Guide to Recovering and Composting Organics in Maine

Pre-consumer food scraps ready for composting; ***Photo by Mike Burden, University of Missouri College of Agriculture***

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I. Introduction

Since the early 1990's, Maine has been steadily working toward a goal of annually reducing the solid waste it generates by half, through recycling and composting programs. With the assistance of residents, businesses, municipalities, and the state, numerous programs and efforts have been instituted and have been successful in capturing inorganic waste products (i.e., newspaper, corrugated cardboard, plastics and similar materials) from the waste stream and shipping those materials to be used in manufacturing. Little attention has been paid, however, to the organic fraction of the municipal solid waste stream. Food scraps and discards, along with lawn clippings and similar vegetative materials, account for over twenty-five percent of the solid waste stream and offer the possibility of reaching, and surpassing, the fifty percent recycling goal if these organics can be collected and recovered through composting programs or as a feedstock in an anaerobic digester.

In August 2012, ME DEP created the Division of Sustainability with one its missions to provide technical assistance and outreach to public, municipal and private entities, encouraging enhanced recycling and composting/organics recovery activities. A goal is to assist municipalities, institutions and businesses in recognizing the value of organics and assist in the growing need for focused organics recovery and management.

This document recognizes that organics management includes vegetative discards, such as grass clippings, leaves, weeds and similar landscape materials, and includes food scraps as well. Handling farm animal wastes such as manure is not addressed per se, but reference to the use of manures and bedding materials is made in the sections on composting, since these products have value when utilized in a composting operation. Pet wastes, from dogs and cats, is not encouraged to be included with composting landscaping materials or food scraps, due to potential health issues with the resulting compost.

The purpose of this document is to provide basic information for those interested in capturing unwanted organics from the waste stream and aiding in turning them into a beneficial product or use. Within this document the reader will find ways and methods of diverting organics from trash, learn the fundamentals of the biology of composting and various composting systems, the regulations that will help guide a program, as well as numerous resources available to assist in the effort.

II. Identification - Separation – Transportation - Issues and Concerns

There are two significant challenges that must first be overcome before successful utilization of the organic portion of the waste stream will occur. The first is informing residents and businesses of the value of diverting organics from the waste stream and gaining their support in separating organics from trash. The second is securing support from haulers and receiving facilities to accept and appropriately manage these organics. But the first step to gaining support is the better identification and understanding of the various components of the organic discards stream and sharing that information with residents and businesses that generate these materials.

Leaf and yard trimmings, and similar landscape residual organics, are widely understood and often are diverted from disposal, and used 'on-site' as mulch or in a backyard compost pile. Food scraps from the family dinner table may be added to these compost piles; but there are many opportunities to expand the separation, collection and composting of food scraps generated from restaurants and institutions. Many of these practices are covered within this document.

Organic food scraps fall into one of two sub-categories: pre-consumer residuals and post-consumer residuals. Note: both categories may also include various types of paper products, such as napkins, wipes and towels. Pre-consumer food residuals are food residuals left over from meal preparation and grocery stores' 'pick overs' or unsold items. Generally, pre-consumer products have not been cooked or processed except for any initial packaging prior to sale. Post-consumer food residuals are any leftover, uneaten food that has already been served.

Like the 'waste management hierarchy', there is a 'food recovery hierarchy', which establishes a priority of actions in appropriately managing unwanted food and its residuals. That hierarchy should guide our efforts in reducing the amount of unwanted food produced, and aid in achieving the state's 50% goal. The hierarchy is:

A. Reduction of the volume of surplus food generated at the source.
B. Donation of surplus food to food banks, soup kitchens, shelters and other entities that will use surplus food to feed hungry people.
C. Diversion of food scraps for use as animal feed.
D. Utilization of waste oils for rendering and fuel conversion, utilization of food scraps for digestion to recover energy, other organic waste utilization technologies, and creation of nutrient-rich soil amendments through the composting of food scraps; and
E. Land disposal or incineration of food scraps.

In general, pre-consumer food residuals are more easily composted because these scraps are generated within the kitchen or at a designated area within a retail store, and contamination can be easily minimized. Training of staff is also easily done and monitored. Reducing the level of 'non-organics' within the collected organics is critical from a compost management perspective; for example, keeping plastic wrapped out of the separated organics is critical, as plastic is an unwanted item at the compost facility.

Post-consumer food separation and temporary storage may require additional monitoring by trained staff to reduce the risk of contamination.

Before starting a food separation program, it is critical to identify potential storage space within the generating facility, secure transportation services for the food scraps to be delivered to an approved facility (composting, anaerobic digestion, other) and establish a relationship with that facility. It may be that the hauler will not have an arrangement with the receiving facility and it will be up to you to develop that, or perhaps the hauler already has a working relationship with an acceptable facility, and your business becomes part of the service route for the hauler.

It is recommended that you start with pre-consumer food separation, which is the easier step to undertake in recovery food scraps and allows for the establishment of a successful collection system. This provides an opportunity to refine the collection/transportation aspect of organics management. Once that system is in place and working well, the post-consumer food residuals can be added to the system.

Continuous employee/consumer education, getting employees/consumers to "buy into the system", and monitoring will help reduce the need to devote to the separation of materials, as will the use of color-coded bins and appropriate signage. Once employees have been trained to the system, there will be only a minimal need for extra time to separate materials as it becomes part of the normal work routine.

Part of the initial program set-up is to identify the types and volumes of food residuals the facility will be generating. A fairly simple way to accomplish this estimation is to measure all the residuals produced in each area during a typical operation week and project this amount over time.

For example, to undertake this measurement effort, measure one typical container of food residuals and multiply this amount by the number of containers that are filled during that week. Keep employees informed of the process to ensure containers contain food residuals only. Typically, disposal costs are billed by the cubic yard (a volume measurement). To convert weight into volume, here are some standard container sizes: 5-gallon container = 0.025 cubic yards; 30-gallon container = 0.15 cubic yards; 55-gallon container = 0.27 cubic yards (National Solid Waste Management Association, 1985).

Volume-to-weight conversions for food waste can vary considerably, depending on the type of food and its moisture content. If trash disposal at your facility is measured and billed by the ton, a standard container filled with representative samples of your facility's food residuals should be filled and then weighed for an approximate conversion between volume and weight.

If an on-site composting program is planned (where the proper mix of feedstocks is important) measuring the food residuals will be critical in developing the recipe for the composting process. Food residuals are typically wet, heavy and provide a source of nitrogen for the composting operation, which will need to be balanced with a material(s) that provides a source of carbon and can 'lighten' the food scraps. Before developing an on-site composting program, it is critical to determine whether food residual composting is right for the business. That review requires a thorough assessment of the facility's waste generation and disposal practices, and assistance is available for that review. Most successful composting programs are individually structured to meet the financial and operational opportunities and constraints of a given operation.

Currently, there are approximately 20 Department licensed composting facilities, about 10 'on farm' operations that compost food residuals, and several 'on-site' composting operations for restaurants or institutions.

It is standard that a composting facility charge a 'tipping fee' when accepting organics from generators. Tipping fees may range from $30 to $40 dollars per ton on average, as opposed to most of Maine's disposal facilities which currently charge $65 or more per ton. Even with the cost of trucking added, composting can make economic sense for most organics generators.

A. Why do it?

1. <u>Lower Costs</u>
   Composting can be a lower cost management method as compared to the cost of disposing the same materials at a landfill or waste to energy facilities. Also, managing organic residuals through composting or anaerobic digestion provides benefits by creating products with value, and aid in extending remaining landfill capacity.

2. <u>Environmental Benefits</u>
   Diverting organic residuals to composting sites reduces the potential for water and air pollution from landfills and reduces air emissions and residues from waste to energy facilities. Compost can be used to improve soil quality, reduce water consumption needs of landscape plants and reduce non-point source pollution from the use of chemical fertilizers. Recovering food scraps and utilizing them through a composting process or directed to an anaerobic digester reduces the carbon footprint of your facility.

3. Enhance Public Relations Through Educational Outreach
Organics have value, and by informing and educating residents, businesses, and institutions to the benefits of a properly managed and promoted community compost program, an opportunity to promote environmental stewardship through sustainability is created. People can support the recovery of food scraps, receive positive reinforcement for their efforts and may be able to use the finished compost for their own use.

4. Produce a Useful and Desirable Commodity
Because composting turns discarded, organic materials and residues into a valuable product, citizens, local businesses and public works departments can be both the suppliers of additional carbon and nitrogen feed stocks, and the end users of the compost.

B. Why now?

1. Composting has proven a track record throughout the State
   As stated previously, municipalities and businesses have been accepting lawn clippings and similar organics for composting for more than two decades. Some of these operations also accept small amounts of food residuals. Due to increased interest in capturing food residuals for composting and for use in anaerobic digesters, there are increasing opportunities for food scrap generators to divert their organics from landfills and waste to energy facilities to composting or anaerobic digester facilities.

2. Current Regulations Encourage Composting Efforts
   In February 2010, the MEDEP published the new Composting Regulations, Chapter 410 (see Section 3 of this manual for the complete rule). This revised rule provides a clear and consistent framework for environmentally sound compost operations.

3. Technical Assistance and Educational Outreach Opportunities
   In addition to knowledgeable staff at the MEDEP, Maine is home to two nationally known resources on composting: the **Compost Team** and the **Compost School**. Both programs are cooperative efforts by the MEDEP, Department of Agriculture, Conservation & Forestry, and the University of Maine Cooperative Extension.

Another source of assistance is available through the Northeast Recycling Council (NERC). Through their on-line blog, numerous discussions on organics recycling are posted. In addition, NERC has created an "Organics Management Guide" that provides a thorough summary overview of separating and recovering food scraps from generators, and possible scenarios for planning and implementing food scrap programs, including discussion on transportation and facility options.

Additionally, MEDEP staff can direct interested individuals to other sources of information as well. The Department has just developed a guide to specifically address food separation and composting within a school: '10 Steps to Starting a Successful School Composting Operation'. For a copy of this guide, please contact Mark King at mark.a.king@maine.gov

III. The Composting Process

Composting is a biological process in which microorganisms consume organic materials (carbon and nitrogen compounds) and convert them into a nutrient-rich, soil amendment material, commonly referred to humus. All the composting processes presented in this guide focus on aerobic activity (with oxygen) of the microorganisms, which is when the activity of the microorganisms takes place in the presence of oxygen, and where the by-products are water vapor and carbon dioxide (CO^2). Examples would be someone's backyard compost pile of leaves, grass clippings and food scraps, where the pile is flipped on a regular basis. Composting can also without oxygen (anaerobic), although the microbes perform poorly and the by-products may be odorous volatile organic acids which may create "nuisance" conditions.

In addition to oxygen, microorganisms also require suitable amounts of carbon, nitrogen, and moisture, to help them thrive and multiply within the compost pile. The moisture serves as the medium in which the microorganisms live; the carbon provides the energy/food source to fuel them; and the nitrogen provides the building blocks for their reproduction, which leads to further composting activity. The composting process begins when the appropriate ratios of materials (feedstocks) have been mixed to form a "recipe". The physical process of mixing the feedstocks usually provides enough oxygen to initiate the composting process.

The first six to eight weeks of the compost process are referred to as the "active composting phase." During this time, microorganisms consume a great deal of oxygen as they feed on the available organic matter. At the same time, they are producing heat, water vapor, and carbon dioxide as they consume and reduce the original volume and mass of the raw ingredients and begin the process of converting the feedstocks to a more stable material, humus.

After the initial active composting period, the pile enters a **"**curing phase**"** where the microorganisms still feed, but at a slower pace, giving off lower amounts of heat, water vapor, and carbon dioxide. Left undisturbed, the microorganisms will continue to feed until all the organic matter has been consumed. The final product is a nutrient rich soil amendment that provides many benefits including increased organic matter, enhanced soil structure, drainage and porosity, and water holding capacity. Because of these qualities, compost is a valuable end-product for the local home gardener and landscape companies.

A. Four common composting systems used in Maine

Over the years, many composting systems have been developed and employed in Maine to facilitate the composting process. Today, though, there are four fundamental composting systems in use: the static pile, the aerated static pile, the turned windrow and the in - vessel system.

1. Static Pile The static pile method involves mixing the compost ingredients together and constructing a pile from the blended material. Subsequent turnings may not be required but are encouraged.

Advantages:

- The least labor/equipment intensive method.
- The preferred method for composting leaves.
- The only equipment needed is a tractor with a bucket or a front-end loader (or a very strong back!)
- The pile may be turned up to four times a year but will usually compost without any further management.

Disadvantages:

- Composting usually happens very slowly due to the steady reduction in the amount of oxygen available throughout the pile.
- When this method is used with materials that are wetter and/or contain more nitrogen, such as food scraps, a lack of sufficient available oxygen may cause the process to go anaerobic and unpleasant odors may result.

Sandy River Recycling Association (Farmington)-Static Pile (Photo by Mark King)

2. Aerated Static Pile This system involves building a static pile on top of an aeration system, either passive (usually pipes with holes drilled in along their length) or forced air, and then leaving the material without subsequent turning until the active phase of the compost process is completed. However, during this phase, air is passively drawn down through or forced upwards through the pile with fans or blowers attached to the pipes.

Advantages:

- This approach requires very little capital investment or accessory equipment, and as a result, has been widely used for manure and municipal sewage residual composting efforts.

Disadvantages:

- Because there can be no mechanical turning of the pile once it is placed on the aeration system, a thorough mix of all materials must be achieved at the outset of the pile formation. Care must be taken to achieve a homogenous blend.
- The building of the pile over the pipe requires careful equipment handling.
- The pipe needs to be 'pulled out' prior to removing the compost once the active composting phase is complete; again here, special care needs to be used to minimize potential damage to the aeration pipe.
- Care must be taken in the layout of the aeration system to allow for the free exchange of air or else odors may occur.
- There must be careful monitoring of the airflow, temperature, and moisture content of these piles as they are prone to excessive drying, that can result in a decrease in microbial activity.

Little River Compost Facility (Lisbon)-Aerated Static Piles (photo by Mark King)

3. Turned Windrow System This is the preferred method for most on-farm and seafood composting activities. It would work equally well for municipal operations with sufficient space and resources. Typically, leaves and yard trimmings are placed down in layers in long piles (windrows) and mixed using a mechanical windrow turner. Windrows are then turned as needed with the same windrow turner. A front-end loader can be substituted to mix and turn the windrows though care must be taken to achieve a good level of mixing. A front-end loader will require more time than a windrow turner.

Advantages:

- The windrow system requires the least amount of time for the composting to occur and allows for a large volume of material to be turned in a short length of time.
- Each subsequent turn further blends the compost ingredients, releases trapped carbon dioxide and water vapor, redistributes air spaces within the row, and aides in the physical breakdown of the materials. This results in a very uniform product.

Disadvantages:

- This method requires more intensive management and more space (for equipment maneuvering) than the static pile/ aerated pile methods.
- Pile temperature must be carefully monitored so that the row will be turned at the appropriate time to ensure successful composting.
- Windrow turning machines can be costly investments.

C

Rainbow Valley Farms (Sidney)-Turned Windrow Composting (photo by Mark King)

4. In-Vessel System As the name denotes, in-vessel composting occurs within a closed system. Usually this means within a building or a container. All the receiving, mixing and composting activities are enclosed, and exhaust gases are collected and processed through a filter. Any leachate generated during composting is collected and recirculated back into the process. Most in-vessel systems combine forced air and a form of mechanical mixing or agitation.

Advantages:

- The immediate benefit of in-vessel systems is the rapid production of a well decomposed product without any concern for odors or leachate generation.

Disadvantages:

- The initial capital investment can be prohibitive.
- Such systems use complex machinery which requires a high level of technical expertise to operate and maintain.


Green Mountain Technology™ "Earth Tub" (Carrabassett Valley)-In-Vessel Compost Units
(photos by Mark King)

B. Challenges to Managing Organic Residuals

The process of siting, developing and managing a compost facility can be challenging. Organic residual generators and compost facility operators have different needs and requirements that must be considered prior to setting up a storage and transportation system to utilize a compost site or anaerobic digester. Additionally, many generators may have little or no on-site capacity for long-term storage of food scraps. This creates an immediate problem, as organic residuals by nature tend to be highly putrescible and odorous due to a low carbon to nitrogen ratio (<15:1) and low solids content (10% to 30%). As a result, residuals tend to decompose quickly, creating odor and releasing liquids, necessitating the need for regular removal off-site.

Ideally, the compost site should be relatively close to the residual generating facility, as trucking these residuals long distances can be cost prohibitive. Additionally, due to sales variations and other factors, generators may not be able to guarantee predictable residual volumes to compost facilities.

It is therefore critical that compost facilities and anaerobic digesters be adequately sized to handle incoming organic streams and properly designed to facilitate flow of materials throughout their process. Where food scraps can neither be composted nor utilized in an anaerobic digester by themselves, the facility must also have adequate amounts of carbon amendment on site to mix with incoming loads of organic residuals, if composting, or an active digester, into which food scraps may be added. Having sawdust, horse manures or other carbon amendments on hand are critical in creating an initial mixing to help control leachate, prevent odors and initialize the compost process.

Note: Most of Maine's organic compost facilities charge a tipping fee to help operate and maintain their sites. This arrangement works well if compost facility operators accept only the volume of organic residuals that the facility can handle. It is important that facility operators do not accept more products than they can process, as this can 'short circuits' the compost process, leading to numerous nuisance problems including odors, leachate, and animal (vector) attraction. Once a facility begins this action, it is often difficult (but not impossible) to recover.

Compost facilities have operating hours and access control to prevent unauthorized deliveries and to properly process incoming loads. Dust, noise, and traffic can also add to nuisance problems at the site, and with neighbors. Nuisance issues are discussed more thoroughly in Section VI, "Trouble Shooting the Compost Process".

IV. Making Compost

A. Setting Up the Composting Site

Once the site has passed initial inspection by MEDEP, it is time to begin setting it up. The first consideration involves determining how large a footprint you will need to handle the volumes that you project. Remember, it is much easier to fill vacant space than it is to create more space at an already cramped site!

Determining the footprint is generally accomplished by developing a site-layout plan. The "On-Farm Composting Manual", published by the Northeast Regional Agricultural Engineering Service (NRAES- Bulletin 54), includes a very helpful chapter on site design and layout. A complete reference citation for this publication is included in the Appendix.

A site-layout plan should include sub-dividing the compost area into designated handling areas, listing facility design features and achieve/facilitate a logical flow of materials through the process at the facility. This plan will identify how many times the same material will have to be handled and how long it will occupy space in the different management areas on the site.

The following section describes a typical compost site-layout plan: (an illustration depicting this site-layout immediately follows):

1. Receiving and Handling Area: This dedicated area allows for the coordinated delivery and handling of delivered feedstocks. Problem residuals may be isolated here. This separate area provides the operator with a first chance to control odors through good residual management (i.e., receiving putrescible materials, such as food scraps, on a bed of sawdust to help absorb leachate) or immediate mixing of seafood processing residuals with sawdust or horse manure.

2. Amendment Storage Area: This area allows for the receipt of and stockpiling of carbonaceous amendment, free from contamination with other feedstocks.

3. Mixing Area: This area allows for pre-determined, measured amounts of feedstocks to be accurately and thoroughly mixed, while also providing for odor and leachate control. This results in a thorough, heterogeneous mixture, which facilitates initiation of the active compost phase.

4. Composting Area: This is the area where active composting begins and is generally the largest portion of the site. This area should be located centrally to the receiving/handling and mixing areas.

5. Curing Area: This area is designed for the aging and final maturation of compost piles or windrows that have completed the active compost phase. Curing is an essential step in the completion of the compost process, allowing natural progression and reduction in active microbial populations.

6. Waste Bypass Area: This designated location provides a centralized area for collection and storage of "non-compostables" for later disposal. Rejected loads of residuals may be staged here while waiting for pick-up. Common contaminants may include:

- Road grit and sand.
- Litter, coffee cups and lunch bags.
- Rocks, roots, and dirt.
- Large branches, and waste wood; or
- Plastic bags, plant containers, and flowerpots.

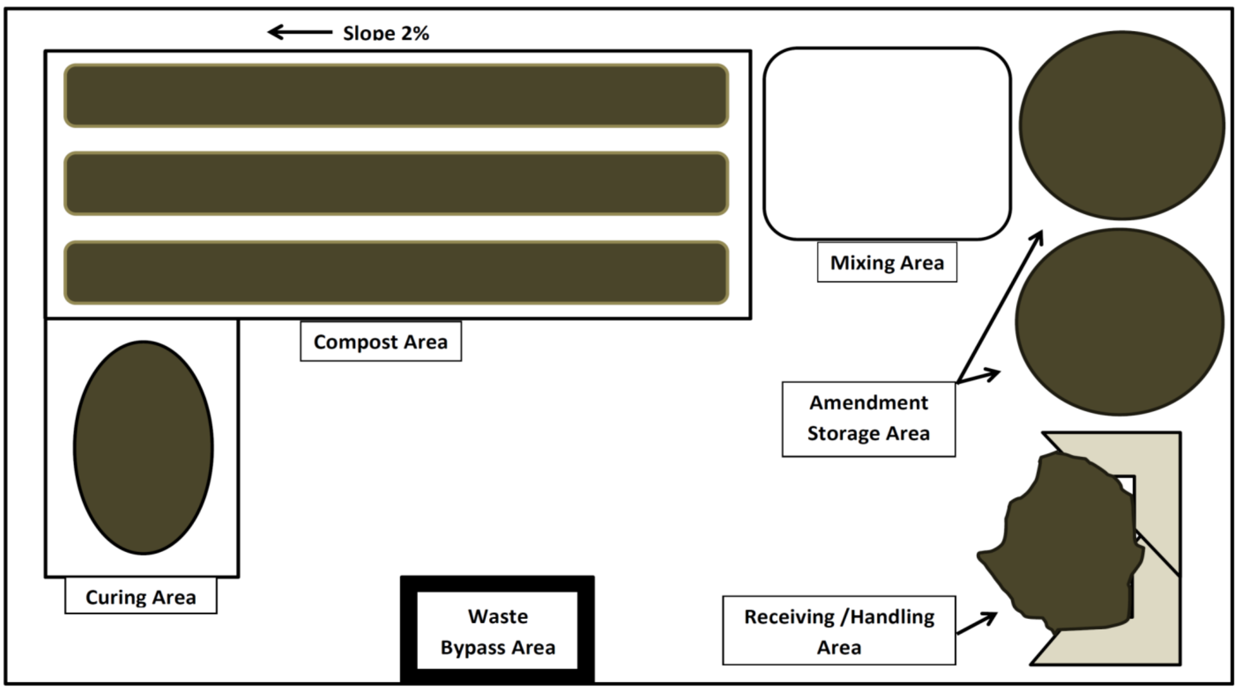


Illustration of the layout of a well-planned compost site

B. The Working Surface

Upon determining the footprint of the compost area, a suitable work surface (pad) should be developed. A flat surface with a 2 to 4% grade (pitch) allows surface precipitation to quickly move off the pad, which prevents ponding and excessive moisture in compost windrows. There has been much discussion regarding the benefits/need of an asphalt or concrete pad over a traditional compact gravel or soil-based pad. Proponents of the asphalt pad state that it provides an impervious barrier, preventing leachate movement to groundwater. In addition, asphalt and concrete pads are very durable and can withstand years of use with very little maintenance. Soil and gravel pads, on the other hand, are prone to leachate infiltration and associated rutting, needing to be scraped and resurfaced on a yearly basis. For leaf and yard trimming composting, a compacted gravel pad is adequate, as very little leachate is usually generated because of composting these feedstocks. However, if you are considering co-composting your leaf and yard trimmings with manure or food discards, you may wish to consider investing in an asphalt or concrete pad to avoid future leachate issues.

Compost facility design should include provisions for site drainage. Every attempt should be made to divert surface run-on (clean water) away from the compost area. This can usually be accomplished using upslope diversion ditches or berms. In areas where surrounding water sheds are significant, stone-lined waterways, and catch basins may be employed to intercept and channel surface water. Compost piles may be protected from precipitation by using pile coverings such as polar fleece to help shed excess water. Roofing over the compost operation is an option if the very high cost can be justified by the scale and goals of the program.

Runoff from the compost pad may be intercepted and treated by placing a vegetated “level lip spreader” on the downslope edge of the composting surface. County Soil and Water Conservation Districts can provide advice on design and placement of level lip spreaders or refer to the technical assistance list in the Appendix.

Facility access roads should also be designed and constructed with site drainage considerations in mind. Run-on from surrounding slopes can be diverted from the compost site simply by constructing a perimeter road perpendicular to the surrounding slopes.

C. Site Operations and Management

The general operations of a compost facility can be broken down into six separate steps:

- recipe development
- feedstock preparation
- mixing and pile formation
- turning
- curing

1. Recipe Development

The first step to beginning any compost effort is to determine what feedstocks are available for use and at what ratios they should be blended. The easiest way to accomplish this is to develop a compost recipe. As a rule, for leaf and yard trimmings, a recipe of three parts leaves to one part grass clippings will yield satisfactory results. If manure is added to the mixture, at least two additional parts leaves should be added for each part manure.

In a more detailed and comprehensive approach, each compost feedstock is representatively sampled and sent to a testing laboratory to be analyzed for:

- % moisture
- total nitrogen
- ammonia
- total carbon
- volatile solids
- bulk density
- pH

From the laboratory analysis, a final mixture (recipe) of feedstocks, which optimizes the chances for aerobic, thermophilic composting (sustained temperatures greater than 131 degrees Fahrenheit), can be developed.

For microbial colonization to occur, a recipe must contain appropriate amounts of carbon (microbial energy source), nitrogen (provides building blocks for microbial replication) and moisture (the medium that the microbes live in). In addition, there must be enough coarseness to the ingredients to promote natural diffusion of air throughout the final mixture. Otherwise, anaerobic conditions producing odors will occur.

The following conditions must be met, within the recipe, for optimal composting conditions to occur:

- moisture - 50 to 60%
- Carbon to Nitrogen Ratio (C:N) - 20:1 to 30:1
- pH 6.5 to 7.5
- Bulk Density <1,000 lbs./cubic yard, and
- volatile solids >40% dry weight basis.

For assistance in developing individual recipes, please refer to the technical assistance reference list that appears in the Appendix.

2. Feedstock Preparation Options

Once the compost recipe has been determined, you should consider preparing the feedstocks for the mixing process. The amount of time invested in initial feedstock preparation directly affects the rate at which materials will compost. The goal is to create a feedstock that can be handled easily but will decompose quickly. The first processing step usually involves material sizing through grinding. Grinding feedstocks prior to mixing increases available surface area for microbial contact, provides for a better mixture among ingredients, and helps to speed decomposition by initiating the physical breakdown of ingredients. The purchase or lease of a grinder can be a costly investment, but grinding services can be hired in Maine on a per day basis. The charge for this service usually consists of the cost of transportation, set up, and the grinding. Grinding should be considered when making up the facility’s operations budget.

Morbark™ 1300— Commercially available tub grinder (photo by Morbark™)

Once the feedstocks have been properly sized, the next consideration is moisture management. Ideally, a feedstock should contain approximately 50% to 60% water. Adding water to a dry feedstock will help optimize conditions for microbial colonization, whereas adding dry material to a saturated pile helps to create additional air spaces for pile oxygenation. To address this issue, the facility should have a water supply contingency plan, or if possible, have water directly available on site so that feedstocks and compost piles may be irrigated if necessary.

3. Mixing and Pile Formation

Next to recipe development, proper mixing is the single most important step determining success or failure of the compost operation. Obtaining a thorough, homogeneous mixture at the onset of the compost process will ensure intimate contact between the carbon, nitrogen and moisture components of the pile, thereby reducing the potential for the formation of “dead spots”. In addition, proper mixing allows for even air distribution throughout the pile, helping to promote aerobic composting.

Mixing can be accomplished by using front-end loaders, manure spreaders or other farm equipment, batch or continuous mixers, and windrow turners. Regardless of the chosen method, the objective is to obtain as thorough a mix as possible to help hasten the onset of the active composting phase.

Mixing Equipment commonly used for composting. Image on left is of Kuhn Knight™- Reel Auggie 3130 Mixer. The image on the right is of a typical manure spreader found on nearly any farm. (photos by Mark King)

The objective here is to create a pile large enough to sustain the “self-heating” process that accompanies active, thermophilic (requiring high temperature) composting. As a rule, piles should be constructed at least five to six feet high by eight to 15 feet in diameter. In areas experiencing long winter seasons, pile dimensions may need to be increased to 10 feet high by 15 to 18 feet in diameter. The size and shape of the compost pile will ultimately be determined by the type of compost system that you choose and the volume of material you will be handling in each season. In addition to adequate mass, the pile must also contain enough porosity (air spaces) to allow natural movement of air throughout the pile. Creating piles that are too high (more than 10 feet) risks compression of the inner core contents due to the excessive weight of the overlying materials.

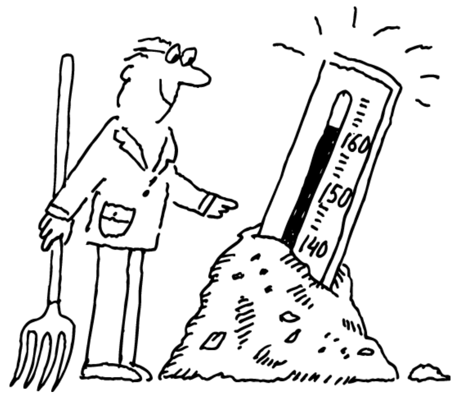
4. Turning

Turning is the physical process by which compost pile ingredients are blended and re-mixed throughout the active compost phase to help sustain thermophilic temperatures. During the turning process, compacted, settled materials are "fluffed up", creating air spaces. The act of turning accomplishes several things at once, including re-mixing of pile ingredients, further physical breakdown of resistant ingredients, and redistribution of air spaces within the pile to help promote passive air flow. In addition, the turning process can be used as a moisture management tool. Piles that are too wet can be turned more often to facilitate drying, whereas piles that are too dry may be turned immediately following precipitation events to help capture and retain moisture. In addition, flattening the top of a pile prior to an anticipated rain event increases the amount of surface area available to absorb moisture. The frequency of turning depends upon the individual needs of each compost pile.

Windrow turner at Rainbow Valley Farms in Sidney—(Photo by Mark King)

Most compost operators prefer to determine pile activity by taking daily temperatures. The best procedures to follow include:

- try and take temperatures daily whenever possible
- try and take temperatures from the same location and around the same time each day
- allow two minutes for the thermometer to reach a stable reading
- take a one foot and three-foot depth reading from same area
- turn the pile ingredients whenever the difference between the two readings is greater than 20 degrees F



The easiest way to track the performance of your pile and determine the need for subsequent turnings, is to take and record daily pile temperatures.

5. <u>Curing</u>

Once the compost mixture has completed the active compost phase, it must undergo a sustained period of curing. Curing is an important, and often forgotten, phase of the compost process. During curing, microorganisms continue the process of organic matter degradation (concentrating on organic acids, large particles, resistant compounds and other particles remaining after the active compost phase), but at a much slower, limited rate. Oxygen consumption, heat generation, carbon dioxide and water vapor evolution are all decreased as the material "matures".

Curing is also essential in preparing your product for market. Prolonged curing can make up for compost process shortcomings while also preventing the inadvertent distribution of an immature product. An immature compost product can potentially damage plant root systems due to the presence of volatile organic acids, high C:N ratios, high salt contents, or simply by competing with soil microbes or plant roots for available oxygen reserves.

When you have a reasonably mature product, you may wish to begin immediate distribution. Some facilities opt to screen the finished compost as a final processing step. Screening improves product quality by removing contaminants and other large, uncomposted particles from the finished product. Screening provides a uniform product that is aesthetically pleasing and therefore, has increased value. The costs involved, including capital investment and extra labor, often deter facility managers from choosing this option. In fact, if you take the time to properly inspect the feedstocks, removing contaminants prior to mixing, the screening step will often not be necessary. Regardless, whether to screen or not is an individual decision dictated by the needs of your community and consumers of the compost product.

Thomas Bandsaw Mills Trommel Screen 3010, made in Brooks, ME. (Photo courtesy of Thomas Bandsaw Mills)

V. Trouble Shooting

No matter how well a facility may be operated, there are invariably going to be nuisance problems from time to time. Nuisance problems are the number one complaint about compost facilities. Engineering and technology to correct these problems can often be expensive and ineffectual. The key to remember is that these are "people problems" and that prolonged nuisance conditions can lead to facility shutdown. Complaints should be met with an immediate response, including an explanation of the cause, if known. Good siting can help avoid potential nuisances by ensuring that you have adequate buffers to neighboring residences. Remember, many people "smell" with their eyes. Valleys and gullies should be avoided whenever possible, as they can carry nuisance odors to neighboring residences. Access roads should be located away from residences, maximizing the use of existing visual screens (tree buffers). However, there is no substitute for proper site management.

Most problems are often interrelated and as a result, addressing one usually solves the others. The key to overcoming nuisance problems is to identify the root cause and correct it.

The key to remember is that most compost problems can be avoided simply by optimizing the compost recipe (creating a homogeneous compost mixture that has a: moisture content of 40-60%; pH of 6.5-7.5; Carbon:Nitrogen ratio of between 20:1 to 30:1; and, has adequate porosity or "air spaces" within the piles) at the beginning.

The following section describes the most common nuisance problems associated with compost facilities and methods that have been developed to correct them. A condensed Trouble Shooting table immediately follows this section.

<u>Odors</u>: Odors signify a breakdown in the compost process. Left uncorrected, odors can drift off site impacting neighboring residences. Odor issues can be addressed by paying strict attention to process control. Incoming loads of seafood residuals should be immediately mixed with carbon amendment as soon as they are received. This is the first chance to control odors. If this is not possible, materials should be received in waterproof, airtight containers until they can be processed. Initial compost recipes should be thoroughly mixed, and the following parameters should be optimized: C:N (25:1 to 30:1), porosity (adequate air space distribution) and % moisture (45% to 60%). Finally, compost piles may also be covered with a 10-to-15-centimeter layer of sawdust, peat or finished compost to act as an odor scrubber.

<u>Vectors</u>: Vectors are organisms capable of transmitting diseases to humans. These organisms include birds (such as sea gulls and crows), mammals (rats and other rodents), and flies. They are attracted to smelly, decaying materials, typically released from food scraps and other residuals that have not been properly mixed into compost piles. Vectors can be discouraged by maintaining a neat and clean operation. Grinding seafood residuals also allows for better compatibility with amendments during mixing, making the organics less

odorous and therefore less attractive. In addition, thoroughly cleaning any on-site emptied storage vessels also reduces attractiveness to vectors.

Leachate: Leachate (typically a dark, brown liquid that is released from the composting process/excess moisture) results from poor moisture management during initial recipe formation and/or from prolonged exposure of compost windrows to heavy precipitation. As mentioned above, initial compost recipes should have a moisture content of 40 to 60%. Because leachate contains concentrated nutrients, it poses a significant threat to groundwater. In addition, if the piles are losing nutrients than your finished compost will be poorer in quality. There are several approaches to leachate management. The first is to prevent it. Leachate can be avoided by achieving proper mix ratios at the onset of composting.

Additionally, composting under a roofed structure or by using water resistant covering materials can help minimize the effects of precipitation on leachate generation. Many facilities try to capture the leachate by amending it with sawdust or other suitable materials and then re-incorporate it back into the compost piles. Other facilities collect the leachate into a storage tank and then reuse it on the piles when moisture adjustments are necessary. Finally, leachate may be discharged onto a level vegetated surface for treatment. The key to leachate control is to manage moisture in the initial recipe development.

Dust, Noise and Traffic: All these problems are often interrelated. Dust is created because of many compost facility operations including materials off-loading, mixing, compost turning, screening and traffic. Dust can also be exacerbated by prevailing winds, carrying particles onto neighboring properties. On site, dust can be irritating to facility workers affecting the eyes and respiratory tract. Noise from compost equipment such as front-end loaders, grinders, mixers, transport trucks and compost turners can annoy neighbors directly abutting your facility. Increased traffic results in noise, dust, excessive speeds and bottlenecks. These issues can be addressed by developing daily operating hours, monitoring equipment noise, setting speed limits on access roads and soliciting feedback from your neighbors. In addition, dust conditions can be minimized by moistening dry compost piles and enclosing screening, mixing and turning operations.

Condensed Composting 'Trouble Shooting' Guide

The chart below lists some of the common problems associated with composting and the creative solutions used to correct them:

Problem	Cause	Solution
Piles Fail to Heat	**Pile too Wet/Dry**	**Adjust moisture to 55%**
	pH too low/high	**Adjust pH to 6.5-7.5**
	Mix is not uniform	**Remix pile (grind if needed)**
	Particle size too small	**Add bulking agent to increase porosity**
	Particle size too large	**Add "finer-sized" particles**
	C:N too High	**Add more nitrogen to get C:N to 20-30:1**
	C:N too Low	**Add more carbon to get C:N to 20-30:1**
	Pile mass is too small	**Combine piles to increase mass**
"Uneven" Temperatures	**Mix is not uniform**	**Breakdown and remix piles**
Strong Ammonia Odor	**pH too high (>8.5)**	**Lower pH by adding sulfur**
	Pile is too dry	**Add moisture to reach 55%**
	Too much Nitrogen	**Add more Carbon to recipe**
Pungent "Rotting" Odor	**pH too low**	**Add Woodash or Lime to raise pH**
	Pile too wet	**Add dry bulking materials**
	Poor pile porosity	**Remix pile to increase porosity**
Final Compost not Stable	**Inadequate "Curing Time"**	**Allow compost additional time to finish**
	Bad recipe	**Remix pile and adjust recipe**

VI. Overcoming Challenges

Boothbay Regional Refuse Disposal District — (Photo by Mark King)

A. Composting in Maine

Operating a compost facility in Maine offers many challenges to the beginning facility manager. Seasonal fluctuations in weather conditions, as well as seasonal availability of feedstocks, require preplanning and site preparedness. In the spring, heavy rains can saturate piles, halting compost activity, while rendering access roads impassable. Likewise, sudden winter storms can paralyze a facility by freezing compost piles and halting compost activities. The key is to develop and stick with a successful operating plan that accounts for these weather factors.

B. Winter Composting

Maine winters are notorious for being long and cold. Accumulations of snow and ice, coupled with extended periods of subzero temperatures, can spell disaster for outdoor (exposed) facilities if caught unprepared. Excessive snow must be removed and access routes kept open to allow continued facility operations. Cold temperatures slow the compost process by increasing the amount of heat lost by the compost pile. As this continues, pile microorganisms slow down their metabolic activity, further exaggerating the heat loss, which may result in complete halting of compost activity.

Prior to the onset of colder weather, composting piles may be combined to increase mass (to retain heat) and prevent freeze-ups. As a rule, finished piles should be at least five feet high by 10 feet wide to assure enough mass to sustain thermophilic temperatures throughout the winter season. Piles (windrows) may also be covered with a commercially available pile cover. The covers, manufactured from a wide variety of materials, help insulate compost piles by preventing heat loss and cold infiltration. In addition, the covers shed water further protecting the pile's surface from freezing. Even if the piles do freeze, it is important to remember that this is only a temporary condition and that the compost process will take off again once the piles thaw.

Spring composting provides additional challenges to facility operators. Periods of heavy rains and slow ground thawing may result in pad rutting and site accessibility issues. This problem can be avoided by designing and constructing an impervious composting surface as well as planning for durable year-round access during the site selection and development phase.

C. SEASONAL AVAILABILITY OF FEEDSTOCKS

Many composting feedstocks are available on a seasonal basis. Leaves, for example, are collected primarily in the fall and to a lesser degree during spring clean-up. They must be composted in large quantities. Facilities must develop contingency plans to make allowances for this sudden influx. Seasonal feedstocks will require additional storage as well as adequate space for their immediate processing. Some facilities may wish to compost on a "seasonal basis", operating only when the feedstocks are available. This method works well for small communities who save a portion of space at the local transfer station to handle incoming leaves in the fall.

VII. Compost Health and Safety Issues

Prior to beginning composting at any facility, it is important to take a step back and review the process for any potential health and safety issues that operators and facility employees might face. This extra step will help you avoid unnecessary and costly injuries. Most potential issues revolve around the compost process itself, and the myriads of equipment used to facilitate daily operations. This Chapter will discuss the major of the Health and Safety issues associated with the compost process, including identification of the potential hazard(s) and introduction of specific steps that can be taken to avoid or eliminate hazards.

When attempting to identify potential hazards, the first step is to conduct an “audit” of the process. This specifically means sitting down and critically reviewing how the compost materials (feedstocks) flow through the facility, from initial receipt to completion of the composting process. Materials handling at each individual step of the process should be considered.

A. Categorizing and Addressing the Hazards

As was alluded to above, most potential compost facility hazards fall into one of two categories: **equipment hazards** and **personal exposure hazards**. Equipment hazards involve traumatic, direct contact injuries such as slips and falls, strains and sprains, entrapment, crushing injuries, amputations, electrocution, injuries from flying debris, or repetitive stress injuries. Equipment injuries are usually more prevalent when employees are physiologically stressed (overworked, fatigued), or may simply be due to ergonomic issues such as bad posture. Personal exposures usually result from indirect contact because of equipment use or feedstock manipulation. These hazards include fumes, dust and other respiratory irritants (bioaerosols), leachate, noise, and environmental stressors (such as extreme heat or cold, wind and precipitation). Most personal hazards are alleviated with personal protective equipment (e.g., goggles, gloves, boots, hearing protection, respiratory protection).

Both equipment and personal hazards may be reduced or avoided by developing “protective measures” beforehand, including:

1. Planning regular breaks for personnel to rest and refocus. Mandatory stretching targeting frequently used muscle groups should be considered as well.

2. Dividing tasks among multiple employees to reduce potential for overwork or early fatigue.

3. Encouraging proper posture, lifting techniques, and other ergonomically correct methods to reduce the potential for repetitive stress and other injuries.

4. Frequent training to reinforce proper and safe use of equipment.

5. Providing personnel with appropriate and necessary personal protective equipment (PPE).

6. Routine equipment inspection and maintenance.

B. Bioaerosols

This chapter would not be complete without mentioning ***Bioaerosols***. Bioaerosols are a group of respiratory irritants, including - bacteria, fungi, viruses, and organic dusts - that may cause respiratory and gastrointestinal issues when inhaled or ingested. Much study has been focused on bioaerosols since the mid-1990s due to health concerns from neighbors abutting large compost facilities. Results indicated that bioaerosols are generally transported on organic dust particles that did not travel far from the area of generation. Thus, indicating that bioaerosols are a facility concern and do not pose a risk to facility neighbors. The studies further conclude that bioaerosols do not generally pose a risk to healthy individuals but seem to specifically impact individuals who have chronic respiratory issues or have suppressed immune systems. Smoking was also found to be a contributing factor to the effectiveness of bioaerosol infections.

Recommendations arising from these studies all focused on reducing dust generation and limiting personal exposure risk by providing staff with initial and routine health monitoring, providing proper PPE (including respiratory protection) in areas where organic contaminants are prolific, or by simply removing susceptible personnel from areas where bioaerosols may be abundant. Dust generation may be reduced by keeping feedstocks and other materials moist, and by enclosing operations prone to excessive dust generation such as grinding, mixing, and screening operations.

VIII. Summary

- ✓ Set the goals of the Compost Program
- ✓ Create a continuing public education program
- ✓ Create the marketing plan for compost before you create the compost
- ✓ Select a site that meets the goals of the program, fits the resources of your community or business, and is compatible with state regulations
- ✓ Follow the guidelines for making compost - - paying attention to the recipe, the mix, the flow of materials through the various stages of the operation, and the slope and condition of the working surface
- ✓ Record the temperature and odor of the piles and use them as your guides throughout the process
- ✓ Be prepared to modify your operation as compost conditions require
- ✓ Distribute the cured and finished compost

FOR COMMUNITIES

Nearly a third of Maine's communities have instituted bans on the disposal of leaves and yard trimmings with their municipal solid waste. Currently, there are 35 centralized municipal leaf and yard waste programs in operation in Maine. This guide is intended to encourage and support more municipalities to consider a composting option for the unwanted organics currently being disposed of.

Programs that have established successful track records in managing leaf and yard trimmings encourage you to think about taking their composting programs to the next stage and adding other source separated organics to their mix. Good examples would be certain kinds of food wastes and fish processing wastes. Food discards comprise as much as 25% of the residential waste stream as compared to 13-14% for leaf and yard trimmings. Such a move would require additional regulatory review and monitoring but would provide an alternative management option at a potentially lower cost than other disposal methods currently available. For more information on composting these and other materials, please see Appendix A (Technical Assistance.)

IX. Resources Available

Maine DEP Compost Resources

Staff from the Division of Division of Materials Management are ready to assist you with all aspects of starting and operating a compost system at your school. The following contact list will help connect you with the appropriate staff to ensure your compost project is a success:

DEPARTMENT OF ENVIRONMENTAL PROTECTION
17 State House Station 28 Tyson Drive
Augusta, ME 04333-0017
Phone: 207-287-7688 or 1-800-452-1942

Maine DEP—Compost Education and Technical Support

Maine DEP Staff	Region Covered	Phone Number	Email Address
Mark King	Statewide	(207) 592-0455	mark.a.king@maine.gov
Margaret Watson-Pierce	Northern Maine	(207) 242-0383	margaret.watson-pierce@maine.gov
Jim Pollock	Central Maine	(207) 592-8343	james.c.pollock@maine.gov
Sarah Smith	Central Maine	(207) 881-7936	sarah.smith@maine.gov
Edward Stamborski	Eastern Maine	(207) 881-7935	edward.stamborski@maine.gov
John Breedlove	Eastern Maine	(207) 530-6601	john.breedlove@maine.gov
Daniel Chea	Southern Maine	(207) 855-8129	daniel.chea@maine.gov
Stephen Morin	Southern Maine	(207) 252-1851	stephen.morin@maine.gov

Publications

Composting for Municipalities, Planning and Design Considerations
Editor: Mark Dougherty. Natural Resource, Agriculture, and Engineering Service, 152 Riley - Robb Hall, Cooperative Extension, Ithaca, NY. 14853-5701. 1998. 126 pages (NRAES publication #94)

The Art and Science of Composting
Edited by the Staff of BioCycle. JG Press, Emmaus, Pennsylvania. 1991. 270 pages.

Yard Waste Composting
Edited by the staff of BioCycle. JG Press, Emmaus, Pennsylvania. 1989. 197 pages.

On Farm Composting Handbook
Editor: Robert Rink. Natural Resource, Agriculture, and Engineering Service, 152 Riley - Robb Hall, Cooperative Extension, Ithaca, NY 14853-5701. 1992. 186 pages. (NRAES publication #54)

Municipal Leaf and Yard Waste Composting
Coordinated by Nancy E. Adams. University of New Hampshire Cooperative Extension, PO Box 200 Epping, NH 03042. 1993. 44 pages. *Heavily Appended, includes glossary.*

Keep It Off the Curb
Harmonious Technologies. PO Box 1865, Ojai, CA 93024. 1994. 218 pages. *A manual for managing a home compost program*.

Field Guide to On-Farm Composting
Editor: Mark Dougherty. Natural Resource, Agriculture, and Engineering Service*,* Cooperative Extension 152 Riley-Robb Hall, Ithaca, New York 14853-5701. 1999. 118 pages. (NRAES publication #114)
Field Guide format, plastic coated pages.

Useful Web Site Links

Maine Compost School

The U.S. Composting Council

The Composting Council of Canada:

US EPA Composting Resources

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