Commercial Composting Systems

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Many systems for composting have been developed and differ with regard to methods of loading and unloading, mixing, aeration, and retention time (Cornell Univ., 1992; The J.G. Press, 1989, 1994). The system used will greatly influence composting time, amount of space required, location of facilities, available funds, and feedstock(s) or waste(s) to be composted. Regardless of the system used, it must be properly managed so that the mass of organic waste will always remain aerobic during composting and curing to minimize odors and produce a quality product. Composting systems generally influence the initial composting period but have little effect on curing, which results in the production of mature compost. Curing of compost occurs under cooler temperatures, during which the more difficult to decompose organic compounds are degraded and compounds formed during composting become stable. Some composting systems require more space than others, which may determine location. Because the composting process generally generates odors, selecting a system that provides odor control may be the determining factor in locating a facility, especially in urban areas. The more engineering that is involved in designing a composting system, the more expensive it becomes. Furthermore, highly engineered composting systems require greater managerial skills and maintenance.

Types of feedstocks can determine the type of composting system that will be needed. Feedstocks that are relatively uniform, such as biosolids, animal manures, bark, and wood waste, require relatively little horizontal mixing (blending of materials between days, weeks, or months) to produce a compost that is consistently uniform. Feedstocks that are highly variable, such as municipal solid waste (garbage), yard and garden trimmings, or waste from produce or processing plants (which may be seasonal), will generate a compost that is highly variable unless subjected to horizontal mixing.

However, the ultimate test of horticultural value is whether the compost can be used for growing plants. Regardless of the composting system used, unless the compost is mature it has little horticultural value except for use as a mulch or to fix nutrients in soils to prevent them from leaching into groundwater.

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COMPOSTING SYSTEMS

Composting systems can be classified as open or in-vessel. Open systems are designed for use outdoors and require a minimum amount of engineering. Depending on the volume of feedstocks to be processed, most require a considerable amount of space. In-vessel systems are generally highly engineered but maximize composting technology and provide for odor control.

OPEN SYSTEMS

The static pile method is the least time-consuming and expensive method of composting. This method requires that feedstock(s) be placed in piles or windrows of limited size and shape to maximize the use of convection currents, in order for the mass to remain aerobic. This system requires minimal management, but requires a considerable amount of space, because the composting process is slow, generally requiring 1 to 2 years, depending on particle size and feedstock(s). If more than one feedstock is used, they may be mixed or placed in layers within piles or windrows. This method of composting is used during the initial composting of poultry and hog carcasses and, to some extent, for yard and garden trimmings. Equipment and facility needs are minimal.

However, static pile composting generally does not generate a uniform compost because the outer layer does not decay. The center of the pile often becomes anaerobic and acidic, and may contain alcohols, especially if the piles are too big or if precipitation is high. Building windrows or piles of the proper size and shape is important, too, if the system is to be used effectively and with minimal problems.

The agitated windrow system is extensively used for composting yard and garden trimmings and food processing waste. This is also used in conjunction with in-vessel systems with short retention times, and when composting highly variable feedstock. It permits horizontal mixing, resulting in a more uniform and consistent compost from variable feedstocks.

Feedstocks in the agitated windrow system must be turned frequently to maintain an adequate O₂ level, especially during the initial composting period. Equipment for turning windrows can be as simple as a front-end loader or as sophisticated as self-propelled or tractor-assisted windrow turners. In addition to providing the necessary aeration, windrow turners rearrange the feedstock to assure uniform composting. During turning, the feedstock is ground into smaller particles, thus accelerating the composting process. As wind-

rows become smaller, they are merged to conserve space and save time, yet maintain adequate mass to maximize the rate of composting.

The agitated windrow system requires a considerable amount of space and certain management skills to produce a uniform quality compost. However, the system can easily be adapted to composting variable feedstock because all windrows are easily accessible at all times.

The aerated static pile system requires less daily management than the agitated windrow system but requires more engineering. Its use should be limited to feedstock that is relatively uniform. The size and shape of the windrow or cone varies with the feedstocks and aeration system. Blending and mixing equipment is essential to achieve a homogeneous mixture that will provide for aeration, and a source of power is necessary. Monitoring equipment is essential to assure that minimum levels of O₂ and optimum temperatures are maintained uniformly throughout the compost. Since the cones or windrows are left undisturbed until the initial composting process is complete, aeration is accomplished by negative or positive ventilation. In positive ventilation, air is forced up through the composting mass, while in negative ventilation, air is drawn down through the pile by creating a vacuum under the compost.

Most of the labor needs are limited to building and breaking down piles, monitoring, and screening. There is no opportunity for incorporating other feedstocks during the initial composting process. However, the windrows or cones are covered with finished compost to insulate the composting mass in order to achieve desired temperatures throughout, and to filter odors. This system is used primarily for composting biosolids, barks, and manures.

The extended aerated static pile system is simply an extension of the aerated static pile system, in which windrows overlap each other and share aeration systems. The overlapping conserves space and provides more uniform heating, especially during cold periods.

One of the advantages of both the aerated static pile and the extended aerated static pile is that they can be established and managed using commonly available equipment. All that is needed is a well-drained surface, front-end loader, a power supply, and blowers to either force or draw air through perforated drainage pipes. Any of these can be replaced should a breakdown occur.

IN-VESSEL SYSTEMS

Many in-vessel composting systems have been developed to conserve space, increase

the efficiency of composting organisms, and obtain better control of objectionable odors. All have two common problems: they require intensive management to maximize their efficiency; and when their specialized equipment malfunctions, repairs may require from a few hours to months. They are also expensive to install and maintain. Furthermore, most invessel systems are designed to maximize microorganism activity during the initial composting period, thus reducing composting time, but do not provide sufficient retention time to produce a mature compost.

The rectangular agitated bed composting system provides for some horizontal mixing of compostables and uses forced aeration to optimize microbial activity. Like most invessel systems, this system is used primarily to compost feedstocks that are relatively consistent. Agitation of the feedstock to assure uniform composting can be done on a timed schedule or as needed. Aeration of the feedstock is accomplished by either negative or positive pressure activated by O₂ or temperature sensors. This system is commonly used for composting biosolids, animal manures, and barks. Retention time is dependent on frequency of agitation and vessel capacity.

The auger agitated bed composting system uses the continuous flow process in a shallow silo. Feedstock is supplied at the outer periphery of the silo and augers move it towards the center where it is discharged. Positive pressure ventilation is also used to provide aeration. Because of the engineering limitations associated with its geometric design, retention time is generally limited from 5 to 7 d if operated on a continuous basis. This is insufficient to produce even a stable compost. Compost removed from this system must be placed in a static pile, agitated windrow, or aerated static pile to complete the composting process.

Because so much horizontal mixing occurs during the initial composting period, this system is used primarily for composting highly

variable feedstock with relatively low bulk density, such as municipal solid waste (MSW), commonly known as garbage.

The rotating drum agitated composting system uses a continuous flow process in a large diameter drum that turns slowly and moves and mixes the feedstock using spiral baffles. The length of the drum and the speed of rotation varies with the volume of material to be composted and desired retention time. Most drums are designed for a retention time of 10 to 14 d. Aeration is based entirely on convection currents through the slowly turning drum. The composting process cannot be evaluated until the compost is discharged. This system is used primarily to initiate the composting of MSW prior to transfer to static pile, agitated windrow, or aerated static pile systems to produce a marketable compost. It is the only system to date that permits the recovery of heat energy from the walls of the drum by either air or water without adversely affecting composting activity.

Tunnel composting systems are limited primarily to composting materials with low bulk density, such as MSW. The MSW is ground and moistened before being placed in aerated tunnels. Rams advance the MSW a few feet each day through the tunnels where O₂, moisture, and temperature are constantly monitored. No visual evaluation is possible until the compost is discharged at the end of the tunnel. Most tunnel systems have 14 tunnels, providing a retention time of 10 to 14 d. A daily allotment of MSW is placed in each tunnel each day. Reasonable consistency is assured by horizontal mixing each day when a portion of the compost is discharged. However, the compost must be placed in static pile, agitated windrow, or aerated static pile in order to mature.

Silo composting systems depend on gravity to move feedstock through the composting process. The feedstock is fed into the top of the silo and it moves downward as a plug for 5 to

7 d. An auger system at the bottom removes the compost, mixing and grinding it as it is discharged. The compost is then conveyed to the top of a second silo, called a curing silo, with a similar retention time as the first. The compost in both silos is under positive pressure aeration. However, since there is no agitation within the silo, channeling of the air can occur. This tends to create pockets of anaerobic activity within the compost and reduces its quality. Also, this system of composting does not allow horizontal mixing until after discharge.

Tipping floors require that the feedstock be placed on the top floor of a multistoried building. The floors are hydraulically operated so that the compostables move to the lower floor on a regular schedule. The movement of the compostables from one floor to the next provides aeration and mixing. Moisture can be added on any floor as necessary. However, there is no mixing between batches until the compost is removed from the tower.

Evaluation of the quality and consistency of compost being generated indicates that composting systems should be selected based on the feedstock and the amount of time required to produce compost for horticultural uses. Two different composting systems may be necessary to assure that the product is mature and consistently uniform. Most feedstocks cannot be made into mature, stable compost in 7 to 14 d. Making quality compost is like making fine wines and cheeses; the time required depends on the feedstock and the processing method used.

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