment such as garbage collection vehicles	• Not necessarily workable as a transport vehicle in a loose material collection system • May be impractical where carts are used for set-out because of the difficulty in hoisting large carts into packer

Semi-automated rear-loading truck

With this truck, an operator positions a cart for a lifting mechanism (e.g., a bar lift) to hoist into a hopper at the rear (with some models, on the side) of the truck. The operation may require a crew of two, one to drive the truck, the other to handle the container. Alternatively, one operator can perform the entire operation, but at a slower rate.

Advantages	Disadvantages
• Initial capital cost is substantial • Efficient collection of material contained in carts • Fewer trucks and workers required compared to rear-loading/bag system • Reduces potential for operator injury	• Time-consuming relative to fully-automated side-loader • More maintenance than for non-automated vehicles

Automated side-loader

This truck has a fully automated loading mechanism. The mechanism grabs a container and hoists above a hopper into which the material is dropped for compaction. The operator can stay in the cab throughout the process.

Advantages	Disadvantages
• Efficient collection of materials contained in carts • Fewer trucks and workers required than for rear-loading/bag system • Less labor required than for semi-automated rear-loader • Reduces potential for operator injury	• Most expensive option • More maintenance than for non-automated vehicles

Use of Transfer Stations for Longer Distance Hauling to Processor

To reduce local collection costs and processing fees, some communities have opted to designate a transfer station for yard trimmings. This allows the smaller volume vehicle to travel a short distance to empty loads and go back to curb collection. Then up to 100 cubic yards of compacted material can be hauled by one driver to the composting facility. Remote facilities may have lower tipping fees due to being located in sparsely populated areas.

Photo: A Syracuse University Physical Plant truck dumps 4.45 tons of food waste on May 6, 2010 at the Onondaga County Resource Recovery Agency (OCRRA) Amboy Compost Site in Camillus.
http://greenuniversecity.syr.edu/UniversityFoodServices.htm

Food Waste

This section focuses on composting food waste or, more specifically, adding food waste to an already successful yard waste composting operation. Concepts covered include: assessing needed capacity; capabilities and the potential cost of adding food waste to operations; maintaining low odor operations; and characterizing, collecting and processing food waste. Practical tips are provided to achieve the best return on processing food waste.

Introduction

Adding food waste to a composting operation is an excellent way to increase the volume and nutrient quality of the end product. As such, it may also increase your customer base, contributing positively to the bottom line. However, the added expense of additional processing and the higher potential for odor incidents may prevent one from taking that step.

Food waste comprises the single largest component of the waste stream by weight. Nationally we throw away more than one-quarter of all prepared food, approximately 96 billion pounds each year. Food waste includes preparation waste and scraps, as well as uneaten food from households, commercial, institutions (i.e. school cafeterias), and industrial sources such as food processors. According to the MRC's Recycling Measurement Project Report of 2001, organic waste made up approximately 29% of Michigan's municipal waste stream in 1999 with 163 compost sites managing only about 10% of that waste.

Characterizing Food Waste

Food waste differs from yard waste in that it is generally characterized as a highly putrescent, rapidly degradable feedstock with a high moisture content and bulk density. A California case study characterized food waste as generally composed of 71% fruit and vegetable waste, 26% bread and starch waste, and 3% other items.

Adding food waste to existing composting operations increases the volume and quality of the end product.

Compostable Food Material

Food waste that can be composted includes, but is not limited to:

- trim from fruits and vegetables, spoiled fruits and vegetables, salads
- day old breads and pastries, excess batter, spoiled bakery products
- dairy products - cheese, yogurt, ice cream, and miscellaneous by-products
- floral waste and trimmings, plants
- leftover food that cannot be served again
- frozen foods
- coffee grounds and filters
- tea bags
- egg shells and cartons
- seafood (including shells)
- consumable liquids (beer, wine, liquor, juices, soda, vinegar, etc.)
- meat processing by-products
- plate scrapings and leftovers, post-consumer food waste

The potential of food waste to produce liquid leachate, combined with its low carbon-to-nitrogen ratio relative to ideal composting conditions, demands that food waste be collected and processed in a timely and efficient manner.

Pre-consumer food waste -- or the vegetative scraps resulting from food production -- is easily separated from packaging and service waste; thus, it usually does not present the contamination issues that post-consumer food waste capture does. Newcomers to food waste utilization often initiate a program with pre-consumer food waste, leading to a higher rate of program success.

Post-consumer or uneaten food waste is often contaminated with paper, metal, glass, and/or plastic food packaging, which complicates the composting process and decreases the value of the resulting compost. However, these problems can be resolved successfully, as demonstrated below.

The inclusion of soiled paper products in food waste composting is common, and may solve a variety of composting and recycling challenges. Paper adds a necessary carbon source to the composting mix, and will absorb much excess moisture.

Most paper products can be safely and beneficially used as a composting feedstock when the paper or cardboard is soiled or wax-coated, or where markets for traditional paper recycling are not available or economical. Composting economics and diversion from disposal are improved by including non-recyclable and soiled paper with the food scraps. Keep in mind that all paper categories contain very low levels of potential contaminants, though in most cases these levels are below those found in yard trimmings and background soil levels.

Compostable paper waste mixed with food waste.

Paper will absorb liquid inside collection containers, reducing spills and seepage from compactors and collection trucks. In the compost pile paper acts as a bulking agent, improving aeration and reducing compaction. Waxed-coated corrugated cardboard and paperboard is abundant in the food preparation industry, and cannot be recycled through common paper recycling channels. Composting wax-coated cardboard is, therefore, an attractive option for both generators and composters, though it may require specialized equipment to shred the cardboard to reduce particle size.

Non-Vegetative Food Waste

Food waste, especially post-consumer waste, may contain meat, dairy, grease, fats, oils and other non-vegetative organics, some of which are prohibited by composting facilities. Although they are organic and degradable, they break down slowly and composting them requires more time, care and supervision because they can contain more pathogens than other compostable items and may attract animals and insects. Local renderers or meat processing by-product specific composters may be a good option for managing significant or concentrated quantities of animal by-products.

Compost operations utilizing meat processing by-products and/or animal bedding can be successfully managed through a variety of techniques, such as utilizing a concrete pad and bunkers or in-vessel composting units with full containment of leachate and run-off, also employing adequate cover for odor control (i.e.: sawdust, woodchips or leaves). Alternatively, another option for non-vegetative organics is anaerobic digestion for methane recovery.

Working with Generators

Conducting a waste audit is important to the success of any waste reduction program; knowing how much food waste is generated by the operation on a daily basis is the key to designing an effective management system. A waste audit is likely to reveal that the heaviest component of most waste streams in grocery stores, restaurants and cafeterias is food waste, and the greatest volume component of that same waste stream is cardboard.

According to the EPA, the organic waste in supermarkets makes up 75-90% of the entire waste stream, and in schools and restaurants 74%. A study compiled by Draper and Lennon Associates estimated the following generation rates: schools 0.35 lbs/meal; health care 0.6 lbs/meal; prisons 1 lb/inmate/day, conferences 0.6 lbs/meal and supermarkets 3,000 lbs/employee/year.

U.S. supermarkets solid waste streams are 75 – 90% organic waste.

Normally, collection costs are billed by the cubic yard (a volume measurement); therefore, food waste measurements must be converted. Volume-to-weight conversions for food waste vary considerably, depending on the type of food and its moisture content. If trash collected is measured and billed by weight, a standard container filled with representative samples of the institution's food waste should be filled then weighed for an approximate conversion between volume and weight.

Standard container sizes and their volume capacity include (202 gallons = 1 cubic yard):
5-gallon container - .025 cubic yards

32-gallon container - .16 cubic yards

64-gallon container - .32 cubic yards

96-gallon container - .48 cubic yards

To avoid odor and health and safety concerns, inform your local health department of your program to eliminate misinformation. Educating employees that would be responsible for separation and management of food waste for utilization is a key component to a successful program.

Food scraps are separated from other wastes at the source of generation -- for example, in food preparation areas -- then collected frequently and routinely. Kitchen and wait staff, and possibly customers (if plate scrapings are collected) must be taught to separate acceptable materials for composting. The selection of food waste collection containers should be coordinated with the waste hauler.

What eventually determines whether a business undertakes a food waste diversion program is if the benefits outweigh the cost. To help make that determination, the following five factors need to be considered.

1. Waste Management Costs

Diverting food waste to a composting program requires a separate collection and transportation system, one that operates in parallel with a waste management system. Remaining trash will continue to go to the landfill, while food waste will go to a compost site. As food waste is removed from the landfill waste stream, the need for frequent trash pickup is reduced, as may be the need for a large trash holding container. Like landfills, compost operations charge a tip fee, but usually at a rate equal to or lower than landfills.

Another consideration is the seasonality of composting sites. Some municipal programs cease collection of residential and downtown yard waste during the winter months, so working with residents to give them home-based alternatives for food waste management during the winter months becomes important. For commercial and institutional establishments, finding a hauler that can continue collection year round so that kitchen staff operations remain constant is key to a successful program.

Accommodating changes to your current waste handling system means renegotiating the contract with your current waste hauler or finding a new waste hauler that can provide the variety of services you now require. Understanding your service needs will allow you to design a program that works.

In order to make an informed decision regarding services, it is important to become familiar with the waste management facilities and associated management costs in your vicinity.

2. Food Waste Separation and Collection

In general, pre-consumer food scraps are more easily collected and composted because it is fairly simple to train food preparation employees to properly separate compostable food scraps from other non-organic waste. Post-consumer food waste diversion will require regular monitoring by trained staff, as well as training of consumers to reduce the level of contamination in collected food waste, which can decrease the value of the food waste to compost operators. Up-front involvement with your procurement department and suppliers to provide only compostable products will ease the post-consumer food scrap contamination concerns, as would switching to reusable trays, plates and silverware. But, the costs and benefits of these types of operational program changes need to be considered and you need to check with your composter to make sure the compostable products are acceptable in their operation (i.e. may require the feedstock to be shred prior to composting).

Keeping things simple at first allows one to establish a successful collection system more easily. Continuous employee education, getting employees to "buy into the system," and monitoring will help, as will color coded bins and appropriate labeling and signage. Once employees are trained, minimal extra time is required to separate materials as it becomes part of the normal daily routine.

It's important to know how much food waste is generated by the operation on a daily basis. A way to estimate the amount of waste generated is to measure all of the scraps produced in each area during a typical operation day or week, and then project this amount over time. For example, if you have several stores or cafeterias measure one typical container of food scraps and then multiply this amount by the number of containers collected. Of course, make sure that employees are informed, and that containers contain food scraps only.

3. Storage and Collection Containers

The selection of outside collection containers should be coordinated with the food waste hauler. (In some cases, the hauler may provide these.) Existing containers can simply be re-labeled, or it may be determined that the number or size of containers needs to be changed. Collection containers will require regular cleaning even if food waste is contained in bags.

The collection system is critical to a food waste utilization program. The system for separating food waste at the source and transporting the materials to a vehicle collection point should be as simple and convenient as possible.

The primary objectives of the collection system are to:

- Maximize the capture rate of food waste
- Eliminate non-organic contaminants such as plastic wraps, rubber bands, glass, and metal
- Minimize labor and space requirements.

Collection bins should be placed in a convenient area for staff and/or customers to use. Due to the high moisture content of food scraps, containers should be a reasonable size for employees to lift and load into a central collection container or on-site composter. Containers should only be filled to 2/3 capacity to reduce spillage.

Whether collected in buckets or small, biodegradable bags, the collections will be accumulated in a larger, centralized tote or small dumpster. If possible, combining food waste with yard clippings and leaves in a cart or dumpster will reduce potential odor and leakage concerns. Haulers can pick-up the food waste in bulk, using roll-off containers, compactors, or specialized vehicles for high volume generators; or they can dump full 32-64 gallon totes and dumpsters from small generators with automated collection vehicles.

Containers collecting food waste will require regular cleaning. One collection option is for the hauler to swap clean empty totes with full totes; this means that totes will be tipped and cleaned at the composting site. The totes can be used by generators at workstations to collect materials, and then be rolled to a pick-up area when full. These totes must be rinsed out and cleaned frequently.

It is important to ensure that the hauling vehicle is equipped with leak-proof seals and seams that are inspected often. Food waste that is collected in biodegradable and compostable bags may reduce the frequency of cleaning collection containers.

The cost to change the number or size of outside and inside collection containers is usually a one-time expense; simply add as few containers as possible when beginning. Clearly marked and brightly colored containers -- such as green for food, blue for recyclables, and brown for trash -- are helpful for proper participation and reducing contamination.

4. Collection Frequency

Just as trash hauling needs to be prompt and reliable in order to avoid health and safety problems, so too does food waste hauling. Some institutional generators of food waste have found it easier and more economical to transport collected food waste themselves. Others contract with private waste haulers to collect and deliver the materials to a composting site.

The collection of food waste should occur frequently, and upon arrival at the composting site, the material should be immediately mixed and incorporated with the other materials on site.

Collection and hauling schedules and routines are dependent upon the amount of food waste collected at the site of generation. Changes in collection frequency necessary to manage food waste will result in fluctuations in “disposal” costs. Once a successful pattern is established, fluctuations will give way to a predictable new reality.

5. Other Considerations

Worker Training

There are minor costs associated with training workers to separate compostable food waste. While a few compost site operators provide this service, many do not. Be sure to figure training time into your cost/benefit estimates. If the business decides to take on post-consumer food waste utilization, training may have to include consumers and will require more rigorous oversight overall.

Employee and worker training requires oversight and continuous training of new employees.

A common practice in food service businesses is to put food waste into the garbage disposal, which then sends the organics into the sewage system. While this may be acceptable in some areas of the country or in biological-based sewage treatment plants or plants that have anaerobic digestion system that need the high biological oxygen demand (BOD) to break down the phosphorus, it is a growing concern.

Reducing the discharge that goes into a garbage disposal by diverting that material for composting is likely to save water costs, save possible BOD and TSS (total suspended solids) surcharges, and avert potential restrictions on disposal into the sewage system. Check with the local sewage treatment plant to find out whether the BOD levels resulting from using garbage disposals is needed in the treatment process, before deciding on the best organic management practice for your area.

Household Organics Collection

Many communities and private businesses around Michigan already provide for the curbside collection of yard waste, grass, leaves and brush. Adding household organics to that service is relatively easy. Including food waste with yard waste collection makes for a less messy, less wet transfer process than collecting food waste on its own.

The overall volume of organics to be processed will increase, as may the need for blending before piling. But the primary challenge for the curbside collection of other household organics is education. Helping householders understand the composting process and in some cases providing the necessary collection containers will make curbside collection of food waste a viable community option.

Working with Haulers

While transporting food waste to an off-site composting operation may be the simplest solution for most commercial enterprises, finding a hauler with the interest, ability and commitment is often the weakest link in the chain of food waste composting. The unique properties of separated food waste require specialized handling to maintain a contaminant-free and manageable material. Regular and more frequent collection will keep odors and pests to a minimum. Food waste hauling, however, also offers new opportunities to increase and expand a collection business.

Hauling Food Waste Efficiently

Waste haulers maximize their profit by optimizing vehicle capacity and collection frequency. If the vehicle is too small, excessive transportation costs may result from traveling to the compost facility too often. Conversely, small loads in a large vehicle may not warrant use of the equipment. The goal for the waste hauler is to match food waste generation with collection frequency and the appropriately-sized vehicle.

The type of collection vehicle can vary from front- or rear-load compacting trucks for dumpsters, automated side-loader for totes, sometimes split compartments if co-collected with recyclables or trash, or even trucks equipped with continuous feed mobile mixing units.

Generators may be required to produce a minimum amount of food waste in order to participate in a collection program to maximize collection efficiencies. When done properly, problems are prevented and transportation costs are kept to a minimum.

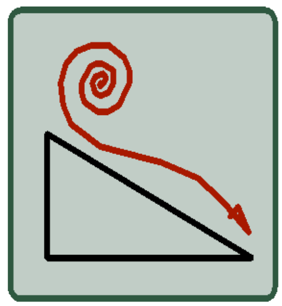
Restaurants, grocery stores, and cafeterias in close geographic proximity might consider entering into a cooperative agreement with a waste hauler to assure the success of a food waste collection program. Separating food waste for utilization from other types of waste headed for the landfill means that waste management costs are diversified. Haulers are taking waste to the landfill, and the generator is paying for transportation and landfill tipping fees. Hauling separated food waste to a composting operation means that generators will pay for transportation and compost tipping fees. Traditional waste disposal fees will be offset by the diversion of food waste to a composting operation. Often the cost to compost is less than the cost to landfill, but this depends on the facilities, services and tip fees available in your area.

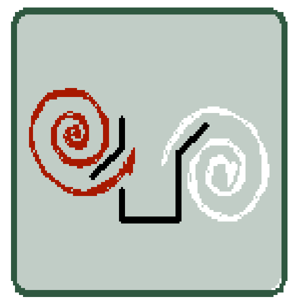
Change in waste disposal and hauling services typically requires a change in service contracts. Likewise, the change in waste management and collection routines may necessitate contract negotiation between the parties involved, as well as education of the employees.

Compost operators should also consider other transportation options. Allowing generators to haul their own food waste to the operation might reduce costs and simplify the process. Compost operators may want to consider adding food waste hauling services to a composting operation, if the proximity to the organic source is economically feasible.

Best Management Practices for Composting

Part 2:
Site Design & Operations





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4 Facility Siting and Site Design

Introduction

The rapidly growing popularity of composting as a low-cost, community-based solid waste management technique can strain the existing compost infrastructure. These overburdened facilities are susceptible to odor production and excessive processing costs that can lead to program failure.

These challenges tend to feed off of one another. Odor problems lead to increased processing costs, which in turn increase the need to process greater quantities of yard waste in order to generate higher revenues. The cycle can continue until the facility becomes legally or economically infeasible to operate. The cycle can be broken, however, because both of these failures can be prevented in large part through the application of good basic site design principles.

This portion of the Compost Operator Training manual describes best management practices for site-related issues associated with intensive windrow composting, where the entire site must be accessed more than three to five times weekly.

Site Planning

A compost site must provide sufficient area and conditions for all-weather composting while limiting environmental risk, odor, and noise. Site development involves creating a plan for finding an acceptable location, adapting the composting method to the site (or vice versa), providing sufficient land area for operations, and implementing surface runoff and pollution control measures as needed.

To help understand geographic and other impacts on site planning, operators should make a preliminary sketch of the facility showing all key areas and factors which will affect operations, including:

- prevailing wind direction
- traffic flow patterns
- land slope
- runoff patterns
- surrounding land uses
- wetlands or water bodies
- activity configuration (materials handling and processing)

Permitting & Regulation

Before beginning the planning process, it's important to understand local and state regulatory requirements including permit applications that may affect the site operation. Also be aware that starting a composting facility will raise concerns among neighbors and local public officials. Educating these groups about composting and its advantages will be a critical part of getting started smoothly.

Michigan PA 451, Part 115 (formerly P.A. 641) governs the composting of non-exempt organic waste materials (exempt materials include leaves, grass clippings, garden waste, and brush/wood chips and up to 5% by volume Class 1 organics such as food scraps, paper, food processing residual). Many local units of government require compost sites to adhere to specific zoning and land use regulations that regulate where composting can take place. All building requirements, surface and ground water regulations, and federally based NPDES requirements should also be investigated. The DEQ's Water Resource Division has created a compliance assistance document entitled "Compost Wastewater & Storm Water Permit Information - Compliance Assistance for Yard Clippings Composting Facilities". This document describes the applicable permits related to wastewater and storm water discharges from compost facilities. The document can be found at www.michigan.gov/deqstormwater (select Industrial Program, then under Storm Water Program Compliance Assistance select Compost Operations Compliance Assistance.)

NOTE: SEE APPENDIX AT THE END OF THE CHAPTER FOR AN OVERVIEW OF CURRENT STATE LAWS ABOUT REGISTERING YOUR COMPOST FACILITY, AND STATE OPERATION REGULATIONS.

This training manual focuses on large scale yard clippings composting with the option to add up to 5% by volume 'other' (Class 1 according to the MDNRE) organics. When planning to compost more than 5% by volume Class 1 organics (food scraps, paper, food processing residuals, etc.), an enclosed in-vessel system or outdoor operation that has a lined pad or groundwater discharge permit is required to control all water runoff and groundwater.

Odor and Site Design

Factors that affect odor

Many factors affect the potential for odor buildup during production at a compost facility, including: economics, site location, weather, community and markets. These must be balanced with care in order to develop a successful composting facility with adequate equipment, personnel as needed, and a system to move product out the door.

A successful compost site design balances the conflicting needs of cost versus quality.

Budgets frequently dictate that yard waste be managed using relatively low-tech windrow type management techniques. Yard waste generation patterns often require that composting be carried out amidst dense populations to reduce transportation costs. However, large parcels of land are difficult to find and costly in suburban communities where yard and garden clippings generation is at it's highest. These sites can be too small with little room to expand because of proximity to neighbors. Increasing the quantity of incoming materials makes these sites more crowded and inefficient. . And, proximity to neighbors requires high operational standards to avoid problem-causing odors and traffic issues. Resolving these conflicts is key to acquiring and developing a compost site that successfully balances the conflicting needs of cost versus quality.

A variety of odors, particularly those caused by anaerobic conditions, are attributable to the pressures caused by the need to intensively process high volumes of organic yard waste material at inappropriately sized sites. Physical topography such as puddles, mud, and acidic conditions also contribute to the development of anaerobic processes but are preventable with good engineering and site design.

The relationship of odor to site design

Odor minimization is a major objective of facility siting and design. Successful site design isn't conceptually difficult; it simply requires the control of water and runoff on the operating surface of the facility.

While good site design alone cannot ensure that operations will produce few odors, poor site design is almost certain to cause odor during production at all but the lowest volume sites. Site design should be the first component employed to minimize the opportunity for odor production.

The existing moisture content of a composting mass, rainwater inputs, and runoff are all important factors that must be actively managed. The operating surface must be prepared in a manner that limits the amount of water that is held on the pad. This includes grading, sloping and hardening of the pad surface. It is important that water drains quickly, leaving the pad strong enough to support heavy equipment despite several days of rain. Runoff water, either from the composting process or from rainfall, must be conveyed away from the operating surface and/or accumulated in a retention pond before reusing for irrigation or releasing off-site. The use of vegetated bio-swales assists in filtering the runoff water before it enters a detention or retention pond.

Anaerobic conditions

If compost piles are located in standing water for even short periods of time, air spaces within the pile will be replaced with water. Recall that when water replaces air in compost piles, there is no oxygen for respiration and aerobic microbes cannot survive. Anaerobic processes can be caused by water in piles, compaction or small particles, where aerobic microbes are replaced with anaerobic ones. Composting still occurs, however, anaerobic respiration produces offensive odors. This can set off a series of problems, even when anaerobic conditions are present in only localized portions of a pile.

Odors can result from several pile environment factors, for example ammonias and sulfides (rotten egg smell), are associated with excess moisture during aerobic composting; amines (fishy smell) are associated with anaerobic conditions; and volatile fatty acids (VFA), are associated with anaerobic conditions; evidence of unstable process.

Byproducts of anaerobic respiration tend to be acidic. If the composting mass becomes acidic, metals and other elements present in the material may leach and become concentrated in site runoff. Leachate is the liquid that has moved through the compost pile and exits the bottom of the pile. The leachate contains dissolved and suspended pollutants.

Water management for odor

Prevent pooling or ponding

Ponding of water, particularly on the composting pad, will cause a number of operating problems. First and foremost, ponding can create anaerobic conditions and generates odor. Pooling and ponding weakens the composting surface. Standing puddles and ponds create saturated soft spots on the pad that become susceptible to rutting and other physical deterioration that eventually necessitates remedial care.

Initially, proper pad construction and sloping should prevent pooling. A surface of rigid or semi-rigid pavement with gravel or slag surfacing and an appropriate sub-base is recommended. After construction, constant pad maintenance and housekeeping activities are essential to preserve drainage and downward slopes to convey all water away from the compost. Windrows should be placed along the “fall line” of the slope, rather than across the slope, to ensure drainage of water away from windrows. As illustrated in the diagram of a sample site at the end of the chapter.

Treat anaerobic pools

If pools of leachate or water form on a composting pad, they can become anaerobic and pose a significant odor and possible pollution risk. Optimally, it would be best to avoid the accumulation of moisture in the first place. Where formation of anaerobic pools cannot be prevented, odor-causing elements can be reduced by adding pulverized limestone to the pool and surrounding area.

Site Capacity and Sizing

An important step in site planning and development is calculating the capacity needed based on projections for volumes of incoming materials, equipment needs and materials handling activities.

Lack of adequate space and equipment, combined with overly large quantities of incoming materials can cause dramatic odor and material management problems. Most sites cannot efficiently handle more than 5,000 cubic yards per acre per year (cy/acre/yr) and 8,000 cy/acre/year is generally the upper limit for an intensely managed site. Too much material makes it difficult for operators to mix and turn material in proper ratios and frequencies.

High capacity approaches (e.g. more frequent mechanical turning and quicker organic decomposition) allow more efficient use of sites.

Estimating Generation

An important planning step is identifying the geographic area to be served by the site, and estimating the volume of organic waste to be generated each year. The following rule of thumb should be considered an average range, assuming leaves, grass and brush are collected:

Average residential generation:	1-2 cubic yards per household per year.
Design key:	Older communities with larger trees may generate more leaves; newer communities with large lawns will generate more grass.

The following table identifies optimal volumes which can be processed annually based on low, medium and high intensity processing means. This can be used as a rule of thumb during the design process to understand that a medium and high intensity site, more equipment and more labor will be needed to push the material through. It is important to note that the Michigan compost rules state a limitation of 5,000 CY per acre at any one time (i.e. if you measure an acre at any time during the year, the active, curing or finished compost volume on that acre cannot exceed 5,000 CY).

If you measure an acre at any time during the year, the active, curing or finished compost volume on that acre cannot exceed 5,000 cubic yards.

Annual Throughput

Capacity	Annual Material Volume- 1 Acre	Annual Material Volume- 5 Acres	Annual Material Volume - 20 Acres
Low	3,000 CY	15,000 CY	60,000 CY
Medium	5,000 CY	25,000 CY	100,000 CY
High	8,000 CY	40,000 CY	160,000 CY

Design Considerations – shared by all facilities but generally require more attention as intensity increases. Any compost site should have adequate drainage away from the piles and should consider staff operations training, turning and incoming volume logs.

Low intensity	Small overall volumes, minimal operational attention
Medium intensity	Speed up organic breakdown through shredding, increased turning to handle higher amounts per year; attention to C:N ratios, moisture content, aeration; engineered pad
High intensity	Attention to C:N ratios, moisture content, aeration; high level of equipment and site development, including self-propelled windrow turners, shredders, screeners, loaders, engineered pad, aeration systems, positive odor control, and +sophisticated instrumentation; extensive staff training

Site Layout

In acquiring or developing a compost site, the operator should plan to accommodate appropriate operating strategies, utilities, material handling areas and other factors.

Site Access

Appropriate site entrances and exits are especially important in providing the facility with a good public image. Important Do's and Don'ts include:

DO locate the site entrance on or near major transportation routes

DON'T allow incoming and outgoing vehicles to travel on residential streets.

DO clearly mark the site entrance with signs

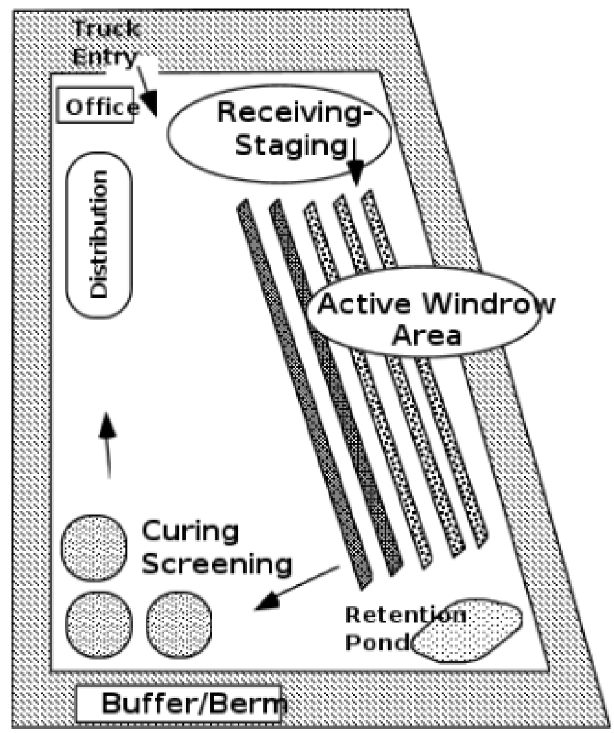
DON'T allow incoming vehicles to back-up off site while waiting to enter.

DO provide enough space for trucks to adequately maneuver off the streets

DON'T allow vehicles to track mud or compost from the site to public roads.

DO insure that entering and exiting vehicles can safely enter and leave traffic.

Material Flow and Site Configuration



Utilities

Access to common utilities will be required by compost facilities. Electricity, water, telephone, internet, and sanitary sewer (or septic tank and drain field) are basics that each site will require for successful operation. Access to water for moisture conditioning the composting mass is particularly critical when conditions and materials are particularly dry and susceptible to combustion.

Compost facilities carry out three types of operational functions. 1) Receiving/Staging; 2) Processing; and 3) Curing/Storage. Space allocated to each of these activities can be calculated based on incoming volumes of yard clippings and other organics on a monthly basis.

Site Security

Access should be controlled to limit liability from illegal dumping, contamination, vandalism, theft, and injury to wandering visitors. Fencing around the facility perimeter, a locking gate, lighting, and utilities help protect the facility from those troubles. Good signs promote efficient site use by visitors, help to prevent confusion, and provide vital information in the case of emergency.

Area Requirements

Efficient facility layout is important to minimize the frequency and amount of material movement from station to station. Some overall layout objectives that each facility designer should consider are:

Area Requirements

	Staging/ Receiving	Processing	Curing/ Storage
% of Total Site Area Needed	**20-30%** (Assuming some leaf storage in processing area)	**55-65%**	**10-20%**

Site Layout Objectives

1. Minimize backtracking, system delays, and material handling.
2. Maintain flexibility.
3. Separate feedstock piles to allow precise combining of materials.
4. Utilize manpower and space efficiently.
5. Provide for good housekeeping and ease of maintenance.

Material Handling Needs

	% of incoming materials	Staging/Receiving Requirements	Processing Requirements	Curing/Storage Requirements
Leaf Stream	50-60%	Accumulate in Fall for following Spring	Incorporate gradually with incoming grass	As finished compost at 3:1 or 4:1 volume reduction
Grass Clippings	30-40%	Accumulate for 1-2 days at most	Incorporate quickly with Fall leaves	As finished compost (See above)
Brush/Wood chips	0-15%	Accumulate until grinding can occur	Grind separately from grass or leaves	As finished compost (See above)
Food Scraps	0-5%	Accumulate for 1-2 days at most	Incorporate quickly with Fall leaves	Incorporate quickly with Fall leaves

Calculating Space for Active Compost

The shape and size of windrows vary depending on the type of turning equipment used. The aisle space needed between windrows is also impacted by equipment selection.

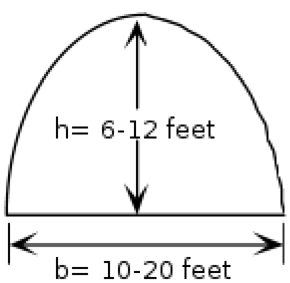
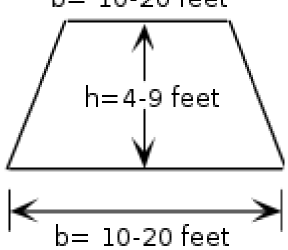
To accurately calculate the footprint of the site which will be occupied by the active processing area, operators will need to estimate the peak volume of organic materials and how much can be placed into each windrow. For additional information on calculating the full range of windrow types, the On Farm Composting Handbook is an excellent reference.

Where more sophisticated indoor or in-vessel approaches are used, the area requirements will be different to accommodate the equipment and building. Often, though, the curing and finished compost is stored outside and the area and pads need to accommodate these volumes.

There is plenty of space at Tuthill Farms for composting.

The table below provides some basic guidelines.

Calculating Windrow Volume

Method and equipment used	Approximate shape	Avg. aisle width	Cross-sectional area
Windrows/piles turned with a bucket loader		11’	A = 2/3 x b x h
Self-propelled and tractor-drawn windrow turners		5’	A = h x (b - h) *

** This formula is an approximation and is valid only when the width is greater than or equal to twice the height.*

Site Selection

Location

The process of composting will at times generate odors. In order to ensure that occasional odors are not a nuisance to the surrounding community, the site should be located away from nearby "sensitive receptors." Usually, rural agricultural areas or those zoned for industrial operations are best suited to outdoor composting technologies. Where more sophisticated indoor or in-vessel approaches are used, the facility siting standards may be modified somewhat. Proper attention during the design phase should minimize the disturbance that a facility brings to the surrounding community.

Setbacks, Buffers and Site Access

Setbacks from sensitive receptors and other factors should be observed whenever possible.

- 500-feet from a sensitive receptor (e.g. hospitals, churches, schools, nursing homes)
- 300-feet from residences
- 500-feet from active wells
- 200-feet from natural or artificial wetlands

Where setbacks of this nature are not feasible, buffers should be constructed to mitigate the effects of compost facility impact.

Buffers can include constructed berms (**berm requirement from rules?), walls, and rows of trees. They serve to block the effects of noise, odor, and visual impacts of the site from neighbors. Buffers should take advantage of natural allies like prevailing winds, wooded areas, hills, and railroad cuts to cost effectively prevent offset impact.

> *Generally speaking, operators become more challenged by the conditions of the site than the actual composting of the organics.*

Site Selection Criteria

- Proximity to customers
- Proximity to transportation corridors
- Minimum travel and materials handling
- Firm surface to support vehicles under varying weather conditions
- Opportunity for expansion
- Cost of space and utilities
- Buffer from neighbors
- Drainage, runoff control
- Avoid sensitive receptors such as schools, hospitals, schools
- FAA regulations prohibit the existence of compost facilities within 10,000 feet of any airport.

Composting facilities set near areas zoned for either agriculture or industrial purposes are the best locations for siting a composting operation.

Site Design

Although a firm processing surface is necessary, it does not have to be paved. Moderate to well-drained soils are satisfactory for some lower intensity yard waste composting situations. A pad constructed of 8 inches of compacted and graded sand or gravel works well when the existing soil conditions are not acceptable.

Paved pads of concrete or asphalt are generally a luxury and only a necessity for high-intensity sites. Pavement does reduce problems related to mud, equipment operation, and pad maintenance. It also minimizes the amount of stones that get mixed into the compost. However, the cost is significant and pad runoff must be managed.

Usually, an impermeable surface is required only when both the soil is well-drained and the water table is high (w/in 4-5 feet). Concrete or asphalt is also sometimes beneficial for special activity areas such as mixing of raw material with a bucket loader.

Sites without engineered pads on which to maneuver equipment have problems when there are significant amounts of precipitation and the ground is soft. Equipment can get stuck in the mud, ruts may form and ponding may occur which can result in anaerobic conditions if a pile or windrow is located in the standing water. Generally speaking, operators become more challenged by the conditions of the site than the actual composting of the organics. And these challenges frequently lead to an unsustainable business operation.

There are three key elements for site surface design that must be considered for any properly built site. 1) The surface should provide adequate stability and firmness for year-round operational access with windrow turners, trucks, and other heavy equipment. This can be constructed in a variety of ways, as compacted gravel to concrete. 2) A pad should be constructed so that its final grade and elevation provide a slope that allows water to flow away quickly and efficiently from the composting material. A 2% slope is recommended as adequate. 3) The presence of clay at the surface of any site should "raise a red flag", indicating the potential for wet areas to form. Sites with clay soils will require special attention to preparation of hardened surface in order to avoid drainage and odor problems.

Successful development of these two design goals will result in a facility that dramatically increases operational efficiency and reduces the chance of odor and off-site leachate contamination.

Pad Surface Material and Design

Several factors will influence the type of pad material and surface preparation which may be required. These factors include the type of equipment to be used, the volume of material expected, and type of soils present.

Pad Type	***Design Keys***
Rigid Pavement	• Strip topsoil and add appropriate base and sub base material • Design pavement cross-sections for refuse packer truck axle weights fully loaded with yard clippings

Prepared Earth Surface	• Strip and compact ground surface as underlayment • Add 8-inch layer of compacted gravel or slag surface layer (4-inch lifts); an additional layer of permeable sand may be required as the final base layer to promote drainage under the entire pad structure where clay soils are present • Use geotextile fabric between base layers and the underlying *in situ* soil where underlying wet clays are present.

Typical Site Preparation and Construction Costs*

Pad Type	**Average Cost per acre**
Earth Pad (no fill)	$7,000 – 10,000
Gravel/Slag	$30,00 – 50,000
Asphalt Pad	$65,000 – 100,000
Concrete Pad	$150,000 and up

**Does not include engineering and construction supervision; note that an economy of scale may be achieved with larger sites, thus reducing the average cost per acre. Cost figures may vary from community to community. Facility operators can reduce these average construction costs by seeking cooperative working relationships with local contractors.*

Note that the significant additional capital costs of placing asphalt or concrete pavement are offset by the operational savings in facility maintenance and other efficiency gains.

Advantages of paved sites

Paving your compost pad can alleviate product management issues. Constant grading and re-grading is not needed to maintain an appropriate slope and surface integrity. Water runoff can be controlled more easily. The annual addition of layers of replacement surfacing material will not be required to make up for losses due to inadvertent mixing with the compost product, erosion, high-temperature composting process, and the scraping action of metal buckets regularly clearing the pad surface to maintain open drainage ways. Paving also allows for easier snow removal for year around activity.

Prospective operators should carefully evaluate the operational benefits of paving all or part of their site. At a minimum, the mixing area and compost pad that houses working windrows should be hard surfaced.

Advantages of Prepared Surface

- Easier year-round access during all climatic conditions.
- Reduced maintenance
- More efficient material handling
- Reduces the likelihood of odor problems

Disadvantages of Prepared Surfaces

- The quality of finished compost can be adversely affected when gravel or slag materials become mixed in the organic mixture.
- High maintenance
- Excess water may be more difficult to control during rainy periods
- Soft muddy pads can mean down time during inclement weather

Where the water table is low and the soils are sandy, less design effort and construction expense will be required to ensure access. In circumstances where the existing ground is clayey and wet, greater effort and expense will be required to ensure all-weather access. In any case, compost facility developers should give pad design and construction the highest possible priority.

Alternative Surfacing Options

Some operators have had success using alternative surfacing material like slag or limestone that can be less expensive than more common construction materials. Other operators with access to heavy equipment have been able to prepare excellent “do it yourself” facilities as part of ongoing construction or landfill management activities. Clearly those composters with involvement or background in earthmoving contracting or landfilling are at an advantage when it comes to constructing a less expensive compost site.

Use of Existing Soils

Under limited circumstances, compost sites can be developed using existing soil units. This approach should be considered only after carefully evaluating the proposed operation and the native soils for appropriate characteristics.

This type of lower strength pad surface is feasible where the proposed operation is to be low intensity (e.g. infrequent use of wheeled loaders for material management and turning). It should only be employed when the surface geological unit is sandy or gravelly materials. Additionally, the year around water table should be at least five feet below the surface of the proposed pad area.

Under no circumstances should any centralized composting facility be sited on a ground surface area that has a clay base without surface improvements.

Cohesive soils like clay cannot support activity in wet weather. Statewide experience has clearly indicated that sites located on a clay base without overlying pavement will become inaccessible and extremely muddy after only a month or two of steady operation.

In the limited circumstances where a pad of compacted native soil is feasible, the actual pad and other high traffic areas (e.g. entry, exit, access roads, and perimeter areas around grinders, debaggers and screeners) should be carefully prepared in the same manner that the foundation preparation is carried out before placement of a gravel or paved surface. These steps are:

1) Clear proposed pad area of all vegetation and manmade structures.

2) Remove organic soil layer from proposed pad area.

3) Grade and compact (with vibratory compaction device) suitable *in situ* granular soil for use as pad surface.

Site Drainage Information

Pad Surface Slope

Any outdoor surface for composting requires a slope that is suitable for the quick and efficient outflow of leachate and stormwater runoff. Pad surface slope is critical to keeping the site accessible in all weather.

In circumstances where non-rigid materials (e.g. gravel, slag) are used, continual regrading of the pad is required. Trucks, windrow turners, loaders and other heavy equipment leave ruts when operating on a non-rigid surface, especially during wet periods of the year. In order to simply and easily keep up with site "housekeeping," regrading of the site should occur every day. Slopes of less than 2% are difficult to maintain, especially when most regrading is undertaken and completed using instruments no more sophisticated than the equipment operator's eyes. The overall slope of the pad, regardless of the material used in its construction, should be able to consistently maintain flow in the direction of the drainage collection ditches.

Design Keys

Rigid and durable pavements:	Minimum slope of 1% in one direction.
Gravel, slag or other non-rigid surfaces:	Gradient of 2% in at least one dimension

Compost Wastewater and Storm Water Drainage

Appropriate management of compost wastewater and storm water is very important at composting facilities. It is critical that each operation is designed, constructed, and managed by knowledgeable professionals in a manner that limits the production of compost wastewater and prevents the contamination of storm water. Site design and management should focus on identifying areas of the site where compost wastewater is potentially generated and areas of the site where compost wastewater is not generated. Controls will need to be implemented in both areas to adequately protect groundwater and surface waters, however storm water runoff controls will be the main focus in the areas where compost wastewater is not generated.

Compost Wastewater Drainage

Compost wastewater is a liquid that is comprised of process water; wash water; and/or leachate that ponds, flows laterally from the base of the compost pile, or collects in an under-drainage system. Storm water that has been allowed to comingle with compost wastewater, as defined, is considered compost wastewater.

Compost wastewater discharges from composting facilities are highly variable and can contain potentially significant levels of nutrients, heavy metals, oil and grease, soluble salts, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), tannins and phenols from decomposing leaves, herbicides, pesticides, fungicides and fecal coliform. The negative impacts to waters of the state from improperly managed compost wastewater include, but are not limited to, the following:

- Elevated levels of BOD and COD cause oxygen depletion in surface water, which could lead to fish and aquatic organism mortality. Additionally, high BOD and COD loads can cause oxygen depletion in the soil column, which can result in the release and mobilization of metals in the groundwater.
- High levels of nutrient loads (mainly phosphorus) to surface waters stimulates excessive growth of aquatic vegetation and algae causing accelerated eutrophication of waterbodies. High levels of nutrients, such as nitrates, are also a human health concern in the groundwater.
- Tannins and lignins are natural dissolved organic acids derived from woody materials that give yard clippings compost wastewater a tea color.
- Discharges of compost wastewater can negatively impact the natural color of waterbodies, which can in turn negatively impact the natural ecological processes within those waterbodies.
- Elevated levels of fecal coliform in the discharge is a human health concern.

Ideally controls should be implemented on site to prevent the generation of compost wastewater. However, if wastewater is generated then it should be managed so that it does not comingling with storm water and it does not discharge to waters of the state.

Compost wastewater generated at the site may be collected in a properly lined basin and reintroduced onto the compost piles. It may not be discharged onto the ground or into surface waters without a permit from the Department of Environmental Quality (DEQ), Water Resources Division (WRD).

Any discharges of compost wastewater to waters of the state would require a National Pollution Discharge Elimination System (NPDES) permit.

Storm Water Drainage

In addition to managing and minimizing compost wastewater, compost sites should prevent the contamination of the storm water that has not contacted production areas (feedstock, raw materials, compost piles, etc.). It is critical that storm water from non-production areas of the site is diverted away from production areas. Remember that when storm water mixes with compost wastewater, the entire mixture is considered compost wastewater.

Compost facilities need to manage storm water discharges from the site so that it does not cause negative impact to the receiving waters. Even with proper construction and management, storm water at the site may still carry some pollutants which can be harmful to surface waters. If compost facilities discharge storm water to the surface waters of the state or to a separate storm sewer system a NPDES industrial storm water permit will be needed. Storm water management at compost facilities will involve the implementation of a number of storm water runoff controls such as:

- Detention and retention ponds
- Diversion berms and dikes
- Storm sewer inlet protection
- Vegetative filter strips
- Check dams
- Infiltration trenches

All storm water runoff controls utilized on site require design by a qualified professional and ongoing maintenance to be effective. The MDEQ Nonpoint Source Best Management Practices Manual should be referenced to appropriately implement controls that will work effectively given specific site characteristics.

Conclusion

Composting plays a major role in both waste management and resource recycling for our organic wastes. However, studies have demonstrated that water quality degradation is likely if the process is not carried out in a professional manner on sites that are appropriately designed, constructed, and managed.

Outdoor compost facilities require a drainage system that will appropriately manage compost wastewater (if generated) and storm water runoff. Compost wastewater if generated should be managed so it does not comingle with storm water runoff. All discharges of compost wastewater and storm water generated onsite needs to be covered by all applicable WRD discharge permits. It is advisable that compost facility operators work with DEQ, WRD staff when considering how to effectively design site drainage and to appropriately permit compost wastewater and storm water discharges to waters of the state.

Compost Facility Planning, Siting, and Design Criteria Checklist

A. Materials to be Composted

- ☐ Yard Waste
- ☐ Yard Waste and other compostable materials (classified as Class 1 compostable material) such as wood, organic garbage, paper products and manures not generated in the production of livestock or poultry, spent grain from breweries, sugar beet limes, drywall, and dead animals not managed under dead animals act

B. Compost Facility Planning

- ☐ Check Zoning
- ☐ Identify public officials with jurisdiction over the proposed compost facility
- ☐ Review local composting regulations
- ☐ Check meteorological parameters (e.g. wind direction)
- ☐ Identify critical surface and ground water resources
- ☐ Identify "sensitive receptors"
- ☐ Detail existing buffers (woods, roads, walls, hills. lakes, etc.) between site and its neighbors
- ☐ Identify possible areas for future facility expansion
- ☐ Detail surrounding transportation routes
- ☐ Identify project team (e.g. engineer, lawyer, contractor, equipment vendors)

C. Compost Facility Site Design Phase

- ☐ Acquire all necessary permits (building, zoning, business, and solid waste management)
- ☐ Prepare a construction erosion control plan to mitigate loss of soil and impact to surrounding water resources
- ☐ Identify types, quantity and seasonal distribution of incoming material
- ☐ Define incoming quantity limitations based on site size and composting technology
- ☐ Define material staging and preparation requirements
- ☐ Identify outgoing quantities of finished material
- ☐ Define size reduction/mixing equipment
- ☐ Define turning and aeration equipment
- ☐ Define screening and blending equipment
- ☐ Define utility equipment (e.g. loaders, dozers, trucks)

- ☐ Define site boundaries
- ☐ Describe major areas of activities (e.g. receiving pre-processing, grinding, composting, curing)
- ☐ Describe major transportation routes to and from the facility
- ☐ Determine traffic flow on site (maintain counter clockwise flow is possible)
- ☐ Define buffers necessary to mitigate effects on neighbors
- ☐ Design pad and roadway surfaces
- ☐ Provide site security (e.g. gate, signage and fencing)
- ☐ Develop appropriate site erosion control structures
- ☐ Develop appropriate retention pond facilities for storm water control and primary effluent treatment (e.g. sedimentation)

D. Yard Waste Only Site Criteria

- ☐ Not in a 100 year floodplain
- ☐ 50 feet from a property line
- ☐ DEQ minimum 200 feet from a residence, recommended 300 feet
- ☐ DEQ minimum 100 feet from a body of water, including a lake, stream, or wetland, recommended 200 feet
- ☐ 2000 feet from a type I or a type IIA water supply well
- ☐ 800 feet from a type IIB or type II water supply well
- ☐ 500 feet from a church or other house of worship, hospital, nursing home, licensed day care center, or school, other than a home school
- ☐ 4 feet above groundwater
- ☐ Pad surface material that allows year-round access and adequate support for expected loads (rigid or semi-rigid pavement; gravel or slag surfacing with subbase)
- ☐ Pad surface slope that allows for quick, efficient leachate outflow and storm water runoff (1% slope for rigid and durable pavements; 2% slope for gravel, slag, or non-rigid surfaces with daily regarding)
- ☐ Drainage conveyance structure that is capable of conveying leachate or storm water runoff to retention pond without overflow or percolation
- ☐ Diversion channels to direct runoff and promote sedimentation removal
- ☐ Stabilization of steep grades with geotextiles, vegetation, or rip-rap
- ☐ Retention pond at sites larger than 5 acres or those with high water tables
- ☐ Restrict/control rate of runoff to reduce quantity and increase quality of runoff

E. Class 1 Compost Site Criteria

- ☐ 50 feet from property line
- ☐ DEQ minimum 200 feet from a residence, recommended 300 feet

☐ If within 500 feet of a residence, visual obstruction from a fence of at least 8 feet in height and 75% screening or an earthed berm that offers equal obstruction is required

☐ DEQ minimum 100 feet from a body of water, including a lake, stream, or wetland, recommended 200 feet

☐ 2000 feet from a type I or type IIa water supply well

☐ 800 feet from a type IIb or type III water supply well

☐ 500 feet from a church or other house of worship, hospital, nursing home, licensed day care center, or school, other than a home school

☐ 4 feet above groundwater

☐ If located within 10,000 feet of any airport runway used by turbojet aircraft or 5000 feet of an airport runway used by only piston-type aircraft the facility must be designed and operated so that the facility does not pose a bird hazard to aircraft

☐ Pad surface material that allows year-round access and adequate support for expected loads (rigid or semi-rigid pavement; gravel or slag surfacing with subbase)

☐ Pad surface slope that allows for quick, efficient leachate outflow and storm water runoff (1% slope for rigid and durable pavements; 2% slope for gravel, slag, or non-rigid surfaces with daily regarding)

☐ Drainage conveyance structure that is capable of conveying leachate or storm water runoff to retention pond without overflow or percolation

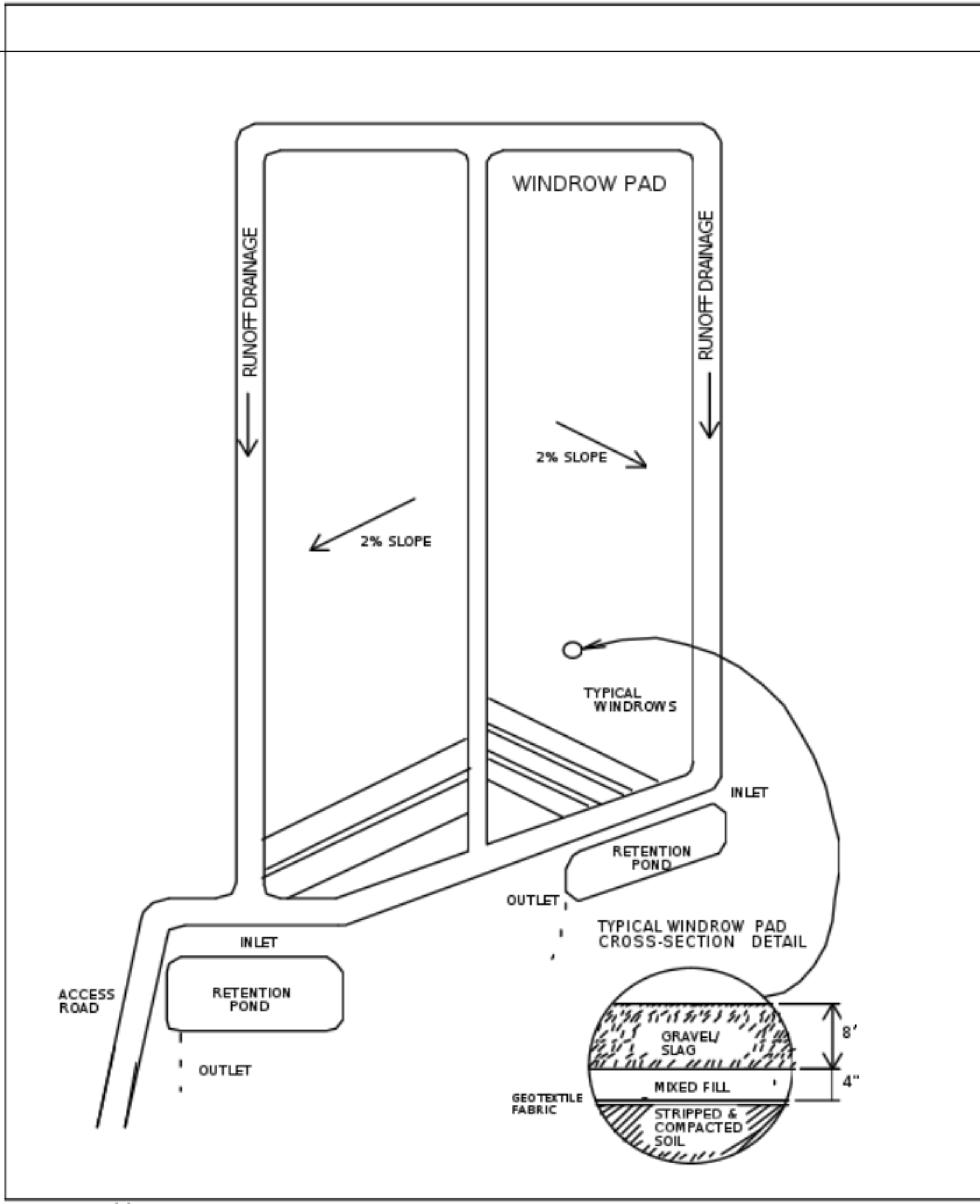
☐ Diversion channels to direct runoff and promote sedimentation removal

☐ Stabilization of steep grades with geotextiles, vegetation, or rip-rap

☐ Retention pond at sites larger than 5 acres or those with high water tables

☐ Restrict/control rate of runoff to reduce quantity and increase quality of runoff

Example of Compost Processing Area with Pad Detail



prepared by RRS, Inc.

Overview of New Composting Law

Contact: Duane Roskoskey 517-582-3445
Agency: Environmental Quality

The law identifies several options for managing yard clippings:

- Composted at the property where they came from.
- Temporarily accumulated under specific conditions at a site before moving to another location.
- Composted at a farm registered with the Department of Agriculture under specific conditions.
- Composted at a composting facility registered with the DEQ Waste and Hazardous Materials Division.
- Composted and used under specific conditions at a licensed solid waste landfill.
- Composted at a processing plant meeting Part 115 requirements.
- Composted at a site that has not more than 200 cubic yards of yard clippings if no nuisance is created.
- Decomposed in a controlled manner using a closed container to create and maintain anaerobic conditions (e.g. anaerobic digester).
- Disposed of at a landfill if diseased or infested or the material is an invasive plant collected through an eradication or control program and inappropriate to compost.

DEQ registered composting facilities will be subject to a $600 registration fee. The registration is for three years. Registered facilities have location restrictions and operating requirements, and are required to submit annual reports containing information about the amount of yard clippings and other compostable materials managed during the previous fiscal year.

DEQ registered composting facilities are subject to a $600 registration fee. The registration is for three years. Registered facilities have location restrictions and operating requirements, and are required to submit annual reports containing information about the amount of yard clippings and other compostable materials managed during the previous fiscal year. Questions may be directed to Mr. Duane Roskoskey at 517-582-3445 or by email at roskoskeyd@michigan.gov .

www.michigan.gov/deq/0,1607,7-135-3312_4123-185537--,00.html

5 Operations

Introduction

Composting is the art and science of managing organic materials to provide an optimum environment for the growth and reproduction of microbes. Experienced facility operators often compare composting to making a fine wine, as a way of acknowledging that large scale compost production requires the balancing of complex interrelated factors. On the other hand, it is neither "rocket science" nor alchemy. Field and laboratory research continues to provide good scientific data on the process.

While today's operators also benefit from the trial and error of earlier composting efforts, there is no substitute for thorough planning, monitoring and analysis of operational data. Proper operation of a compost facility requires an established protocol for materials handling, and the right equipment and trained staff to carry out those procedures in a timely manner.

Many factors are important in development of a successful composting facility. This module covers all facets of site operations, from material receiving through processing and monitoring. Principles of operation and recommendations presented herein are applicable to both large and small facilities.

Building a pile

Incoming Material Stream

Composters must continually monitor the incoming material stream in order to avoid odor problems and produce high quality compost.

Managing incoming materials

It is essential to evaluate the quality and quantity of incoming organic materials in order to operate a compost facility effectively without creating nuisance odor problems. Important aspects of managing incoming materials include:

- reduction of grass volumes and/or addition of extra carbon material
- paying immediate attention to grass and food scraps as they enter the site
- rejecting foreign materials or contaminated material

Grass

Reducing the amount of grass in the waste stream greatly reduces the potential for odor generation. Grass collected in plastic bags may be odorous even before it enters the facility.

One way to reduce grass is through an aggressive community education program. The Southeast Oakland County Resource Recovery Authority (SOCRRA) demonstrated a 60% reduction in grass from its member communities in the last four years through an education program and financial incentives (higher tip fees for grass).

Food waste collection truck

Food Waste

Food waste differs from yard waste but is similar to grass in that it is generally characterized as a highly putrescent, rapidly degradable feedstock with a high moisture content and bulk density.

The potential of food waste to produce liquid leachate, combined with its low carbon-to-nitrogen ratio relative to ideal composting conditions, demands that food waste be collected and processed in a timely and efficient manner, and may require chipping or grinding if mixed with compostable products like forks, spoons and cups.

As grasscycling programs are becoming more popular, more volumes of food waste in the feedstock may be desirable. Food waste is high in nitrogen and speeds up the decomposition process of compost. Adding food waste to yard waste for composting will reduce water needs throughout the process and increase the nutrient content of the finished product. Once composted, food wastes contribute to the overall beneficial characteristics of compost as a soil amendment and nutrient additive.

Brush

A key processing issue for Michigan composting facilities is whether to accept loads of brush commingled with grass and leaves, or only in separate loads. Depending upon the type of equipment used, grinding wet material such as grass can increase the rate of wear on cutting edges, resulting in costly maintenance and downtime. By accepting segregated brush at the gate, an operator can increase processing options and possibly reduce equipment costs. Brush alone can be stockpiled without causing odor, whereas commingled brush and grass cannot. The woody component of yard waste helps the compost process in chipped form, providing some carbon for microbes and enhancing aeration. Another disadvantage of separate collection programs for grass and brush is the added cost for two trucks and extra employees.

Managing grass, food waste and brush

- Accept only enough grass to make the desirable C:N ratio, based on available leaves and brush.
- If food waste is accepted, limit this volume to 5%, or to the amount accepted for your facility by the MDNRE, to manage C:N and moisture.
- Give top priority to securing adequate leaf volume.
- If accepting brush commingled with grass, invest in grinding equipment designed to handle wet materials.

Gate management

The condition of material arriving at a compost facility affects variables such as:

- collection containers
- type of delivery truck (degree of compaction)
- amount of physical contaminants
- the length of time since grass has been cut and in transport
- curbside collection quality control

Grass stored in plastic bags or a truck for several days will be more odorous than in bulk or paper bags and delivered on the day collected.

If a facility's fee is based on volume rather than weight, haulers may compact more material into each load to save money. This densifies the feedstock and makes it more difficult to aerate. Also, the site operator loses money when the amount of material is measured by volume rather than weight. Charging by weight effectively discourages this practice, although scales are costly. Signs of over-compaction include evidence that moisture is being removed due to compaction (streams of liquid draining from incoming vehicles) and obviously overloaded packer trucks (compressed springs and flattened tires).

Bagged yard waste waiting for collection.

Plastic bags

Yard clippings collected and delivered in plastic bags present a major operational concern for composters. Accepting grass delivery in plastic causes foul odors, raises operational costs dramatically, and can reduce both the quality and value of the finished product (plastic bits, pH problems). Plastic bags cause odor problems because grass turns anaerobic and foul-smelling inside the airtight container. Nitrogen-rich grass, especially with high moisture, begins to decompose soon after bagging, and uses up oxygen. When placed in plastic bags, grass can become anaerobic within hours.

Debagging is costly, whether done mechanically or by hand. To save money, some operators build compost piles without first debagging, and rely on a turner or grinder to shred the bags open. This system relies on screening to remove plastic later and often produces poor quality compost containing tiny pieces of plastic which blow around the site. Compost with plastic in it looks like trash and will be harder to sell.

Gate management tips

- Don't accept material in plastic bags. If you must, follow a rigorous and effective debagging protocol.
- Reject non-compostable wastes at the gate. Track incoming loads so haulers can be held accountable for trash.
- Determine the maximum volume of grass and food waste your site can handle; divert to another site if this peak capacity point is exceeded.
- Charge higher tip fees for grass and food waste than for leaves and wood chips.

Quantity of Incoming Material

Estimating incoming volume

In designing a composting facility, decisions and estimates must be made about the type and quantity of yard waste to handle. Site design and equipment depends on the volume of material expected. Objectives for estimating volumes include:

- ensuring a sufficient supply of carbon-rich materials on-site to manage the C:N ratio as windrows are built,
- sizing and equipping the facility for peak volumes, and
- planning effective operating procedures.

One approach to estimating yard waste is to multiply the number of homes by an average yard waste generation rate. The following table shows data from Illinois.

Table 1: Yard Waste Generation Rates per Single Family Household per Year

Material	Pounds	Cubic Yards Loose
Leaves	160	0.8
Grass	1,040	2.6
Brush	300	1.0
Total	1,500	4.4

Seasonal generation

The amount of yard waste generated varies by season. Up to 60% of yard clippings in Michigan consist of grass and weeds collected in the growing season from May through September. The overall amount of leaves appears larger because it arrives in a shorter time period than grass. Brush from pruning and storm damage occurs primarily in two peaks in the spring and fall. Moderate quantities of brush accumulate in the summer and winter months. Food waste volumes in the spring may be high due to households 'storing' food scraps in their compost carts over the winter when yard waste collection services weren't provided. Food scrap volumes may also be higher in the summer and fall when local, fresh food are prepared.

Changes in weather, landscape practices and population can alter yard waste volumes from year to year. To successfully handle fluctuations, a site must be sized to accommodate estimated peak capacity.

Receiving areas should be large enough to store fall leaves and the grass surges expected in the spring and early summer.

Recommendation

The best time of year to start composting is autumn, because leaves can be stockpiled and available to mix with succulent grass clippings the following spring. Store leaves in large piles with good drainage, away from property lines, to keep as dry as possible and slow the rate of decomposition over winter.

Bulking agents

A bulking agent is a carbon-rich material added to a compost mix to enhance air flow or convection through the windrow. Commonly used materials include wood chips, leaves, sawdust, cornstalks or straw. In order to aid natural convection, bulking agents must be large enough to physically support small pockets through which air can pass. A compost pile with an acceptable C:N ratio is less likely to become anaerobic because sufficient bulking agents are also present to facilitate air flow.

Rule of Thumb

Mix 2-3 parts leaves to 1 part grass, by volume for optimal C:N ratio of 30:1 and add wood chips for bulking agent.

Balancing C:N Ratios

The carbon to nitrogen ratio (C:N) of incoming materials must be actively managed in order to have a predictable composting operation, avoid problematic odors and produce consistent, high quality compost. The optimal mixture of yard clippings has a C:N ratio between 25:1 and 35:1. Too much nitrogen (C:N below 20:1) results in ammonia odors while excess carbon (above 80:1) significantly slows the composting rate. Dry brown leaves have an average C:N ratio of 80:1 and compost slowly without additional nitrogen.

Table 2: C:N Ratios of Common Materials

MATERIAL	C:N RATIO
Grass Clippings	20:1
Green Leaves	40:1
Dry Leaves	80:1
Sawdust/wood chips*	500:1
Dry Straw	100:1
Cow Manure	20:1
Food Scraps	15:1

* Carbon in wood is released over a number of years.

New Jersey public and private compost facilities recommend no less than three parts partially composted leaves (from previous fall) to every one part grass. While this may push the C:N ratio above 30:1, it has the advantage of added bulking material in the mass and increasing air flow, which prevents odors.

Leaves stored over the winter lose approximately half their volume by the time they are mixed with spring grass. Due to the volume reduction that occurs in leaves stored over winter, operators who use the three parts brown to one part green rule will actually be consuming six parts incoming leaves to one part spring grass. As shown in Table 1, the typical generation pattern for communities cannot accommodate this formula. Practical strategies are therefore needed to manage grass effectively. The following materials handling tips offer suggestions on how to balance materials to produce an acceptable C:N ratio.

Pre-processing

The goals of pre-processing include reducing the size of brush, creating a homogeneous mix, and ensuring that compost mixes have acceptable C:N ratios and moisture levels.

Particle size reduction

Tree trimmings and brush over 1" in diameter must be physically broken down by a chipper or grinder before they can be added to a compost mix. Unchipped, these materials do not have a sufficiently small surface area to make carbon accessible to microbes. Although costly to process, chipped brush provides carbon to composting microbes and enhances pile aeration by providing structure. Brush can be stockpiled prior to processing for long periods of time without causing odors. This allows the operator to chip or grind less often, during slow periods or when leased equipment is available.

Brush must be size-reduced or ground into chips in order to compost. Brush mixed with grass and leaves (*commingled*) can be costly to grind with equipment that is not designed specifically to handle wet materials. Many grinders on the market are most effective on dry woody materials and require extensive maintenance when handling a wet, green mixture.

The costs and benefits of a commingled yard waste stream should be carefully considered in designing a program.
Specialized equipment is available to separate commingled brush from smaller particles such as grass and leaves, and some composters use this approach. This kind of separating equipment can be cost effective because it reduces wear on the hammers and knives in grinding equipment. If accepting food scraps with compostable products, you may need to grind this material in order to promote the degradation of the forks and spoons. Otherwise, you may find small bits of plastic in your final product.

If possible, grind woody material separately from grass and leaves. Particle size reduction also occurs each time a mechanical windrow turner with knives or blades is used to turn

Recipe Tips:

1. Provide enough space on the site for actively composting windrows, storage of leaves and wood chips, and processing activities.
2. Keep enough leaves and wood chips stockpiled on-site (approximately 1 to 2 months at expected rate of use) to balance the amount of grass that will come to the site in the spring and summer.
3. Incorporate spring and summer grass into leaf windrows incrementally to “stretch” the value of the leaves. The ratio of grass to leaves in the initial mixture should be limited to 1 part grass to 4 parts leaves. Subsequent "doses" of grass added to each windrow should also not exceed one part in four.
4. Repeated incorporations can bring the final grass to leaf ratio to a much higher level, without creating odors, than would be possible using a single incorporation approach. This incremental grass incorporation technique substantially limits odor potential.
5. One good way to form a windrow is to build a grass sandwich: place a load of grass on a leaf/chip layer; add grass; cover with another leaf/chip load, and mix.

windrows. This cannot, however, be used as a substitute for chipping larger pieces prior to mixing into the compost pile. Only brush smaller than 1” in diameter can be mixed into a pile without pre-chipping if a Scarab or similar turner will be used to turn the piles.

Mixing/moistening

Incoming material must be mixed and watered to achieve the desired C:N ratio (30:1) and moisture level (50-60%). Although Michigan composters are rarely troubled by lack of moisture, drought conditions can occur and a method of watering windrows is essential. Water trucks equipped with overhead hoses can be leased or rented, because rarely-used, single-purpose equipment is not cost effective.

Water should be applied to piles when they are “open,” that is, when a concave depression has been made at the top of the pile. A triangular or peaked top effectively sheds water.

Mixing is essential to good composting. Incoming grass must be mixed into windrows or piles within 24 hours of when it arrives. Grass that is already odiferous should be incorporated into leaf piles immediately. A thin covering of wood chips has been shown as a good bio-filter and further measure of odor control. Under no circumstances should grass be left over the weekend without being incorporated into a pile.

Odors can be generated in localized anaerobic pockets in compost piles that have acceptable C:N and moisture levels overall. In order to prevent pockets of high nitrogen, dryness or excessive moisture, piles must be mixed well.

Materials Handling Tips:

- Grass and food waste must be incorporated into compost piles or windrows within 24 hours of when it arrives.
- Begin composting with an optimal moisture content of 55% and C:N ratio of 30:1.
- Mix raw materials thoroughly to distribute C:N and moisture.
- Costs are incurred every time material is moved. Design the site and material handling procedures to reduce unnecessary relocation of material as it moves through the stations of activity.

Compost Production

Site influences

Sites constrained by close neighbors may require additional considerations before a composting system is designed. The compost system must be appropriate to the site, expected volume and type of incoming materials. The proximity of neighbors can create the need for a composting approach that focuses on minimizing odor production, thereby increasing the need for more costly equipment. Turning and screening operations on smaller sites must be more intensive in order to manage the compost process and use of space effectively. Intensive utilization usually requires additional or more expensive equipment.

Scarab windrow turner in action at a USDA demonstration site.

Composting systems

Windrow composting

Windrow composting consists of placing a mixture of raw materials into long, narrow piles that have a triangular cross-section. These piles, or windrows, are then agitated or turned as needed. Windrows are usually formed by a front-end loader or dump truck and can be turned with bucket loaders or specialized windrow turners.
Dimensions for height and width of a specific windrow will be related to the machinery used to create and/or turn it. A pile turned by a front-end loader will be no higher than the loader can reach. A pile turned by a windrow turner must be appropriately sized for that turner.

It is recommended that windrow height not exceed 12 feet due to the potential to develop anaerobic conditions in the center of the pile. The lower limit is approximately 3 feet because piles smaller than this are not insulated well enough to support composting temperatures during winter. Current research has indicated that very wide windrows also impede natural air flow.

Table 3: Windrow Composting Technologies

Compost system	Common applications	Size of typical system
Windrows (w/turners)	Yard clippings	Small - large volumes, capital intensive
Windrows (w/front-end loaders)	Yard clippings, food waste	Small - medium volumes.
Trapezoid Windrow (specialized turner)	Yard clippings	Large volumes processed on less acreage

Trapezoidal windrow composting

Trapezoidal windrows are large square shapes built approximately ten feet high. Turning is accomplished by a rotating milling drum with cutters that shaves a thin layer from the windrow and discharges the material laterally to form a new windrow to the side. The trapezoid method was designed to handle large volumes of material on limited acreage.

The center of the trapezoid is insulated from the convective forces that take place on the surface of the windrow. Because air cannot penetrate naturally through such a large mass, the center tends to develop extremely high temperatures or anaerobic conditions.

Passive or Static pile composting

Passive, or static, piles are essentially windrows turned infrequently with a front-end loader. Piles are limited in height by the reach of the loader, but should not be taller than 12 feet high.

Turning

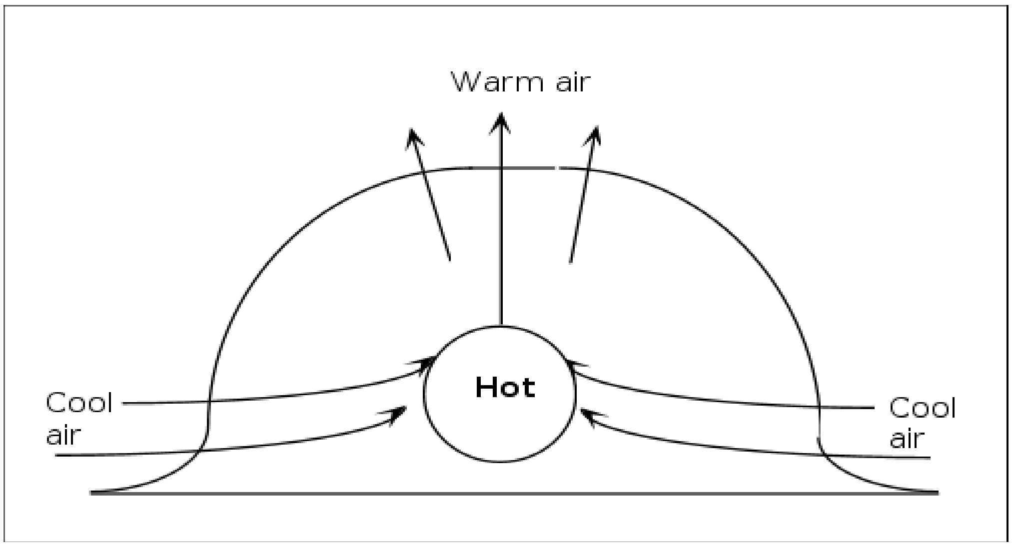
Turning of compost windrows and piles accomplishes the following: homogenizes compost materials, ensures that all materials are located in the center of the pile for some length of time where temperatures are highest, reduces particle size, and temporarily aerates the mix. Turning should occur when the temperature at the center of the pile reaches 140ºF. Turning should occur more frequently in the early stages of composting and less frequently when the composting rate is slower. Sometimes conditions within a pile or windrow warrant more or less frequent turning. This is covered more fully in the section on troubleshooting.

Aeration

Aeration within a compost windrow or pile is achieved primarily by natural convection which is a result of the shape of the pile. Cool air flows up from the bottom of the pile through the hot center and out of the top in what is commonly referred to as "the chimney effect". Air flowing out of a compost pile is warm.

The rate of air flow through the pile will be related to its porosity which, in turn, is related to the size and amount of bulking agents such as wood chips. Figure 1 shows how air flows through compost piles as a result of the chimney effect.

Figure 1 Convection of air through compost piles



Compost "Recipe"

Carbon:Nitrogen ratio

The mixture or "recipe" used to combine organics for compost production is important for a number of reasons. Characteristics of materials added to a mixture can aid or inhibit the decomposition process, aeration, microbial growth and odor production. The mix of incoming materials can dramatically affect the composting process, odor production and the quality of the finished product.

Summer collections are mostly grass

The most important aspect of the compost "recipe" is the Carbon: Nitrogen (C:N) ratio. The best balance for a compost mix will permit composting to proceed at an acceptable rate without generating large volumes of odors that can offend neighbors. A mix too high in carbon will decompose at a slow rate and a mix too high in nitrogen runs the risk of generating ammonia.

The relative C:N ratios of grass (20:1), leaves (between 40:1 and 80:1) and woody trimmings (500:1) require balancing to achieve the optimal mixture with a 30:1 ratio. Seasonal generation patterns require that leaves be accumulated on-site in the fall for mixing with grass and food waste as it arrives in the spring and summer. This method of accumulation can be used to obtain an overall C:N ratio of almost 30:1. A handy rule of thumb for achieving a workable C:N ratio is to mix two parts brown material (high carbon content) to one part green (high nitrogen content) by volume.

Bulking agents

One of the primary reasons for using leaves or wood chips as a primary constituent in a compost pile is the need to provide sufficiently available bulking materials to the compost pile. Bulking agents increase the porosity of a compost pile which, in turn, enhances the capacity of the mass to aerate itself through convection.

Leaves are the most common carbon based bulking agent used with grass clippings because they make carbon readily available when added to highly nitrogenous fresh grass clippings. Other bulking agents that can be used include sawdust, cornstalks, or straw. Leaf piles formed in the fall will be half their original size when spring rolls around.

Grass

The simplest approach to operating a low odor compost site cost effectively is to minimize the quantity of incoming grass. As indicated above, optimal mixes of leaves to grass are between two and three parts leaves to one part grass, by volume.
When a mixing regime of one part grass to three parts leaves is followed, the amount of grass that can be effectively handled is approximately 1/6 of the amount of incoming leaves.

An obvious approach is to reduce the incoming quantities of grass. Some Michigan communities have banned curbside set out of grass as a means of reducing grass volumes accepted at local composting sites. Instead, residents are asked to leave cuttings on the lawn or compost cuttings themselves. Many communities have reduced the quantities of grass generated through educational programs and economic incentives. Grass cycling with mulching mowers and home composting programs are successful mechanisms for reducing the cost of collection, processing, and potential odor production of grass. These programs have helped to reduce monetary and non-monetary costs of operating composting facilities.

Anaerobic materials

The focus of odor prevention is often solely on the composting facility. But all too often odor problems are caused by materials that arrive in an anaerobic state. Grass that has been placed in plastic bags can begin anaerobic decomposition within hours.

Facility operators should discourage haulers from collecting materials and letting them sit overnight or for the weekend in sealed vehicles. Haulers should make an effort to collect residential grass clippings early in the week in order to ensure that lawn materials generated on the weekend do not remain sealed in bags or cans any longer than absolutely necessary. Operating contracts with haulers can be written in order to allow compost operators to refuse tipping rights to loads of grass at the gate that are obviously anaerobic and problematic. This will give haulers an incentive to work to minimize the development of anaerobic loads. It will also provide facility operators with the opportunity to reject incoming loads as a means of corrective action on the behalf of the facility and its neighbors.

Monitoring the compost process

Temperature

Temperature must be monitored regularly since it is the primary indicator of the level of microbial activity and composting rate. Temperatures can be monitored using a temperature probe that penetrates the center of the mass.
Active composting occurs within the temperatures of 70 to 145ºF. Temperatures below 70ºF are too low (microbes become inactive and weed seeds are not killed offf); temperatures above 160ºF are too high (see the chapter on -Troubleshooting).

Moisture

Aerobic microbes need moisture to live. The optimal moisture content of 45-60% moisture can be determined by a simple test called the Squeeze method.
Determining moisture content of compost requires measuring both wet and dry weights. Drying compost samples in a soil oven at 110 degrees Celsius for 24 hours will reveal the percent moisture. The formula for this is:
Wet weight – dry weight/100 = %moisture
It is easiest when you begin with a 10 gram sample before drying
Improperly assembled and maintained piles or windrows may not reach high enough temperatures during the active phase of composting for killing all weed seeds and pathogens.

The "Squeeze" method to monitor moisture levels:

Squeeze a handful of compost to see if any water can be expressed. It should be moist but not wet. Damp as a wrung out sponge. If not, water needs to be added.
If more than a few drops of water can be squeezed out, it may be too wet. If there is significantly more water than this, it will be necessary to add dry bulking agent to avoid anaerobic conditions.

Soil lab drying ovens

Oxygen

Oxygen meters can be used to determine the oxygen levels of the compost mass, however, the data collected from an oxygen meter is more difficult to interpret than temperature data. Oxygen meters are also more expensive than temperature probes.

Compost curing

Compost quality is enhanced by aging, or curing the finished compost to eliminate phytotoxins and stabilize the product. Curing is the final stage of the composting process that occurs after most of the food supply for the microbes has been consumed. It entails placing compost in piles and leaving them undisturbed for a period of several months. Curing occurs when the readily metabolized materials in the original feedstock have been consumed by microbes. Biological activity drops to a low level, as indicated by failure of piles to re-heat and low demand for oxygen and nitrogen, although moisture and aeration needs must be met.

Curing can be done before or after screening, but it is easier to maintain aerobic conditions in the pile if the compost is cured first and then screened. In this way, bulking agents such as wood chips can still be there to enhance aeration.

It is necessary to keep the moisture content in the curing piles between 40% and 50% to keep the compost from drying out. If curing is to be done in static piles, ensure that enough moisture is in the piles when they are formed, since it is hard to uniformly add moisture at a later date without turning. Mature compost is a dark brown humic material which cannot significantly degrade further. The degree of maturity can be measured through laboratory tests, seedling germination tests or estimated by compost reactions in the field. Mature compost is free of phytotoxins that can interfere with plant germination and growth.

Contamination with soil or uncomposted residues, especially after the active phase of composting has finished, can lead to the reintroduction of weed seeds or plant pathogens.

Finished compost can become recontaminated with weed seeds if weeds are allowed to grow and go to seed on or adjacent to the pile or windrow. Keep vegetation adjacent to stored compost mowed short, and tarp piles or windrows to prevent contamination by wind-blown weed seeds. When moving or spreading finished compost, avoid picking up soil or other contaminants from under or around the pile or windrow.

Composting Equipment

Equipment choices should be based on the condition and volume of the incoming materials. The need for more sophisticated equipment generally increases as the volume of materials processed increases. Organic materials in plastic bags require debagging and screening. Brush and other large woody materials need chipping or grinding whether they are commingled with or separated from grass. All materials composted require mixing. Finally, screeners and bagging equipment that may enhance marketability of the final product can be purchased or rented. Changes in the overall waste stream including those brought about by climatic differences, changes in community growth, and the community's yard waste management practices can all dramatically affect the type and relative volumes of materials expected at a site. Facility developers should be aware of community trends before a site is developed in order to anticipate long term organic management needs.

Equipment selections must be robust and flexible in their ability to withstand changes in the incoming stream. Equipment must be flexible because it is less likely to be used frequently if it is suited to management of only one type or form of material.
Equipment Tips:

- ✓ Lease or rent as-needed equipment such as grinders and screeners, if used infrequently.
- ✓ Use equipment with a history of high quality service; try to do an on-site "demo" before purchasing equipment.
- ✓ Have a reliable backup processing plan for equipment failure.
- ✓ Purchase equipment that flexibly suits the incoming material and site.

Equipment replacement and preventive maintenance expenses should be budgeted. Equipment failure during peak times can break a composting business. Annual maintenance costs can be as much as 10-20% of the purchase price of equipment. If you carefully monitor and plan regular replacement the chances of production slowdowns are greatly reduced.

Turning

Turning equipment is used to homogenize compost materials, ensure that all materials are in the central portion of the pile where temperatures are highest for some length of time and reduce particle size. The two major types of equipment used to turn piles include: front-end loaders and specially designed turning equipment.

Front-end Loaders

Front-end loaders can be used for: compost mixing, pile or windrow formation and turning, and moving raw material from one location to another on-site.

Front-end loaders often serve as the most important piece of equipment for small composting systems. A drawback to using loaders to turn compost is that thorough mixing is more difficult with a loader, because materials mat together. The potential for unmixed areas within a pile is greater with loaders than mechanical turners.

Windrow Turners

Windrow turners are specially designed for turning and aerating compost windrows. Large turners are self-propelled, straddle the windrow and allow more intensive use of land. Smaller windrow turners are side-mounted on loaders or tractors which are driven in aisle ways beside the windrow. Windrow turners mix piles more thoroughly than front-end loaders and generally produce a final product with superior texture. Windrow turners are less flexible than loaders because they cannot be used to move material from one area to another and cannot be used to turn static piles.

Table 4: Turning equipment

Equipment type	Cost Range	Capacity	Comments
Front-end loaders	$50,000 to $100,000	500 to 750 cy/hr	Small volume systems
Tractor-driven turners	$10,000 to $90,000	2,000 to 4,000 cy/hr	Also need a loader or tractor
Self-propelled turners	$40,000 to $200,000	2,000 to 4,000 cy/hr	Large volume systems, smaller acreage.

Grinding

Grinding and chipping equipment is used to reduce the size of brush and tree limbs before it is mixed with other materials. This equipment is available in different styles and sizes which vary significantly in price. Hammer mills and tub grinders use metal hammers to break apart material. Hammers need to be maintained frequently and wear quickly when grass is processed with brush. Chippers and shredders process brush by slicing or cutting it with blades. In general, chippers and shredders handle smaller material than grinders and hammer mills. Table 4 lists cost ranges and capacities for grinders.

Table 5: Grinding/Chipping equipment

Equipment type	Cost Range	Capacity	Comments
Grinders	$20,000 to $700,000	10 to 500 cy/hr	Hammers and a rotating tub reduce size.
Hammer mills	$17,000 to $250,000	60 to 450 cy/hr	Uses hammers to crush materials.
Chippers, shredders	$5,000 to $135,000	5 to 300 cy/hr	Uses knives and blades to cut materials.

Mixing

Mixing equipment is used to mix organic materials before composting. Many small compost facilities use only front-end loaders to mix materials for composting. Other mixing equipment includes pug mills and batch mixers.

Pug mills use rotating paddles to mix materials and work faster than batch-operated mixers. Batch mixers are adapted from agricultural applications and produce a homogeneous mix of materials. Windrow turners can be considered a means of mixing compost after it has been formed into windrows. Cost ranges and capacities of screening equipment are listed in Table 5.

Table 6: Mixing equipment

Equipment type	Cost Range	Capacity	Comments
Pug mills	$20,000 to $50,000	20 to 2000 cy/hr	Continuous mixing systems, faster than batch mixers
Batch mixers	$10,000 to $150,000	10 to 500 cy/hr	Batch systems, adapted from agric. uses.

Screening

Screening equipment is used to remove large particles from finished compost before it is sold. This includes rocks, twigs, large wood chips or any other foreign matter that reduces final product quality.

Operators that are interested in marketing their finished product to specialty markets should investigate particle size requirements of that market. For example, compost that is to be used as topdressing for a golf course would need to have a smaller particle size than material that will be used to replant vegetation after road construction. Trommel screens are commonly used at compost facilities. A trommel screen is essentially a rotating drum with holes that is either inclined or contains internal flights to move material along as the drum rotates. Other types of screens shake or vibrate to separate finished compost from unwanted objects.

Table 7: Screening equipment

Equipment type	Cost Range	Capacity	Comments
Screeners	$50,000 to $180,000	10 to 200 cy/hr	Screen sizes vary. Investigate sizing needs of the markets being served.

Other equipment

Other equipment that can be useful at compost facilities is listed in Table 8. This equipment is often only cost-effective for sites that handle large volumes of material, or volumes of food waste that exceed optimal mix ratios and need to be contained.

Table 8: Other equipment

Type of Equipment	Purpose	Comments
Debaggers	Breaks up plastic bags	Finished compost likely to contain plastic pieces
Bagging equipment	Used to place finished compost in bags	Very expensive, used primarily at high volume sites.
In-vessel or enclosed composters	Containerized composting systems to grind and compost food waste, compostable food serving products, animal bedding, bio-solids in a controlled environment	Expensive, used mainly where food waste or bio-solids is the highest volume material (not considered yard waste composting)

Equipment reliability

The resurgence of composting popularity in the last few years has driven the development of new equipment and new approaches. Windrow turners, screeners, and other “specialized” composting equipment have come to the market with many claims about capability and quality. Some of this equipment was developed for markets that handle different materials such as agriculture and the gravel and waste management industries. Equipment developed from agricultural applications has the greatest number of characteristics in common with composting.

Development of windrow turners and screeners has been an area of great innovation and difficulty. Facility operators need to be sure to work with equipment that has been developed and refined for use in yard clippings compost programs. Conditions prevalent at a particular site also need to be taken into account.

Equipment "disasters" often occur during periods of heaviest use. Develop a back-up plan for when equipment fails.

In late spring and early summer, an inability to turn and incorporate incoming grass can mean the difference between idle neighborhood curiosity and court restraining orders.

A facility operator should try to purchase equipment with a track record. Because composting equipment is a relatively new development, operators often end up with prototype or early design versions of equipment. Under such conditions, it is advisable to obtain a guarantee from the manufacturer for the cost of service and reworking defective parts.

Prototype equipment, while frequently innovative and effective in test circumstances, often requires considerable field experience before adequate durability can be achieved.

Equipment Tips:

- ✓ Talk with other operators to find out what equipment they have used and what the service record has been.
- ✓ Have equipment demonstrated on-site with your material. If possible, have it demonstrated during adverse weather conditions.
- ✓ Purchase equipment with a proven track record.
- ✓ Air conditioning is necessary.

Scarab windrow turner

Staffing

Qualifications

The pool of skilled compost facility operators is small and it is unlikely that hiring experienced staff is a significant consideration, particularly at the laborer level. However, there is a tremendous need for mechanically talented individuals with the ability to reason systematically. It is necessary to ensure that all site workers understand the need for hard work and attention to detail. Operational costs depend on a number of staff on-site and the effectiveness with which they work. Choosing and training staff well are a significant part of a facility developer's job. Large equipment operators and farmers provide a good pool of applicants.

- **Hire people who have solid mechanical skill and demonstrate attention to detail.**

Personnel utilization is seasonal. The most intensive operation of a yard waste composting site is during the late spring, summer and early fall months when most organic materials are generated. The need for staffing can drop practically to zero in the winter when deliveries to the site are limited. New hires need a basic understanding of the biology of decomposition and how daily operations might affect that process. Development of successful operations is a site-specific process dependent on the efforts of individual staff members in individual situations.

- **Train all staff in the basic principles of composting.**

The successes of your employee depends on both training and on-the-job experience each play a role in. Staff will be required to operate and maintain equipment, monitor and sample compost piles, administration and gate management. Laborers will also be needed for debagging and other unskilled jobs.

- **Initial training**

Initial training should include the basics of composting operations, data collection, and record keeping. Simple operations such as recording the temperature of windrows and piles, determining moisture content, and monitoring oxygen levels are all important diagnostic tools which form a lasting record of the daily successes and failures of site management. Like many other long term processes, composting requires early attention to indicators of failure in order to respond to problems on a timely basis.

Another area of importance at any compost facility is equipment maintenance and repair. All equipment, whether specialized or simple, is under constant pressure to operate. This means that preventive maintenance programs require religious adherence and that frequently replaced or hard to obtain parts should be kept in inventory. Because downtime is risky for a compost operation, a talented mechanic must be available in the event that failure occurs in spite of preventive maintenance.

Safety is an important issue although few standardized rules have been developed to cover compost operations. Basic "common sense standards" should apply with regard to safety. Lock-out and tag-out procedures should be employed to ensure that maintenance workers and mechanics are not injured. All staff should also be aware of problematic climatic conditions that can lead to heightened odor emission, the presence of *aspergillus fumigatus*, and other airborne hazards.

Operators of tub grinders, windrow turners, and other heavy equipment should be fully trained in the operation of this equipment and should be required to wear the appropriate safety protection. This may include safety shoes, hard hats, eyeglasses or other gear as appropriate. Visitors to the site should be restricted from operating areas and should be given standard head and eye protection when they accompany staff into working areas. Exposure to the elements is another concern for workers, particularly under extreme weather conditions.

Training Tips:

- ✓ Train staff members in proper data collection and record keeping techniques.
- ✓ Train staff members in proper safety procedures.
- ✓ Training in equipment maintenance is extremely important.

Ongoing training

Training at a composting facility is an ongoing process. New developments in composting practice occur constantly and are frequently presented in periodicals devoted to composting practice. The most effective training, however, is achieved in the process of developing an operator's "feel" for what works on a particular site with a particular waste stream.

All staff should be encouraged to share insights into successes and failures that occur on a daily basis. Records of all test and monitoring should be made available so that they can be used to inform operating decisions routinely, rather than only during crisis situations. As an incentive, operators and staff should be rewarded for their increasing knowledge with the opportunity of increased compensation, short courses and seminars where they can share their experience and learn from others. Encourage staff to continue composting training through participation in short courses and seminars.

Trained employees help to maintain consistency and quality.

Regular Operations Schedule

Time period	Operation
Daily	Accept yard clippings, monitor quality, record volumes/weight (trash or debris is removed by person who brought it) Check for odors and take action when necessary. Process (grind or chip) incoming materials, incorporate grass within 24 hours of when it is dropped off. Check site for trash & debris, remove. Check for dust, take action when necessary. Check equipment, lubricate according to maintenance schedule. Maintain pad to provide drainage and access.
Weekly	Turn windrows when they reach 140 ºF Monitor and record representative area of windrows for temperature and moisture levels. General clean-up of site. Clean equipment. Mix windrows as they reduce in size.

Low-Odor Facility Operations

Remediating odor problems can lead to increased processing costs, which in turn, increases the need to process larger volumes of yard clippings to generate higher revenues. Site improvements or additional equipment which might be required to defeat odor problems also require cash. This cycle can continue until the facility becomes legally or economically unfeasible to operate.

At facilities where large amounts of grass are processed, composting must be done under carefully controlled circumstances. Operating standards and methodology play the primary role in maintaining the necessary control, in conjunction with a properly conceived and executed site design.

It is difficult to maintain low odor operations on lowland sites such as this one near a river.

Problematic odors

Composting is a natural process producing little odor in the forest or a homeowner's backyard. Larger amounts of yard clippings increase the possibility of odor generation. A variety of odors can be produced as a result of the composting process. Typical odors include ammonia, amines (fishy smell), sulfides (rotten eggs) and volatile fatty acids. The type of odor produced can provide the compost operator a clue to what's causing the problem and how it can be remedied.

Table 9: Common odors at compost sites

Odor	Cause
Ammonia	Too much nitrogen
Amines (fishy smell)	Anaerobic conditions
Sulfides (rotten eggs)	Anaerobic conditions
Volatile fatty acids (VFAs)	Anaerobic conditions

Managing Operations Summary

Factors affecting process and odors

No matter how big an investment has been made in facility development, the level of operations management represents the most important difference between success and failure. Odor producing compost sites often have difficulties producing a high quality finished compost product. The pursuit of maximum compost volume production must be modified by the pursuit of minimal odor production.

Composting rate

If the primary operational goal is to maximize production of compost, then the most important task of facility managers is to produce an appropriate quality of compost in the shortest amount of time. However, operating experience frequently demonstrates that production cannot be the only variable considered. The rate and quality of the composting process can be linked to the health of the organisms that are decomposing the mixture, which in turn depends on the C:N ratio, moisture levels and aeration. Whether the primary organisms of decomposition are aerobic or anaerobic will also be linked to these factors.

Moisture

Moisture content of the composting mass is one of the most important management variables. Moisture levels should be maintained between 45 and 60% for optimal microbial activity. At most sites the appropriate level of moisture is adjusted when the windrow or pile is first formed. Inability to provide the required amount of moisture will ultimately slow the composting process and require additional management and expense in the long run.

Unusual weather conditions can lead to circumstances where moisture contents are too high. However, excessive moisture contents are sometimes the result of poor recipe mixes with too much grass in the mix as the most frequent cause. Excessive grass in composting mixtures has a number of bad side effects, especially the opportunity for the development of odors. Turning is a technique useful for drying out piles that are too wet because moisture is released during turning. Excessive turning of windrows or piles dries the materials to the point where moisture content is below optimal. For this reason the turning program should be carefully timed to maintain the correct moisture content.

Many facilities in Michigan have found it effective to turn windrows while it is raining in order to add moisture and to prevent excessive evaporation of moisture. This can also be helpful in minimizing off-site odors when turning windrows of anaerobic material.

Moisture levels should be maintained between 45 and 60% for optimal microbial activity.

Aeration & turning

Until recently, few controlled experiments had been completed on the effects of turning frequency on outdoor windrows of yard waste. Work performed at the Southeast Oakland County resource Recovery Authority

(SOCRRA) during the summer of 1994 clearly demonstrated that aeration within a compost windrow or pile is related more closely to pile shape and porosity than to turning frequency. Turning should not be depended upon as the primary mechanism to maintain oxygen in windrows or piles.

This research showed that any additional oxygen made available as a result of turning was removed within hours by the natural microbial activity of composting. Aeration of yard waste windrows or piles is primarily the result of static aeration or gas flow through the pile, commonly referred to as convection or “the chimney effect”. In order to ensure proper aeration of a yard waste windrow or pile, the following guidelines are recommended:

Recipe

Compost must be prepared with sufficient bulking agents to allow adequate interstitial air flow.

Moisture content

Windrows must be prepared so that excess moisture does not inhibit or prevent the flow of air through the windrow/pile.

Windrow/pile dimension

The composting mass should be shaped so that it has a reasonable surface to mass ratio. If the distance to the center of the pile is too large, central portions of the pile will not be adequately aerated, and localized areas of anaerobic decomposition may occur.
While windrow/pile turning is not the primary method of aeration, it should be done routinely in order to promote homogenous and efficient material breakdown. Scheduling of this activity should be done with consideration of the following factors:

Weather conditions

Weather conditions can affect the decision to turn in a number of ways. Most importantly, the site operator must determine the potential for odor generation and transmission.
Turning of piles that are anaerobic or otherwise odiferous should be done with care. It should not be turned on hot humid days when there is little air movement. Similarly, windrows/piles that are known to have low moisture content should not be turned on hot sunny or windy days. Moisture can be added to these piles naturally by turning on a rainy day. Windrows with high moisture content should be turned on windy or sunny days to limit additional water intake. Wind direction is a major in deciding whether to turn piles. Turning and other odor-causing tasks should be performed when prevailing winds favor the composter (winds that carry possible odors away from site neighbors).
It is important to monitor wind direction and postpone activities that release odors when wind is blowing towards most sensitive neighbors.

Time of day

Turning any kind of composting material has the potential to generate odors. Therefore, turning should be moderated any time residential areas or other sensitive receptors (schools, hospitals, churches, office buildings) might be impacted.
Turning during the working day is likely to generate fewer complaints than turning during the evening after most families have returned home. Weekend work in residential areas is likely to be risky during the warmer months.

Season

The worst odors are generated when grass is collected in the spring and early summer. As the season wears on, incoming grass typically becomes drier and less odorous.

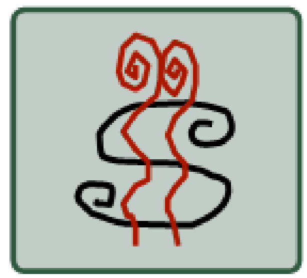
Turning operations during the late summer and the fall have a lower chance for odor production than the same operations completed during the spring and early summer.

Summary Table 10: Low Odor Production Compost Facility Recommendations

DESIGN ASPECT	COMPONENTS
Site Surface Design	Pad Surface Slope • Suitable for quick, efficient leachate outflow and stormwater runoff • Minimum 1% slope for rigid and durable pavements •2-5% for gravel, slag, or non-rigid surfaces with daily grading
Site Drainage Design	Drainage Conveyance Structures • Capable of conveying leachate and stormwater runoff to retention pond without overflow or percolation • Diversion channels to direct runoff and promote sedimentation removal • Stabilization of steep grades with geotextiles, vegetation, or rip-rap Retention Pond Design • Required at sites larger than 0.5 acres or those with high water tables • Restrict/control rate of runoff • Adequate design should reduce quantity and increase quality of runoff
Other Factors	Site Location • Rural or industrial-zoned areas for outdoor technologies to minimize impact • Away from schools, hospitals, or dense residential sectors Quantity of Incoming Material • Too much material can cause insurmountable odor and management problems • No more than 5,000 - 8,000 cy/acre/yr • Establish peak site capacity based on equipment. ***NEVER*** exceed peak capacity-instead, send additional yard clippings to another site. Compost “Recipe” • Balance of several factors: C:N ratio; moisture content; pile shape/size; temperature; oxygen; bulking agents Composting Technology/Operations • Tailor system and operating procedure to type and quantity of feedstock

Best Management Practices for Composting

Part 3: Marketing & Finance



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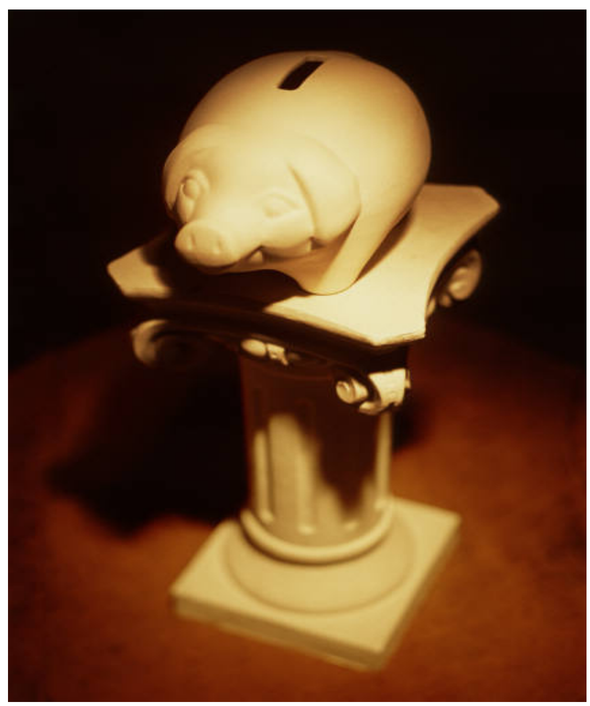
6 Facility Financing

Introduction

Composting facilities have become an integral component of our solid waste management infrastructure. Finding capital to finance composting facilities, especially in light of budget constraints in local communities, present both a challenge and an opportunity for facility developers whether public or private sector. Partnerships between the public and private sectors, in a range of variations, often result in successful financing strategies.

In the sections following, this module will outline several strategies for financing facility capital and operating costs and help you determine which one is best suited for you based on your needs. We will also address the importance of establishing both project credibility and public acceptance to the ultimate success of your project.



The financing tools best suited for you will depend on a variety of issues, including level of private and public sector involvement, size of proposed facility, support for composting in the community, public/private partnership possibilities, public concern about taxation, and the organizational structure of the compost operator.

Establishing Project Credibility

The basics of establishing project credibility vary little between the private sector and public sector. Neither a private entrepreneur nor a community will be convinced to fund a multi-million dollar facility that is poorly conceived or designed. In order to obtain financing for a project, developers should be able to ensure the following elements within their business plan.

5 Key elements of successful operations:

1. Developer Credibility
2. Political Acceptance
3. Technical Soundness
4. Adequate Revenues
5. Regulatory Approval

Developer Credibility

A credible project team has experience in designing cost-effective, technically sound facilities that produce quality compost. When selecting or assembling a project team, look for the following elements:

Management Skills

Compost facility managers have a multi-faceted job. While they must directly manage site operators, technicians and laborers, they must also work to satisfy customers with quality service and products. The project team should be experienced in managing the design and construction of a successfully operating facility in a community similar to yours.

The management team should be: well organized, experienced in working with the public and community officials, and capable of selling the project to financiers and the community.

Technical Skills

Organic waste streams, composting technologies and approaches, and climates differ dramatically from one facility to the next. Not all technologies are appropriate in every situation. In order to determine the most suitable technical approach, it is likely that either a formal or informal feasibility study will be required during the facility development process.

Realistic Financial Considerations

Whether public or private, even the most successful projects encounter difficulties and unanticipated expenses along the way. In order to avoid frustration and delay as much as possible, the Project Team should carefully review the successes and failures of similar existing facilities. Having a source of contingency funds available to meet unexpected developments should be an integral part of facility financing.

Political Acceptance

The perfect site for a composting facility (or any other solid waste management facility) is one far enough from civilization so that noise, traffic, and odors will not be disturbing, while close enough to minimize transportation costs to and from the facility. In reality, these two criteria are usually competing.

Gaining political acceptance of a project frequently hinges on where you plan to build the site. Development of a composting facility within a community is a delicate business.

Before financing a composting facility, the project team should seek a letter of support from the host community and the necessary planning and zoning acceptances. Property that will be purchased or leased should also have purchase agreements and lease agreements contingent on the availability of project financing.

The most effective strategy is to locate the site on public land committed to the project. One way to achieve this is to offer a financial benefit, such as a reduced tip fee or host community fee, to the community which owns the site.

Positive community relations means:

- sharing development plans
- incorporating reasonable criticism
- demonstrating care and concern for the project's impact on businesses and personal lives

Technical Soundness

Most compost facilities employ the most basic windrow technologies, and do not require substantial resources to develop a technically sound facility. In fact, with experienced project team members this could happen quite efficiently without elaborate designs and reports. However, the development of a technically sound facility must be taken seriously and given adequate resources if the project is to succeed. Technical Soundness means: quality product in a reasonable amount of time and cost-effective manner, while minimizing nuisances.

Choice of Technology

The project developer must make every effort to ensure that their choice is one that can succeed. Existing, successful facilities can provide good reference. The industry is young enough, however, that developers should not be overly-biased against new approaches: if successful, they could well provide a substantial and competitive advantage.

Project Engineer

The project engineer should be registered and insured, with experience in designing facilities for communities with similar needs. This will ensure that the developer has recourse if the facility is not developed according to contractual specifications.

Adequate Revenues

Many sites, especially those that concentrate their efforts on processing yard debris, have an uneven flow of revenues throughout the year. These facilities require a cushion of resources in order to continue year around operation when tip fees and sales revenues decline in the colder months.

Tip Fee Generation

A consistent flow of revenue can be generated from tip fees. These fees should be at a contractually designated amount for a defined period. Most facilities attempt to cover operating costs and sometimes capital recovery as well through the tip fee revenues. Typically, a compost facility relies on two sources of revenue: tip fees and material sales.

Material Sales

Startup compost facilities are similar to other small businesses. Every effort must be made to create adequate cash flow by developing long-term contracts at predetermined tip fees, ensuring that a cash cushion is available to carry the operation through slow months, and that high value markets for finished product continue to develop.

The strength of compost markets varies widely between regions for a variety of reasons. Overall, compost is increasingly finding niches, however, as soil amendment, designer potting mixes, horticultural growth media, and for specialty applications.

Regulatory Approval

The regulatory requirements placed on compost facilities vary dramatically from state to state and are based on the types of materials being composted. Similarly, public opinion of composting fluctuates between active support and shrill opposition. A clear understanding of the legal requirements and an open, honest approach to gaining approvals are essential to the success of a facility.

State Requirements

The degree of regulation by state governments varies widely. Some states like California have very stringent regulatory approaches while others have little or none. This has the effect of creating an earlier demand for composting in many areas. However, it is likely that states will increasingly move toward some kind of regulation of composting.

Michigan now requires compost facilities be registered if they produce 7,500 cu yd of compost or more annually.

Local Requirements

The most important regulatory and permitting requirements can come at the local level. Here, regulations can be developed to deliberately encourage or directly impede the development of composting facilities. Frequently, composters interested in starting a site find that local zoning and planning agencies have not considered composting. Project developers may experience a range of reactions based on local folklore about the effects of composting sites.

Prospective facility operators must thoroughly understand the regulatory and permitting climate in which they intend to develop their compost facility

Prospective facility operators must thoroughly understand the regulatory and permitting climate in which they intend to develop their compost facility. Some areas might well impose requirements that are too burdensome for successful project implementation. Even where regulations appear conducive to facility development, care should be taken to preserve good community relations and influence the regulatory climate to make it more favorable to composting.

Financing Capital Costs

This section provides compost entrepreneurs ways to identify appropriate funding sources. It is not intended to provide an in depth education but to briefly summarize each approach to developing sources of capital to assists the user in determining an appropriate approach.

For quick reference, Table 1, at the end, summarizes the advantages and disadvantages of each type.

Solid Waste Management Fees

To fund publicly-owned solid waste projects like composting facilities, public agencies may levy a solid waste management fee on all persons owning property and benefiting from waste collection service or a disposal facility. The public agency may use these fees to pay for the cost of solid waste management facilities, for the operation and maintenance of facilities, and for the payment of principal and interest on bonds.

A fee established by a public vote creates a strong source of revenues and usually results in a more favorable credit rating.

Variable fees are the most equitable type of fee, since costs are based on the amount of service provided. Variable fees can also be based on the difficulty in providing the service (e.g., distance of property to the facility). Flat fees, while that are equally distributed among taxpayers may not necessarily represent the most equitable distribution among those receiving solid waste services.

The major disadvantage is the potential difficulty in obtaining public approval for the fee. However, the fee and the solid waste service should be perceived as connected and, if distributed according to benefit accrued, this mechanism may create an incentive for waste reduction or material recovery. This approach is best suited to small, cohesive communities that perceive composting as beneficial and worthy of public funding.

Fees can be assessed several ways:

- A flat charge for each residence or building
- By weight or volume of the refuse received
- By average number of containers or bags of refuse received
- Relative difficulty of collection or management of received solid waste
- Other criteria unique to the client

In some cases, a public notice and a public hearing is required prior to establishing these fees.

Tax Levy

Within some public agencies such as an Act 185 County Department of Public Works or an Act 179 or 245 Solid Waste Authority, the public agency may impose special taxes for the purpose of providing solid waste management services to residents within a specified jurisdiction. These services are increasingly being viewed as including organic material recovery through composting. Although this power may vary based on local conditions depending on property taxation limitations and other factors, some degree of tax levy is usually possible. In any case, without the financial protection of flow control for a public facility, double-barreled bond issues (tax backup plus revenues) may be necessary if this approach is used in financing compost facilities. ***Flow control*** uses regulatory or economic means to direct materials to a designated facility. *Regulatory* flow control has been successfully challenged as unconstitutional and is not considered a viable means of ensuring supply. Communities may still employ *economic* flow control, offering favorable tip fees to attract materials to a desired facility

A tax levy provides a very predictable revenue stream for program financing. As such, it is well-suited for longer term costs such as debt retirement.

A tax levy carries with it certain disadvantages as well, especially when used to cover program or facility operating costs. Put another way, tax-based systems remove consumer choice from the funding mechanism. Additionally, it can be the cause of the second major problem with tax-based systems: public acceptance.

Tax-funded public services have become politically unpopular in many places of the United States, an anathema to the meaning of good government, regardless of the quality of the service being provided. As with the agency fee system, public acceptance must be cultivated and the provision of services carefully matched with implementation of the tax collection mechanism.

Bond Financing

Two types of bonds may be issued by a public agency: general obligation bonds and revenue bonds. Generally, bond financed capital facilities must either accept public bids for the facility or adopt a resolution approving a request for proposals.

General obligation bonds are issued against the assurance of the financial stability of the state, city, or public agency issuing the bond. Each entity has a limit on the amount of debt that it can incur. The issuing body may levy a special property tax to fund the issue of waste management district bonds for the payment of facility costs. These bonds are special obligations of the city, state or public agency, not a corporate obligation or indebtedness of the units comprising the bonding authority. Proceeds from the sale of the general obligation bonds must be kept as a separate and specific fund to pay the cost of the facilities or services.

Revenue bonds are special obligations of the public agency and are payable only from pledged facility revenues. A city, state or public agency may borrow money and issue revenue bonds. Revenue bonds are funded based on the strength of potential income streams generated by the infrastructure project. The revenues may include monthly user fees, disposal fees, or revenues from sale of materials.

All bonds, bond anticipation notes and interest, and securities issued in connection with financing of solid waste management facilities are tax-exempt, as are revenues received by the city, state or public agency governing authorities.

Backed by tax revenues, bonds are the most secure type of tax-exempt financing. The market acknowledges this in pricing such debt, with lower interest cost than revenue bonds of the same rating.

The service provider can usually provide additional credit support through construction, performance and operating guarantee, and the governmental body will provide “put or pay” contracts. These contracts commit the county to guarantee delivery of a minimum tonnage of solid waste and pay a tipping fee whether or not the guaranteed waste is delivered and the facility is operating.

Lease Financing

Capital purchases can also be funded through lease financing. This method is frequently used to purchase either fixed equipment to be installed in the facility or rolling stock equipment, such as forklift, wheel loader, containers, collection vehicles, or windrow turners. The term “lease” is typically for a shorter period (three to five years) than bond finance arrangements, and the cost of financing is typically higher. In many cases, however, the security on the lease is provided by the equipment itself.

Lease financing of equipment is most useful when other capital financing approaches are not available. However, costs of lease financing are high because shortened terms require that capitalization be recovered over a shorter period. The cost of lease financing prevents it from being used as an ongoing capitalization strategy. It can, however, be a useful approach for small equipment purchases between major capital projects or as a means for “bootstrapping” a project in its infancy when there are few other alternatives for capitalization.

Agency Funds

Public service organizations, whether county, city or public agency, will have access to ongoing agency funds from their annual operations. Larger operations will have an equipment-capital replacement line item in their budget and an annual capital appropriation mechanism that guides long-term capitalization and capital replacement.

Advances from other fund reserves in the system can be the source of capital that is replaced through the capital replacement payments in that year's budget. New capital acquisitions, if timed correctly or if small enough in size, can be fit into this system.

This type of funding allows local governments to enter the composting business and works well with publicly-funded, privately-operated facilities. Assistance from the public sector can make private responsibility for composting a reality in a community. Operating improvements, such as truck purchases, drop-off station equipment, building modifications or processing equipment, can be handled through an agency funding approach if there is a large enough public organization already in place. Many counties with large public works departments in place may find this extremely useful.

Grant and Loan Opportunities

Many states have developed solid waste management funds, grants and loans, and outright subsidies for waste reduction, recovery, and management initiatives. These programs were created to focus economic development efforts on integrated solid waste programming. In many projects, inexpensive loan financing makes a project possible. Careful attention to the rules of such funding programs should be paid in order to distinguish the general eligibility of composting facility development. Many economic development loans are offered at interest rates equal to or below the prime rate.

The obvious advantage of grants or public sector loans is that they lower overall project costs. Loans, while requiring a payback, may still be advantageous at a five percent interest rate. There are drawbacks to a grant program, foremost among them future funding uncertainty. In addition, the timing of grant application, award and receipt of funds can disrupt project development. The effect of any waiting period on reaching program goals must be weighed.

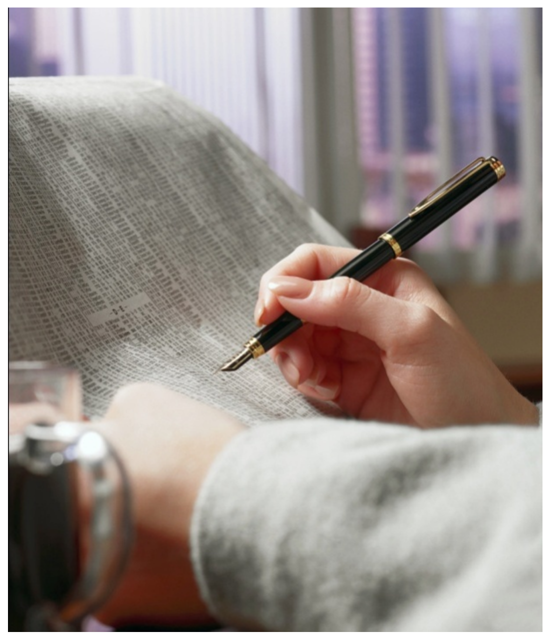
Private Sector Equity and Bank Financing

The public sector can leverage significant investment in solid waste facilities and services from the private sector. Public-sector leveraging can take the form of capitalization through equity contributions, cash reserves from larger private firms, or bank financing allotted to private firms

The public sector may take steps to guide, encourage and control this investment through licensing, goal setting and economic flow control.

Private financing avoids placing an administrative or tax burden directly on the county (ies) or local units. Such financing can often be implemented more quickly since the approval process may be much simpler. As well, private sector financing also offers more flexibility in timing and quantity than public-sector funding, unlike a large public sector bond issue.

Perceived lack of public sector control is often the most common argument against private sector project capitalization. There are ways to introduce some control, however, through licensing, contracts, and flow control. The use of private sector financing does inevitably bring with it the risk of abandonment as private sector firms may go out of business or pursue other more lucrative markets.



Private sector financing has an element of uncertainty and unpredictability. Contingencies include a binding public sector contract that provides appropriate guarantees and remedies should private financing fall through. This is one of the main reasons that reliance on private sector financing is typically matched with suitable contractual commitments as required by the public sector.

Financing Operating Costs

Operating costs are typically funded through a combination of operating revenues. The following section briefly summarizes each approach to developing sources of operating revenue and assists the user in determining whether a given approach is appropriate.

For quick reference, Table 2, summarizes the advantages and disadvantages of each type. It also provides the names of contacts with experience in the use of the fee.

Facility Tipping Fees

Facility tipping fees, paid at the gate of a compost processing facility, are the most common method used in other sectors of the solid waste and material recovery industry to cover costs of operation.

Variable or differential tip fees are used to allocate accurately the cost of processing each material. For instance, tip fee surcharges may be assessed against materials requiring additional processing, e.g., bagged materials. Where possible, this type of economic incentive provides the operator with an excellent opportunity to use best management practices (i.e., to achieve quicker material degradation or higher quality product) on a consistent basis.

Tipping fees are used in many composting facilities. Differential tipping fees can offset costs and encourage material recovery. Additionally, where service programs are linked, for instance a compost facility at a landfill, tipping fees can be used for cross-subsidization. If recovery is to be encouraged, a landfill tip fee surcharge can help to subsidize total compost facility costs.

Once composting facility operations are underway, sometimes higher landfill tipping fees can be established to encourage use of the new facilities. One advantage to tipping fees is that they equitably apply to all facility users. They can also be easily increased or decreased to cover costs. In the absence of flow control, a disadvantage is that fluctuations in the market may result in haulers using other facilities with lower tipping fees. As a result, revenues cannot always be easily predicted. In the presence of flow control, haulers have complained that tipping fees are higher than those of competing facilities.

Facility tip fees…

- are the most common form of operating revenue
- should be set lower than rates charged for other forms of disposal
- can be collected on the basis of *weight* or *volume*

Scalehouse and scales at BVSWMA landfill entrance College Station, TX.

Collection Fees

This funding mechanism is presently used by many refuse haulers to cover both collection and disposal costs. It is also used as a method for funding composting collection and processing services to businesses, multi-family complexes and households.

Under a standard subscription service, all users pay the same fee for collection services. This easily administered approach has the advantage that revenues can be simply and accurately predicted. However, this type of fee provides no economic incentive to recycle or reduce organic waste production.

Collection fees are usually established in the form of a periodic subscription service.

A variable rate fee structure is another type of collection fee system commonly used. These systems allow the user to pay for refuse collection proportional to his or her actual use. Variable rate structures should be encouraged whenever possible if collection fees are to be used as a major funding source for composting facility operations.

Among the advantages of this system is that it offers an equitable charge based on the volume of material generated and encourages organic recycling when the rate structure has lower charges (or no charge) for recyclables. The primary disadvantage is that it costs more to administer.

Bundling of collection fees is a good way of guaranteeing user participation. Under this approach, the costs for the recycling and yard waste collection are bundled into a single collection fee. The bundled fee is based on the amount of waste placed for collection. The recycling service, however, is provided as an add-on service that does not increase the fees if more recyclables are set out. This approach rewards recycling behavior while increasing costs when they put more trash out.

Landfill Tipping Fee Surcharge

Communities that own or host a site may consider levying a surcharge to landfill tipping fees to align fees with true disposal costs, raise funds, and provide a negative incentive for disposal.

A local surcharge offers an effective method for capturing the avoided cost benefits that are realized in future years – such as rising disposal costs – or to finance start-up and large capital investment costs.

A surcharge is also a good means of supplementing operations of recovery efforts throughout an entire community. As such, the operation of compost facility would not be substantially dependent on this means of funding. Instead, funding from a surcharge could be used to do extra things like fund special equipment, create education/ promotional programs, and develop markets for composting. Facilities entirely dependent on this mode of funding suffer in the long run as resources dwindle.

Local tipping fee surcharges may be legally challenged that are imposed by local legislation and if private landfills do not contractually agree to participate. Local surcharges are generally negotiated with the landfill operator in exchange for public sector support of the facility and as part of a broader host community agreement.

Another disadvantage arises because a steadily increasing rate of waste stream diversion, composting, and source reduction results in a steadily decreasing revenue stream. Thus, if composting activities are financially dependent on the surcharge as a major revenue source, they can be financially encumbered by their own success.

Some of the collected revenues should be directed to benefit community members directly. Tax reductions, general fund subsidies, or special project funding could all be considered. Tipping fee surcharges can be used: to compensate communities for road use, odor problems, etc. to discourage disposal and encourage recovery and recycling efforts

Bagged compost is ready for retail sales labeling and quality assurance stickers or for wholesale to a retail outlet that will apply its own label.

Material Sales

Material sales are another cash revenue stream that can be used to offset costs.

In general, markets for composted organics are becoming stronger. The successes of some compost-based products in different areas around the country lend credence to the claims that market revenues will eventually be a considerable source of cash flow.

Material sales provide the operator with an additional source of revenue to go along with tip fees or collection fees. Sales are directly related to the facility's success in efficiently composting its incoming organics. Strong material sales revenues create strong incentives for the operators to continue to be good operators.

Materials revenues are a good funding source for operating costs, but the variability of markets means that no facility should consider them a *sole*, or even *primary*, source of revenue. Because supply and demand fluctuate widely, it is difficult to accurately predict prices and therefore difficult to predict the revenues to be available. Eventually, revenue streams from the sale of materials will become more stable and predictable.

Bulk sales may make up the largest portion of your business.

Table 1: Comparison of Financing Sources for Facility Capital

Source	Advantages	Disadvantages	Contacts
Solid Waste Management Fees	Public support creates a mandate for development Costs are equally distributed	Costs may not be equitably divided between system users Public approval is difficult to get	County or District Solid Waste Coordinators BPW, City or County Councils
District Tax Levies	Can be used in conjunction with bond issue Predictable stream of revenue	Allocation of tax is not based on facility usage Reduces the leverage of consumer choice Require a tax increase	County or District Solid Waste Coordinators BPW, City or County Councils
Bond Financing	Bonds issued by City, state or districts are tax exempt Extremely secure and predictable financing means	Bond payments need to be regular Repayment often requires “put or pay” contracts	Bond counsel to cities, states, or districts Small business assistance agencies
Lease Financing	Easier to qualify Equipment can be its own security Lease can be arranged quickly	Limited to “lease-able” equipment High financing costs	Equipment manufacturers and representatives Credit agencies Small business assistance agencies
Agency Funds	No cost of funds Expenditures can be planned in budget cycle Sometime capital reserves can be tapped	Major facilities could take years to fully fund Inaccessible to private sector Threatened by budget cutbacks	City Manager, County Executive, and Solid Waste Coordinators
Public Grants and Loans	Low or no cost funding Provide good seed for other sources	Uncertainty of funding Timing of grants is usually longer Elaborate rules for grants limit fund uses	State DNR, Commerce, and EPA officials State legislators Solid waste consultants
Private Equity and Bank Financing	Unlimited and immediate funds for attractive projects Management assistance from financiers Reduces tax burden	Financing is risk-averse Management interference from financiers	Local bankers Venture capitalists Private investor services Small business assistance agencies

Table 2: Comparison of Financing Sources for Operating Costs

Source	Advantages	Disadvantages	Contacts
Facility Tipping Fees	Common, well understood means of collecting revenue Can easily be used to create incentives for recovery Differential tip fees are a fair way to allocate costs	Fluctuations in markets may tip fees to rise and fall In the absence of flow control, revenues are unpredictable	County solid waste coordinators and planners State DNR and EPA regulators
Collection Fees	Common, well understood means of collecting revenue Can easily be used to create incentives for recovery	Costs more to administrate When fees are poorly applied, costs of composting can be misrepresented	Local solid waste haulers
Landfill Surcharges	Can be contractually negotiated as part of permit or support process Effective means of capturing future year benefits	Illegal for public sector to impose on private landfills Steadily increasing rates of landfill diversion reduces revenue stream	Privately owned landfills Publicly owned landfills
Material Sales	Revenues are proportional to size of facility Strengthening markets bode well for economic strength of facilities	Lack of market awareness reduces current sales Strength of market varies regionally	State and national EPA, Departments of Agriculture Natural Resources, and Commerce Land grant universities •Composting Council Soil and Bark Producers Assoc. National Recycling Coalition, National Solid Waste Management Assoc.

7 Compost Marketing: Concepts & Tools

To produce compost that meets consumer expectation, it is essential to ascertain the potential buyers' requirements for quality and quantity when designing the facility. Attention to in-coming material, procedures, and adequate curing will ensure consistently high quality compost.

A good marketing strategy must demonstrate the benefits of and applications for compost to compete successfully with other soil products. While compost imparts a broad range of benefits to soil and plants, different grades of compost are appropriate for specific uses. In all cases, the compost operator must concentrate on delivery of a consistently high quality product that is available in reliable quantities.

Good marketing will include a variety of ways that will attract the attention of the consumer.

Benefits of Compost

Compost is best known for its soil enrichment value. The addition of compost improves the physical, chemical and biological properties of soils and potting mixes. The use of compost for plant growth purposes requires consideration of factors such as the crop or plant to be grown, type of soil at the site, and specific compost characteristics. Benefits of compost as a growing media are included in Table 1.

Mature, properly produced compost has also been gaining recognition for its ability to absorb odors, bind contaminants from polluted water and soil, control erosion and degrade toxic chemicals. Between increased research on the benefits of compost as a growth media and interest in its use in bioremediation, the future for compost markets is promising.

Table 1: Benefits of compost

Physical:	•Decreases bulk density, reduces compaction, allows better root penetration	• Improves soil structure and increases water holding capacity
• Darkens soil and increases heat absorption	• Improves drought tolerance	• Reduces soil erosion
Chemical:	• Slowly releases nutrients	• Reduces fertilizer needs by up to 50 %
• Good source of micro nutrients	• Increases cation exchange capacity which enables soil to hold nutrients more strongly and resist leaching	• Buffers soil pH
Biological:	• Increases microbial activity in soil, releasing nutrients from organic matter	• Good source of micro nutrients
• Increases plant survival rate and growth	• Strengthens plant resistance to parasites	• Produces higher crop yields
• Buffers soil pH	• Can reduce soilborne plant diseases	• Plants develop thicker and more active root systems in a short period of time.

Compost Market Planning

Composting should be approached as the production of a revenue-generating organic material, rather than disposal of a waste. The shift in focus toward revenue generation will affect the quality of the finished product and the way customers view compost, resulting in higher demand for the product. Efforts spent in planning to produce a quality compost from the start will pay off in returning customers.

Basic marketing strategy and steps:

1. Understand compost attributes

2. Assess volumes and sources of compostables

3. Identify market sectors in your region

4. Survey organic soil product consumers

5. Identify processing needs

6. Analyze cost/benefit markets trade-offs

7. Follow your plan

8. Evaluate results and modify plan

Repeat as needed

Understand Compost

If you aren't already well-versed in the organics industry, DO YOUR HOMEWORK! Specific attributes of compost make it similar to, and therefore a potential replacement for some competing soil products.

Compost also offers unique benefits; however, negative effects can result from using compost incorrectly. New research and field experience is rapidly expanding our understanding of compost properties and the ways it can work.

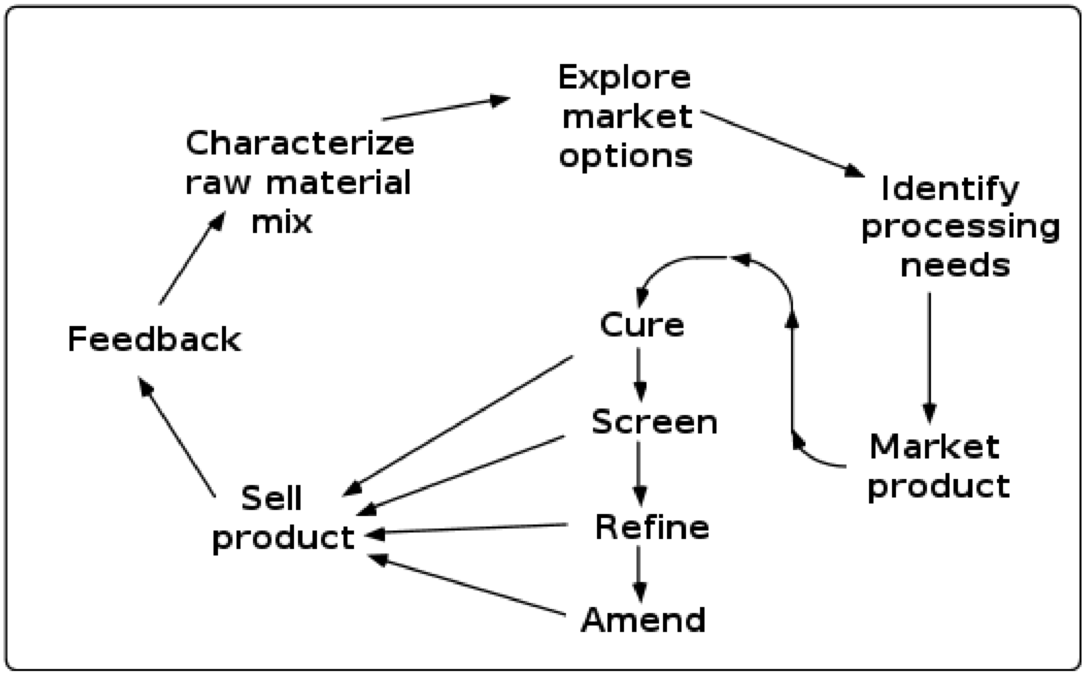
Identify the people and institutions your potential customers trust for advice regarding new soil products. Develop a relationship with researchers and extension agents at the colleges and universities in your area. Extension agents work regularly with growers and equipment manufacturers and are well educated with regard to scientific research. The list may also include researchers, product distributors, journals, and conferences where the industry gathers to look at new products and discuss ideas.

Assess Quantity of Available Compostables

The total quantity of compost produced will affect marketing options, as well as facility sizing and design. Growers may decline to try compost because sufficient quantities might not be available to meet the needs their whole operation.

To determine the annual volume of compost that will be produced, municipal managers should estimate the volume of compostables generated within their political boundaries. From this figure, the amount of finished compost can be calculated, which is roughly one-fifth of generated compostables. Private compost operators may have a more complex decision regarding the sizing of their facility.

Compost Market Planning



Explore regional markets

The full spectrum of compost market sectors should be considered. Because actual markets for compost vary widely from one community to the next, an assessment of the organics industry in your region is essential to understand the potential for compost use in your locality.

Prospective market sectors
• Landscaping • Sports Turf • Home Gardening • Nursery/greenhouse • Agriculture (fiber, food, sod, forestry) • New Uses • Soil blenders and brokers

Consider markets within a 50-mile radius of the composting facility. With a low value in relation to weight, transporting soil products beyond this range is rarely cost effective, even in wholesale quantities.

Survey consumers

When choosing an organic product, buyers look for particular effects such as quick drainage, low weight, durability, or dark color. By focusing on a grower's objectives, compost producers can gear their product to meet those needs, or decide to market the compost to one they can meet.

Soil amendment buyers also examine service factors such as availability, bulk purchase pricing, pickup options, storage and delivery services.

A market survey can help identify potential users of compost products, level of demand, price paid for similar products, desired qualities, location, peak demand months, purchase terms and delivery conditions. Listed below are five key questions for representatives of market sectors.

Key Questions for Potential Users

- Do you purchase soil products? (topsoil, peat, etc.)
- What are important attributes in determining product use?
- How much does your operation consume annually?
- What is the cost per cubic yard for soil products?
- What packaging, delivery, storage, payment options are important?

Get to know the needs of potential users of compost in your area before choosing where to focus precious marketing dollars. Keep an eye on similar products available to buyers and look for marketing opportunities.

Identify processing needs

Raw materials influence the physical and chemical properties of compost. Yard clippings alone tend to produce a compost with lower nutrient levels than food waste and animal manures. High rate aerobic composting will prevent sour, low pH or odorous finished products. Removal of visible manmade contaminants is essential for most markets, and requires control of incoming feedstock and screening equipment. Complete curing requires storage space.

Analyze trade-offs

The extra expense required to meet quality standards of a higher value market should be analyzed thoroughly. Estimate the profit margin for each sector, taking into account the extra costs you would incur in meeting specifications. Consider the advantages and disadvantages of finding one buyer for the majority of your compost or of contracting out the marketing of your product.

Marketing compost requires specialized knowledge, skills, industry contacts and time. As the amount and variety of compost in the marketplace increases with new compost facilities coming on-line, competition for buyers can be expected to increase. On the other hand, potential markets become more familiar and comfortable with compost with use.

Companies that control a big share of the organics market often hire customer service staff. Their role is to educate consumers on the proper use of the product and ensure that last year's product performed satisfactorily and to know ahead of time what custom processing or refinements must be done for next year's product to keep up with the changing needs of their repeat customers.

Follow your plan

Once you have surveyed your regional options and designed a marketing plan, give it time to succeed. Fits and starts and changing direction will not yield results as quickly as persevering with a well designed plan.

Evaluate results

Systematic monitoring of your marketing strategy will reveal its effectiveness. If no one makes it their job to inquire about customer satisfaction, you cannot be certain whether or not they were pleased with the product.

Product Quality Standards and Control

Why have standards?

Standards define a material in a way that allows consumers to match the product with their needs. Standards let consumers shop for value and purchase product with known characteristics that produce a desired effect. User needs tend to be specific; no single standard of quality is universally accepted. However, the Michigan Recycling Coalition and Composting Council, and the National Composting Council continue to refine compost standards, test methods, and user guidelines.

Compost Quality Issues

Compost quality is enhanced by curingafter stabilization. Compost is cured when readily metabolized material has been consumed by the microbes. Biological activity drops to a low level, as indicated by failure of the pile to re-heat and low oxygen demand indicates that moisture and aeration needs are met.

Compost quality is a function of many variables, including appearance, pH, organic matter and nutrient content, phytotoxicity due to lack of maturity, odor and other properties

Curing takes from one to six months, depending on complexity of the feedstock and efficiency of the composting process. The curing stage eliminates phytotoxins (poisonous to plants), and kills weed seeds and pathogens. Mature compost is a dark brown humic material which degrades at a much slower rate. The degree of maturity can be measured through lab tests or estimated by compost reactions in the field.

All compost products are not created equal.

Finished compost can vary significantly in chemical attributes like pH and soluble salt content, and in physical qualities like particle size, color and bulk density. These differences can result from variance in the initial recipe mix, feedstock characteristics, processing methods, refining steps, and additives.

Although native soils buffer crops to some extent from variations in pH and other parameters, container-grown plants are more susceptible. Commercial growers raise high-value crops and can ill-afford even small failures due to poorly formulated growing media. Although its capacity for storing plant nutrients is enormous, compost is not a magical treatment for every plant.

Understanding and effectively communicating the properties and capacity of your product(s) will ensure their proper application and overall success in the field.

Testing

Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, requires that composting facilities maintain records that demonstrate that the composting is being done in a manner that prevents nuisances and minimizes anaerobic conditions. Included in the records that must be kept is the requirement to perform testing on the finished product. This ensures that the composting process has been completed and that the end user understands what the finished compost contains and how to use it. Each pile or mix design should have a sample tested, on a yearly basis. The Department of Environmental Quality (DEQ) suggests that the finished compost be tested for the parameters listed below, at a minimum.

- Ph
- Carbon to Nitrogen (C:N) ratio
- Electrical Conductivity (i.e. soluble salts)
- Total nutrient analysis
- Total N, P, K
    - Calcium
    - Magnesium
    - Sodium
    - Zinc
    - Manganese
    - Copper
    - Iron
    - Boron
    - Aluminum
    - Molybdenum
- Chloride
- Sulfate
- Foreign matter content
- Pathogens (Fecal coliforms and Salmonella sp.), if manures were composted
- Maturity test (i.e. Solvita Test)

Soil Blending

Soil blenders often add ingredients to soil products to adjust attributes such as pH, color, or nutrient value as needed by customers for specific applications. Possible additives include:

Table 1. Additives used in Soil Blending

Additive	***Source***	***Objective***
Ammonium sulfate	chemical fertilizer	increases nitrogen content
Bone meal	bones	increases phosphorus, pH
Ferric sulfate	chemical salt	lowers pH, darkens color, adds iron
Peat	partly decayed vegetation	holds water; decreases ship weight
Perlite	volcanic ash	Increases

		aeration, drainage
Sulfur	element	lowers salinity, pH

When adding amendments to compost, it is important to measure and mix well for a homogeneous product. Specialized equipment for metering and blending is advisable.

Work hard at making a consistent product. Higher quality won't attract customers if they cannot depend on it with every purchase. A container nursery operator will be less forgiving of product deviations than some other buyers, because the crop at risk is so vulnerable and valuable.

Products that compete with compost sales include: Peat moss, reed-sedge peat, sphagnum peat; manufactured or blended topsoil; and composted animal manures (bagged).

MDOT standards

The Michigan Department of Transportation (MDOT) in partnership with the Michigan Recycling Coalition and Composting Council (MCC) developed a special provision that sets forth requirements for compost used in MDOT projects. See the Resources section for a copy of this provision. Compost producers who wish to have their product considered for use in MDOT projects must be enrolled and fully compliant members of the US Composting Council Seal of Testing Assurance (STA) program and provide test results to the Michigan Department of Transportation to certify that their compost falls within the acceptable ranges for all test items.

STA participants will:

- Regularly sample and test compost products based on production volumes
- Complete test analyses for the compost properties listed below and simply report
    - screen size
    - pH
    - soluble salts
    - nutrient content (total N, P2O5, K2O, Ca, Mg)
    - moisture content
    - organic matter content
    - bioassay (maturity)
    - stability (respirometry)
    - particle size (report only)
    - pathogen (Fecal Coliform or Salmonella)
    - trace metals (Part 503 regulated metals)
- Use USCC approved laboratories to carry out product analyses
- Provide lab results to USCC as prescribed
- Make test results readily available and provide a "Compost Technical Data Sheet" to buyers which includes directions for product use, a list of ingredients and test results
- Assure that the facility and product is in compliance with all state and federal regulations
- Have the right to use the Seal of Testing Assurance logo on products in compliance with the program

Compost Characteristics

Quality, stability, consistency, availability, and price are key elements in marketing finished compost as a valuable product. Not only do consumers need to be aware that these attributes are present, but the they also need to be able to rely on them being there with every purchase.

Quality can be established by analytical testing and demonstration plots. Demonstrations are particularly effective if planted and maintained by someone other than the compost operator.

Analytical testing is essential to verify your compost product attributes and also to ensure worker safety, avoid environmental degradation, and maintain a viable compost process. Producers often forego testing because it's costly or they are uncertain as to what parameters to test and what those results mean. But testing is an important investment in the process and the end product and provides a wealth of information.

The main purpose of testing compost is to determine the concentrations of components and characteristics of the compost so that an evaluation of its quality can be made. Knowledge of a compost's quality enables it to be used responsibly. The chemical and physical characteristics of compost depends on the feedstock. Since the characteristics of compost can vary greatly, tests have been developed to measure various important parameters of the compost. Parameters that are typically measured are shown in Table 1 below.

Table 1. Typical ranges of test parameters in quality compost

Test Parameter	**Range**
pH	6.8-7.3
Soluble Salts	0.35-0.64 dS/m (mmhos/cm) (1:5 v/v method)
Nitrogen	1.0-2.0%
Phosphorus	0.6-0.9%
Potassium	0.2-0.5%
Moisture Content	45-50%
Organic Matter	35-45%
Particle Size	passes 3/8" screen
Bulk Density	900-1,000 lbs/yd^3

Source: http://ohioline.osu.edu/anr-fact/0015.html

Additional quality factors include: **Characteristics** of both physical and chemical properties concern consumers.

Physical Characteristics

- Particle size
- Odor
- Color
- Contaminants

Biological/chemical characteristics

- Nutrients (N, P, K)
- pH
- Stability
- Organic compounds, pesticides, herbicides
- Pathogens
- C:N ratio (optimal: 10:1 to 20:1)

Stability is essential if customers are to return for additional purchases. If compost produces odors or harms vegetation in any way, a poor reputation will result for the compost operator.

Consistency of both product quality and supply are of particular importance when selling to professionals who need large volumes on a regular basis. Inconsistency or lack of product at a crucial time can result in lost business.

Price of compost must be comparable to compost sold at nearby facilities. It is also important to compare compost prices with the price of comparable materials such as peat moss and topsoil.

Compost has a limited shelf life.

Unlike antique furniture or durable goods that increase or maintain their value as years go by, compost is a perishable product with a limited shelf life. Since the benefits of compost are derived from its organic matter content, much is lost from stockpiling compost after it is fully mature.

The shelf life of compost from yard clippings is estimated at two to five years in Michigan's climate. After this amount of time compost will reduce to little more than a mineral soil. The natural process of *mineralization* causes organic forms of nutrients, such as nitrogen, to convert to an inorganic form. This occurs over time as mature compost sits and at a higher rate in hot climates, both moist and dry.

Because of the limited shelf life of compost, operators should store mature compost only for good reasons (for spring buyers) and, if unavoidable, store finished compost for 6 to 9 months in large piles to minimize loss of nutrients and organic matter. Part 115 Solid Waste Regulations limit storage of materials for more than three years in most cases and limit volumes to no more than 5,000 cubic yards on any acre.

Market Sectors

Compost users can be grouped into six categories, each with their own application quality. Compost operators must become familiar with the specific applications, needs and concerns of the market sectors they are targeting. In this way, decisions made throughout the entire composting process will work together to produce a final product that is suitable, even superior, for that market.

For example: If an operator wanted to target golf courses, it would be necessary to find out what characteristics are important in material used for the various turf requirements of a golf course. Compost used in the construction and maintenance of golf greens would have different characteristics than that used for fairways.

Market sectors and the relative volume, quality and pricing are included in Table 2.

Table 2 Compost market sectors

Sector	***Quality***	***Volume***	***Pricing***
Landscaping	Medium	Medium	Medium
Sports Turf	High	Medium	High
Home Horticulture	Medium	Medium	Medium
Nursery/ greenhouse	High	Medium	High
Agriculture	Medium	Large	Low
New Uses	High	Variable	Variable

Compost Uses

Compost is used for a multitude of purposes, some of which are specific to a market sector, while others overlap. Some general uses include:

- Turf establishment (sod, lawns)
- Erosion control
- Greenhouse potting mixes
- Golf course construction, topdressing
- Stormwater filter material
- Final landfill cover
- Biofilter for odor control

Agricultural usage of compost could potentially be a very large market, however, low profit margins drive down the price for compost sold for agricultural purposes. Exceptions to this trend are specialty crops with high value such as berries, herbs, certified organic crops and even sod, where higher prices for compost can be obtained.

Matching Process to Market Specifications

Assess capabilities and costs of your facility

Compost quality is a function of feedstock composition and effectiveness of the processing operation. By conducting market research to identify target markets, decisions regarding feedstock volumes, quality and processing will be based on the results of that research. In addition, purchase of specialized equipment may be necessary in order to produce a finished product that is acceptable to the target market.

How much compost will you produce annually?

Rule of thumb:

20% of incoming volume (cubic yd)

OR

Volume In ÷ 5

What does it cost to produce compost for a target market?

The production of compost to meet the needs of a high-value market calls for rigorous quality control. Additional equipment to grind or shred incoming material or screen the final product is necessary, as well as market.

Formula to estimate production costs per yard of compost produced: [(Amortized capital) + (Annual op. cost)] ÷

(Est. cy finished compost/yr) =

$__ /cy

What feedstocks does the site take in?

A carbon to nitrogen ratio of 25:1-35:1 is ideal for composting without producing ammonia odors. To achieve this ratio, roughly twice the volume of leaves (wintered over) to grass must be available whenever forming a windrow.

Wood chips add structure and carbon to the pile, though the carbon is in a less readily available form than with leaves. Compost made from leaves only (leaf humus) differs from leaf/grass compost and from woody compost. High percentages of grass raises the pH of finished compost. The organic matter content of wood-based compost has longer durability due to the slow breakdown of lignin and cellulose.

Add equipment, staff, space or supplies to make a better product. Flexibility in the production process, such as different size screens, allows the facility to accommodate a wider range of consumer needs.

Screening removes contaminants and oversize compostables, resulting in a cleaner product with uniform particle size. Screening compost costs about $2 per cubic yard, but can increase its value from the $6-8/cy range to $12-20 *[H. Hoitink, BioCycle]* The moisture content of compost has a big impact on the effectiveness of screening equipment; optimum is 40-45%; less creates dust and more clogs the screen.

Active composting has a natural drying effect over time, but it is difficult in Michigan's comparatively wet climate to achieve correct moisture content on schedule without controlling precipitation. **To guarantee the ability to screen compost prior to spring sales, a facility** may **need a covered drying area**. A roofed, possibly enclosed area where compost can cure protected from precipitation, or be spread out in order to dry as quickly as possible. Translucent roofing material allows sunlight through and aeration provided by blowers can speed the drying process.

A curing area is very important for quality assurance, and should be sized to allow finished compost to be stored for a

minimum of one month. Curing piles use less space per cubic yard than windrowsA shipping, receiving and distribution area would include a loading ramp, enclosed bays, traffic access and parking, storage for bags, containers, tools, boxes, pallets, push wall, scales and office.

Compost Process

Organic materials that are composted can result in a variety of products because of different feedstocks, processing techniques and management controls. Composting facilities have typically been governed by the incoming materials or “waste” stream, with managers pressured to move large volumes of material through the process as fast as possible at the lowest possible cost in equipment, land and labor. While the conditions for microbes can be optimized to speed up the decomposition process, the necessary time to produce a mature compost is often shortchanged. This results in an unfinished product with a lower quality. Low quality products can tarnish consumer confidence in compost products. One bad experience with compost can cause a consumer to consider all composts to be poor.

One bad experience with compost can cause a consumer to consider all composts to be poor.

Target uses must govern process decisions

Decisions regarding product quality, collection methods, processing and refining are dependent upon the uses planned for the compost. The exploration and evaluation of market options are the first step in designing a compost program.

Quality begins with raw materials that have minimal impurities when the generator puts yard clippings at the curb. Collection equipment, public education program and gate inspection policies and practices all contribute to ensuring that the compost facility will receive clean feedstocks.

An ongoing program to inform haulers about exactly what is acceptable at the facility and the penalties for violating these requirements must be implemented. To maintain quality standards at the gate, the operator needs a good inspection program, requires anactive gate attendant and a staging area large enough to dump and inspect loads as received. Maintaining records of haulers using the facility, including the date, amount and origin of each load, enables bad loads to be traced.

Upgrading finished compost

Finishing activities can include curing, refining, screening, amending, storing, vehicle loading, packaging, and/or shipping. Each activity requires space for storage of equipment and compost. Equipment such as screeners, shredders, mixers and baggers are used by some compost operators to upgrade their final product. Although some of this equipment is quite expensive, operators that process large volumes of compost may find them a worthwhile purchase.

Staff

Improving the quality and consistency of the finished compost can involve a number of additional activities, and potentially additional staff. This should be included in your long term business and marketing plan.

Hiring heavy equipment operators (loader, truck, and screener) requires finding people with training and experience. Dispatchers for deliveries, loading, payment receipt often requires persons holding commercial driver's license (CDL) and bonding.

Customer service personnel are often dedicated to that task but many times serve multi-task roles as bookkeepers and general office support. To sell your product the operation requires marketing and sales representatives. Sometimes the same person can fill both roles.

Using Compost

Compost has numerous uses related to soil improvement; biofilters for odor control, bedding for farm animals, and stormwater filtration. Compost is an excellent soil conditioner which can be customized and applied as a soil amendment, mulch, topdressing or as an ingredient in potting mixes.

Compost characteristics must match plant requirements (e.g. pH, soluble salt levels), and application rates will vary depending on use, soil type, and plant needs. Often, soil has either too much sand or too much clay. In both cases, compost use can help remediate the soil encouraging proper root development and plant growth.

Compost users rely on accurate product data to obtain and apply compost correctly.

Some specific uses for compost include:

- Mix with existing soil to create a superior topsoil
- Use in all landscape areas for soil improvement - lawn, flower, vegetable gardens, around trees and shrubs, bed preparation
- As seed cover when seeding turf areas
- Backfill mix for planting trees and shrubs
- To heel in nursery stock during transplanting
- Erosion control
- Seedling establishment
- Frost-heave control for nursery field crops
- Weed control

- Reclaim disturbed lands
- Landfill final cover
- Plant bed renovation
- Lawn core aeration & overseeding
- Replacement for cover crops
- Topsoil extender, to increase percent of organic matter in subsoils
- Basis for making compost extracts and teas

Soils amended with compost show increased water holding capacity reducing the need for irrigation in volumes and frequency.

Tips for Using Compost

More is not always better

Excessive use of compost can result in reduced plant growth, succulent plants that are disease prone, ground water contamination, and potential surface run-off.

Plain compost made from yard clippings will not likely contain sufficient nitrogen (N) causing over-succulence, but a compost product supplemented with manure or fertilizer could. Applying too much compost wastes money and resources, and can jeopardize the crop. Compost used and applied properly, however, will increase the success of almost any project.

Compost isn't ideal for every occasion.

Generally speaking, compost improves soil and helps make most plants healthier. It is a living material, rich with microorganisms and small amounts of slow-release nutrients. Organic gardeners and farmers have praised the tremendous benefits of compost for years, declaring it the best single material to add to soil.

However, unlike apple pie, all composts are not good for every occasion in the plant kingdom. For example, acid-loving rhododendrons will respond poorly to the neutral or alkaline pH of compost.

Long term residual effects

There are long-term residual effects from applying compost to soil. Nitrogen and other nutrients tied up in compost are released slowly over a number of years. When used as a mulch or top-dressing, the mineralization rate of compost is much slower because of the wetting and drying that occurs on the soil surface.

Soil with 1 percent organic matter (OM) will generate 10 pounds of nitrogen per acre per year, compared to 100 pounds from soil with 10 percent OM, based on a mineralization rate of 8% to 10% of N at 72°F. *[source: F. Gouin, Better Composting School]*

Further research is needed to better understand the long term benefits of compost, and how to use it, as exemplified in the following findings. Based on extensive laboratory and field tests, addition of compost to compacted, structurally deficient soils led to consistent improvement of that soil.

Surface application or very shallow mixing resulted in increased crop yields and ensured a much better response than the traditional farm practice of ploughing down added material. In fact, ploughing down compost or manure increases the probability of restricting oxygen supply in the soil. [Avnimelech, et al.]

Promotion and Distribution

Compost does not sell itself.

In addition to process controls to ensure consistent quality, successful marketing depends on convincing the consumer to buy your compost product or products.

Some selling points include:

- Soil benefits
- Renewable resource
- Lower cost than peat moss
- Recycles beneficial nutrients

It is crucial to broadcast a persuasive message about the benefits and advantages of your compost to target audiences through a variety of media. Establishing continuous, high demand for your product is important to keep product moving, from running out of space at the site, and having old or poor quality compost to remove. Establishing sales goals and a distribution strategy before starting the compost operation will prevent this.

Promotion and Education Leads to Increased Sales

1. Target a specific audience.
2. A name and logo increases product identity and recognition.
3. A detailed user’s guide educates both sellers and buyers about the product; helps ensure correct application and better results.
4. Include complete contact information and a feedback website or mail in card.

User’s Guide

A User’s Guide is a great marketing tool that can serve to familiarize potential customers with the advantages of compost use. Some items that may be useful in a User's Guide include:

1. Suggested application rates and procedures for soil types, plantings
2. Local case studies of successful uses of your compost
3. Benefits of compost
4. Laboratory results of product testing

5. Comparisons with other soil products
6. Results of growth trials conducted by unbiased third party

Media advertising and publicity

Newspapers, television, radio will reach a large audience, especially if timed right to match the interests of prospective buyers

Direct Mail

Your best customers may be those who have purchased compost in the past. By keeping a mailing list of buyers, and communicating with them periodically, you can increase re-orders. This also gives you a direct line to consumer feedback and sends a clear message that you care about both your product and your customers.

Green Industry Expos, Home and Garden Shows

By attending conferences and trade shows where soil blenders, landscapers, and growers go to keep up with developments and products in their industry. You can network with colleagues, learn about competitors, introduce your compost, identify potential buyers, and learn more about what buyers want.

Distribution Methods Increase Sales

Making your compost available to consumers by various means will optimize sales levels. Convenience is an important consideration in purchasing decisions for residents and businesses, so provide as many options and as much convenience as possible. Per unit costs for services such as home delivery can be reduced through volume purchase and passed along to the compost buyer. Some distribution programs include:

- On-site pick up, self-load with shovels and even containers (by bushel or cubic foot)
- On-site pick up, operator loads trucks (by cubic yard)
- Operator delivers truckloads to outlets such as garden store, DPW yard for local sales
- Home delivery by truckload (minimum quantity, pre-payment)
- Retail in containers such as plastic or burlap bags, large plant pots.
- Donations to community programs to raise awareness.

Work with municipal managers to use finished compost in parks and roadside landscaping. Signs can be placed so that they draw attention to the use of compost in public areas. Successful demonstrations can educate residents and businesses about many aspects of compost and increase their confidence in using it. In addition, it is important that information regarding availability of compost, cost, looks, applications, and overall benefits of increased organic matter in soil be readily available.

Public procurement

Public agencies such as parks departments and the road commission use substantial quantities of soil products to build and maintain parks, roadside plantings, and landscapes surrounding buildings and institutions. Public sentiment favors use of local, recycled products in place on non-renewable resources, and can be rallied to support your compost marketing efforts. Procurement policies and price preferences for compost products are effective tools for market development.

Best Management Practices for Composting

Part 4: Troubleshooting

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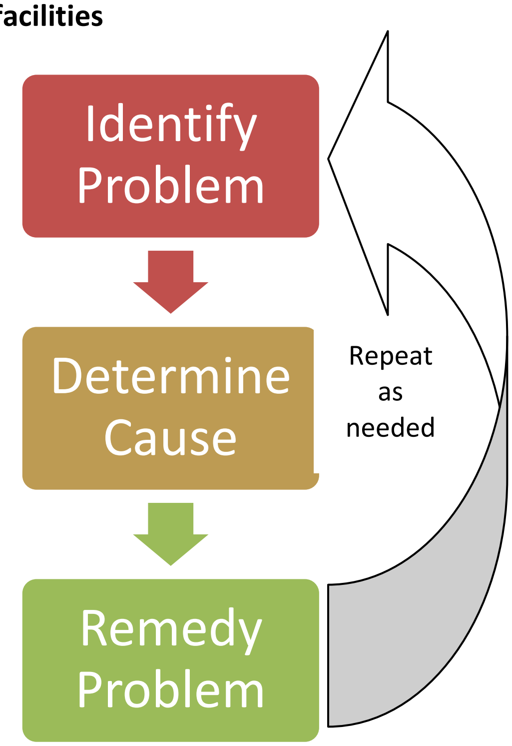
8 Troubleshooting

Introduction

Under normal conditions at a well-designed composting facility using sound management practices, most problems can be avoided. However, a number of factors alone or in combination can cause an operator to *lose control of the composting process*, resulting in foul odors, leaching, vectors, and inferior product quality. These problems are serious and must be corrected or the facility will be susceptible to complaints which can lead to legal ramifications. There have been numerous instances where odor problems have resulted in costly legal fees and permanent closure of the composting facility. Other problems that can trouble compost facilities include dust, noise, litter, unwanted wildlife, site degradation. In addition, operational problems can occur such as piles that don't heat up sufficiently or temperatures that are too high.

Compost operators may perceive complaints from neighbors as unfounded harassment based on NIMBY attitudes (Not in My Backyard). However, sensitivity to odors and other nuisance conditions is normal and should be anticipated. This is especially true in residential and commercial areas where people live and work. Good relationships with your neighbors will pay dividends when (if) you do have problems.

Figure 1: Problem-solving at compost facilities



The best remedy is to prevent operational problems from occurring in the first place through proper site design and facility management. However, even with facilities that have been designed properly and are well-run, problems can occasionally arise that must be addressed.

This fact sheet includes information on how to identify a problem and determine its cause. It also includes actions that can be taken by the compost operator to remedy a problem.

As depicted in Figure 1, problem-solving at compost facilities is a process of identifying problems, determining their root cause and applying appropriate remedies. As needed, this process is repeated until the problem is under control.

Problem: *Anaerobic smell.* ***Cause:*** *Water pooling on compost pad.* ***Solution:*** *Restore grade and repair pad to remove low spots that allow water to puddle.*

Odor Problems

Identify the Problem

Odor is generally the most frequent and serious complaint from neighbors of compost facilities. The first and most important task for the operator is to determine what problematic odors are present and where they are being generated. Only then can appropriate remedial actions be taken. Compost that is properly made under aerobic conditions will have an earthy aroma that is not offensive. However, partly decomposed feedstocks or poor composting techniques can generate problematic odors including ammonia, hydrogen sulfide (the smell of rotten eggs) and volatile fatty acids (VFAs). VFAs are compounds for which most people have very little tolerance.

While determining that there is an odor may seem simple, identifying the source and cause of problematic odors at a compost facility can be complex. Sites are large open areas with many potential odor-producing sources, and odors travel in unpredictable ways.

It is essential to determine whether odors are generated by piles of incoming material that have not yet been incorporated, or from a specific compost pile, standing water, holding pond or another source. Identification of the source of the problem is important because the actions required to remedy each of these problems will differ.

Determine the Cause & Remedy

Odors occur at compost facilities for several reasons. Identifying the source and type of odor can give an indication of the root cause of the problem.

Ammonia

An ammonia smell is usually generated in a compost pile that contains too much nitrogen-rich material such as fresh grass. Incoming material can already generate ammonia odors if it has been closed up in plastic bags for very long.

Ammonia can also be generated when carbon has been supplied to the piles in particles that are too large, such as uncut brush. In either of these examples, there is too much nitrogen in the original mix for the amount of available carbon (low C:N ratio). An ammonia odor can also sometimes indicate a pH level that is too high.

If the ammonia odor is related to an imbalance in the amount of carbon and nitrogen in the recipe (C:N ratio), add more carbon-rich material such as leaves or wood chips. It is important that the particle size of the carbon source is small enough that it can be used by microbes. A carbon source such as brush or very large wood chips may need to be chipped or ground to a smaller particle size.

High pH (greater than 8) can cause excessive ammonia loss and kill bacterial decomposers. If the pH level of a compost pile is greater than 8, add acidic material such as leaves or sulfates and avoid adding more alkaline material to the pile.

Hydrogen sulfide

A smell of hydrogen sulfide (rotten eggs) indicates that anaerobic conditions are present. Anaerobic conditions form if there are not enough air spaces through which air can flow. This can be caused by too much moisture and/or a lack of aeration. A pile with too much moisture will lack adequate aeration because too many of the air spaces are filled with water. Anaerobic conditions can also develop when the pile becomes compacted or air flow through the pile is short circuited. Compaction occurs when there are not enough large or rigid particles such as wood chips to maintain structure and air spaces in the mass.

Short circuiting is a term used to describe the tendency of air to follow the route of least resistance through the pile. Channeling most often occurs in a compost pile that is not mixed during the composting process. In short circuiting, air flows preferentially through the channels rather than being distributed evenly throughout the mass. Air does pass through the pile when short circuiting occurs, there are areas or pockets within the pile with no air, creating localized anaerobic conditions. Rapidly falling temperatures within a compost pile can be an indication that short circuiting is causing the odor problem.

Hydrogen sulfide odors (rotten eggs) indicate that anaerobic conditions are present within the compost pile. This is either because the material is too wet or because there is insufficient aeration.

If the hydrogen sulfide odor is caused by wetness, add dry bulking agent, remix and place piles in an area where they won't be located in standing water. If insufficient aeration is related to poor structure or compaction, add bulking agent and remix the pile. If airflow through the pile is uneven (short circuiting), turning piles more frequently should eliminate the problem.

Volatile Fatty Acids (VFAs)

VFA's are not only offensive to the olfactory senses, their presence can contribute to phytotoxicity problems in finished compost. Like hydrogen sulfide odors, VFA odors are generated by microbial decomposition that occurs under anaerobic conditions. Because VFAs are generated under anaerobic conditions, it is necessary to determine why those conditions exist and eliminate them.

Occurrence of VFAs also indicates that anaerobic conditions are present within the compost pile. The remedy applied should be the same as when hydrogen sulfide odors are present.

If malodorous conditions persist despite taking the actions previously described, it may be necessary to time the turning of compost piles carefully. Turning is best when done with sensitive receptors in mind, such as when it is raining or when the wind direction is opposite of where sensitive receptors are located.

Table 1. Summary of Causes and Remedies for Odor Problems

Situation	Possible reason	Clues	Remedy
Ammonia odor	High nitrogen level	C:N ratio less than 20:1	Add high carbon ingredients
	Slowly available carbon source	Large woody particles, C:N ratio less than 30:1	Increase available carbon content via leaves, smaller particle woodchip
	High pH	pH greater than 8	Lower pH with acidic ingredients (leaves) or avoid adding more alkaline material
Hydrogen sulfide (rotten-eggs) or VFAs **Both odors indicate anaerobic conditions**	Material too wet	Low temperatures	Add dry bulking agent Turn to remove moisture (also releases odors)
	Poor structure		Add bulking agent
	Pile compacted		Remix pile and add bulking agent if necessary
	Insufficient aeration		Decrease pile size
	Pile too large	High temperatures	Remix pile so that it's smaller, change recipe
	Airflow uneven or short circuiting	Falling temperatures	Shorten time between turnings

Temperature

Identify the Problem

Temperature of the composting mass is a primary indicator of microbial activity. Compost piles that don't reach the temperatures that indicate active composting will take much longer to fully decompose. The ideal temperature range for active composting is 105-145º F. Compost piles that have not heated up within 3 days of being formed should be considered problematic and in need of adjustment.

Temperatures greater than 170º F create potential for spontaneous combustion. Mesophilic organisms thrive from 104°-122°F and their activity is inhibited outside of this range. High temperatures can be the result of compost piles that are too big or too dry, and from lack of heat removal due to insulation or lack of aeration.

Determine the Cause & Remedy

Low temperatures

A compost pile can fail to heat up because the materials are too dry or too wet. The material is too wet if the material looks soggy and too dry if no water can be squeezed by hand out of a handful of compost. Piles should be maintained at 50 to 60 percent moisture to stimulate and maintain composting organisms and to eliminate problems. The "squeeze method" as described in BMP#4: Operations can be used to test whether there is enough moisture in the compost pile.

Other conditions under which material will fail to begin composting include where there is too much carbon or where the structure of the pile is extremely poor. If large amounts of woody material are present in the pile, there is probably too much carbon for the amount of nitrogen present. If the pile settles very quickly, it can be assumed that structure is the primary problem.

A combination of cold weather and piles that are too small (3" tall or less) can also result in failure of piles to heat up.

If low temperatures are caused by materials that are too wet, add dry bulking agent and remix. If dryness is the cause of low temperatures, add water or wet ingredients. If the C:N ratio is too high, add high-nitrogen ingredients (grass or "green" materials) and remix. If the piles are too small, combine piles together or enlarge by adding highly degradable ingredients.

High temperatures

High temperatures can be caused by insufficient aeration for heat removal within piles, low moisture levels or because piles are too large. If high temperatures are caused by insufficient aeration, there will be adequate amounts of moisture, as determined by the squeeze method.

If high temperatures are caused by low moisture levels, add water, turn and aerate to control temperature. If the pile is overheating but sufficiently moist, turn the pile or increase air flow to release heat. Overheating piles that are over 8 feet tall should be re-built into smaller piles.

Table 2: Causes and Remedies for Temperature Problems

Situation	Possible reason	Clues	Remedy
Pile fails to heat up	Too dry	Can't squeeze water out from a handful of compost	Add water
	Too wet	Materials look soggy	Add dry material
	Not enough nitrogen	Large amounts of woody material	Add nitrogen-rich material
	Poor structure	Pile settles too quickly	Add bulking agent
	pH too low	pH <5.5, garbage-like odor	Add lime or wood ash, re-mix
	pile too small	Compost piles 3' tall or less	Re-mix and combine piles
Temp. too high	Insufficient aeration	Pile is moist (as determined by squeeze method)	Turn pile more frequently or increase air flow.
	Moderate to low moisture levels	Pile is dry (as determined by squeeze method)	Add water, continue turning
	Pile is too large	Height >8'	Decrease pile size

Source: The On-Farm Composting Handbook, Northeast Regional Agricultural Engineering Service, 1992.

Dust

Identify the problem

Dust is often considered a problem by neighbors when if drifts off-site. Dust consists of fine, dry particles that become airborne easily. It irritates eyes and lungs and settles on surfaces and affects employees, customers, neighbors and equipment. It is a hazard to workers if it is inhaled on a regular basis.

Dust problems have been associated with *aspergillus fumigatus*, a fungus whose spores can produce an allergic response in susceptible individuals and can cause infections in persons with weakened immune systems. Although this fungus is omnipresent to varying degrees, it has been the basis of costly litigation at some composting facilities.

Dust can also clog radiators, foul oil and fuel filters and require more frequent lubrication of bearings. Dust can also promote corrosion because it traps moisture on metal surfaces and its insulating properties can cause equipment to overheat. Therefore, dust problems should be dealt with well before they become a nuisance to neighbors.

Determine its cause

Determine where the dust is originating. Dust can have many sources. It can come from unpaved or dirty roads, from emptying dry loads and from handling dry materials at any stage of the production process. The very presence of dust from compost feedstock materials, windrows or finished product is a sign that conditions are too dry for composting organisms.

Remedy the situation

The singular solution to dust problems is to simply <u>add</u> <u>water</u>. This can be done in a variety of ways, but often requires specialized equipment such as a watering truck, hoses or irrigation systems. While Michigan's climate usually provides adequate moisture to prevent dust, one month or season of drought can create significant dust problems.

Water can be added to incoming yard waste most easily at the pre-processing stage before the windrow is built. Thereafter, the moisture content of active windrows should be maintained at 50 to 60 percent. The squeeze method can be used to test whether there is enough moisture in the compost pile.

Unpaved or dirty roads and other unimproved surfaces should be wet down as needed to keep dust down during extended periods of dry weather.

Noise

Identify the Problem

Noise is a sound that is perceived as unpleasant or unwanted. Noise can affect facility employees, neighbors and customers. Although noise complaints from neighbors are often the driving force behind having to deal with noise problems; noise is unlikely to harm the hearing of neighbors. It can, however, irreversibly damage the hearing of facility employees or customers.

Excessive noise can be caused by equipment that needs to be maintained, on-site vehicle traffic, engines, hammermills, hydraulic motors or the warning signals of loaders and other equipment when operated in reverse. Truck traffic to and from the site can also cause noise problems.

Determine the cause

Sound levels are measured in decibels (dB) and the Occupational Safety and Health Administration (OSHA) has set standards for exposure to sound at different dB levels. Purchase of an inexpensive meter that gives a direct measurement in dB permits objective measurement of this often subjective problem. Exposure of employees who work directly with equipment such as hammermills should be measured to determine whether or not ear protection is warranted.

Talking to neighbors should help to determine the nature of the noise that is troublesome to them. It is also important to identify what times of day neighbors are most sensitive to noise so that activities at the compost facility can be done at a time that is least disturbing to them.

Remedy the situation

Equipment that is in need of maintenance should be given the attention it requires. This may mean lubricating bearings or replacing worn parts. This is important not only for neighbor relations but is also important for the hearing of the equipment operator and the longevity of the equipment itself.

Employees who, of necessity, must work under extremely noisy conditions should be provided hearing protection and required to wear it. Site modifications that can protect neighbors from unwanted noise include vegetative buffers or berms around the site, installing sound walls and enclosing noise-producing equipment. If permitted by safety regulations, normal backup alarms may be substituted with intermittent alarms.

Flies and other pests

Identify the problem

Flies and other pests such as gnats, rodents or other small wildlife are attracted by the odor of decomposition, and need to be controlled for public health and aesthetic reasons. Flies may deposit their eggs on the compost and the warm, moist conditions just below the surface provide an ideal environment for their larvae. While pests may become a problem at any compost facility, they are often a sign of a poorly managed site. Process control and good housekeeping can limit both the number and impact of pests.

Determine the Cause

Flies and other insects are generally attracted to semi-anaerobic environments and can be attracted to a compost pile from far away. Points of attraction include grass clippings and food waste that have not yet been incorporated into a compost pile or organic matter located in standing water.

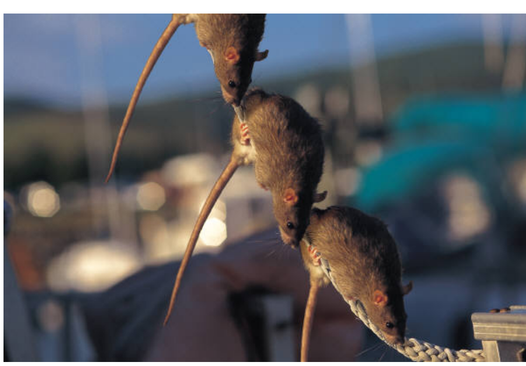
Rodents and small mammals are attracted to compost piles for the warmth that is provided when the pile is burrowed into.

Remedy the situation

In order to eradicate flies and other insects, anaerobic conditions must be eliminated. Remix and turn compost piles if they are too wet and ensure that compost is not located in standing water. Drainage at the site must be improved if standing water is causing anaerobic conditions.

Because ammonia is such a strong attractant for flies, it is essential to control ammonia production and kill fly larvae by frequent turning.

Rodents can be kept away from a compost site by turning piles more frequently. Rodents will not burrow into frequently turned piles or cured piles.



Insects, mammals and birds can all become pest problems in poorly managed compost sites.

Inferior Final Product Quality

Identify the Problem

An inferior final product will result in low sales and a poor reputation. Problems associated with final product quality:

- plant toxicity related to immature compost;
- physical contaminants such as plastic bits, other manmade inerts, and stones;
- chemical characteristics such as odor, high pH and soluble salts content;
- clumping of screened compost.
- weed growth in screened compost.

Immature compost can interfere with plant growth and develop odors during storage. Tests for maturity include seedling germination and growth, lab analyses, and rough field methods.

Plastic and stones can be identified by a visual examination. Screened compost should have a uniform particle size, though sizes can vary for different uses.

Although compost is typically described as having a neutral pH, levels above 8.0 are not uncommon for yard waste compost. Field test kits for various chemical parameters work well.

Determine the cause

Phytotoxicity is due to immature compost or compost that went anaerobic during storage. Maturity requires proper curing: time, moisture and aeration.

Plastic in compost results mainly from accepting yard clippings in plastic bags. Bags are removed prior to windrowing, or shredded along with the contents and screened to remove plastic bits after composting is complete. Debagging is done by hand or machine. Plastic pieces become smaller by turning and grinding, but do not biodegrade.

Small pieces of compostable plastic from accepting compostable products with food scraps may remain even after active composting and curing. Screening the pre-cured or cured product may remove these pieces.

Contamination with soil or uncomposted residues, especially after the active phase of composting has finished, can lead to the reintroduction of weed seeds or plant pathogens.

Finished compost can become recontaminated with weed seeds if weeds are allowed to grow and go to seed on or adjacent to the pile or windrow. Similarly, compost can become contaminated with vegetative reproductive structures from some weeds—Canada thistle and rhizomateous grasses, for example—if they are allowed to grow on or adjacent to the pile.

Remedy the situation

Compost matures through a process called curing that involves ongoing low levels of microbial activity. It begins after active decomposition is complete, takes up to 120 days in larger piles with good aeration and drainage, 40-50 percent moisture.

For most end uses, plastic bits are not acceptable. The best ways to eliminate pieces of plastic is to not accept yard clippings in plastic bags or debag before composting. Small screens do a reasonable job of removing inert particles, but screening is costly and small screens remove extra compost.

Some compostable products may break down completely and others may not, so testing products and giving your customers feedback on what products to use and not to use may reduce this issue.

To prevent clumping, ensure correct moisture content of compost and screening rate to allow enough time for clumps to break up.

When moving or spreading finished compost, avoid picking up soil or other contaminants from under or around the pile or windrow and avoid adding fresh material after the active phase as it can cause reintroduction of weed seeds or plant pathogens.

Keep vegetation adjacent to stored compost mowed short, and tarp piles or windrows to prevent contamination by wind-blown weed seeds.

Site-related problems

Identify the problem

Even well-designed compost facilities can experience problems over time due to facility use and poor maintenance. These may include ponding, poor drainage and anaerobic conditions in a retention pond.

Poor site design is almost certain to cause odor production at all but the lowest volume sites. These situations are often accompanied by odor because they result from standing water on-site or development of anaerobic conditions. Detailed information on site design are presented in the chapter on Site Design.

Determine the cause

Poor drainage happens when runoff water collects in places that result in standing water (ponding), and the potential for erosion as water flows across the pad. This can be caused by poor pad design or rutting that occurs when heavy equipment operates on a wet surface.

Ponding related to poor site design results in wet areas of the pad even where there isn't much traffic. Where both of these problems, (ponding due to equipment traffic and poor site design), are interacting to create ponding problems, it can be difficult to establish which is greater.

Development of anaerobic conditions in a holding pond can be identified by heavy algae and weed growth and/or gas bubbles on the surface of the pond. This could be the result of anaerobic leachate from compost piles that enters the holding pond as runoff. It could also result from organic materials decomposing anaerobically in the holding pond. Placement of fresh grass directly into a holding pond can also result in anaerobic conditions.

Remedy the situation

Regardless of why ponding occurs, the integrity of the pad surface must be maintained through regrading and re-surfacing as needed so water will move quickly away from the composting piles and into a drainage ditch or holding pond. If ponding is related to ruts caused by the activity of heavy equipment, alternate plans must be developed to keep equipment off the pad while it is wet. This can include allowing only smaller, lighter equipment to be used on the pad when moisture levels are high.

Anaerobic conditions in holding ponds can be remedied by effectively handling drainage and ponding problems. In addition, sediment traps can be installed and the pond's surface area can be enlarged.

Handling Neighbor Complaints

Identify the problem

Unhappy neighbors may register complaints with a local or state government regulator before letting the compost facility operator know how they feel. It is preferable for an operator to be the first to know about a perceived problem their facility may be causing. In order to deserve that kind of relationship with neighbors, compost operators must demonstrate an openness to hearing neighbors' complaints and willingness act on complaints immediately.

By reaching out to the surrounding community at each stage of facility development, educating residents about the process, and giving tours to show procedures for handling materials, fears and confusion can be alleviated in advance. Also, posting the telephone number and contact person to call regarding any complaints will send a clear message of concern for neighbors.

Following up with neighbors after remedial action has been taken is important so that they will know their complaints were heard and the problem was resolved. Regular contact with neighbors regarding positive events will help to foster good relations.

Determine the cause

The first and most important rule for handling complaints is to take each one seriously. Is your fencing or berm properly screening your property? Is the wind blowing their way today? Did your front gage landscaping not get maintained properly? Are your trucks leaving a mess on the roads? Not practicing regular good neighbor relations?

Find out why neighbors are complaining and get to the source of it right away. Is this a regularly occurring complaint? Periodically survey and talk to your neighbors. Find out what if any complaints there are. Ask them to contact you any and every time they have a concern or think something is amiss.

Remedy the situation

The best remedy for neighbor complaints is to let the individual or group know what the facility is doing to address the perceived problem. Even if it will take more time than they would prefer to eliminate the problem, a prompt, sincere response and clear plan of action will be appreciated. Corrective action must then be taken quickly, whether a change in procedure, equipment or the facility is required.

Turning piles, screening and other activities that can bother neighbors should be done with neighbors in mind, whenever possible. By determining when neighbors are most sensitive to certain activities, a compost operator can try to work around those times. In addition, turning compost piles can be done when the wind is blowing in the opposite direction from sensitive receptors or when it is raining. Thoughtful timing of these activities should reduce the potential to annoy neighbors.

Conclusion

Proper processing of compost will result in fewer complaints from neighbors than haphazard practices. Consistently applied procedures will produce minimal odors, draw few pests and produce high quality compost. However, even in well-run facilities, problems can occur.

It is important to address these problems quickly and with attention to the underlying cause of the problem at hand. In this way the cause can be eliminated and the problem should not repeat itself.

Careful attention should also be given to the concerns and complaints of neighbors with regard to problems at a facility. These complaints should be addressed quickly and completely. Results of the actions taken to remediate a problem should be clearly explained to neighbors as soon as possible.