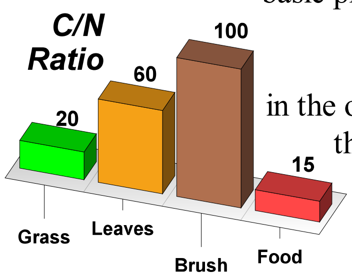
Processing Food Scraps and Soiled Paper

After the food scraps and soiled paper have been separately collected, they must be processed at a composting facility capable of managing the challenges that the food scraps in SSO programs present.

Composting Basics

To understand the capabilities and limitations of each type of composting system in light of the new challenges posed by the implementation of programs that collect food scraps, some basic principles need to be reviewed.



Composting relies upon a balance between the carbon and nitrogen content in the organic feedstock, along with other conditions, in order to optimally regulate the rate of decomposition. That balance also avoids volatizing pollutants or odors into the atmosphere, while providing cellular structure and nutrient value to the bacteria and fungi that makes up the humus returned to the land.

Composters strive for a ratio of carbon to nitrogen (C/N) in the range of 20:1 to 30:1. With more carbon than a ratio of 50:1, the rate of decomposition slows significantly. A ratio of less than 15:1 will generate ammonia and other volatile organic compounds (VOCs), creating air quality and odor problems.

Composting also requires at least 5% oxygen distributed throughout the mass of organic material to prevent anaerobic conditions that worsens air quality concerns, as well as moisture levels between 40%-60%, in order to optimize decomposition and reach peak temperatures of about 140°F that will destroy pathogens and weeds and provide an environment for the heat-loving bacteria that produce the healthiest humus.

When food scraps in the organic stream are significantly increased, the nitrogen component is magnified, which lowers the C/N ratio, rapidly accelerating the rate of decomposition, along with the tendency to turn anaerobic, and with major odor problems. These are the problems that SSO programs have to properly manage.

Types of Processing Systems

The selection of an existing, or construction of a new, processing facility for SSO programs turns on many factors as to which will:

- Be located within a reasonable distance from the collection routes
- Not create air quality or odor problems
- Have sufficient capacity and residence times to handle the program's thoughputs
- Produce a marketable product

- Be reasonably priced

But, while there are workarounds for most of the issues, *the* limiting condition is the prevention of odor problems, which risks compromising an entire program, and in parts of California, such as the South Coast and San Joaquin Valley regions, that applies to VOC emissions as well. That is the reason why the paramount decision in planning a program is the type and operator of the processing facility, and their capacity to properly manage high nitrogen food scraps.

HOW TO FIND A COMPOSTER IN YOUR AREA

Go on-line to Find-A-Composter, which is maintained by the Biodegradable, BioCycle and Greenscapes, to find the location of composters, including those which accept food scraps, in your area.

The wide array of technologies in use commercially to process SSOs can be categorized into three groups – windrows, in-vessel and anaerobic digesters. They reflect a continuum of greater costs, complexity and capabilities to manage food scraps. The first two, which process material either outdoors or in a building, both use aerobic decomposition, and the third uses anaerobic decomposition, which is always enclosed, and is followed by aerobic composting of the residual digestate.

As one moves from open air and covered windrows to in-vessel silos, containers, channels and drums, and finally to enclosed anaerobic digesters, the costs and the complexity of the systems will increase significantly. At the same time, so will the system's capabilities increase to process more material, higher nitrogen ratios and volatile fatty acids, very low porosity and more contamination, and to do so more quickly and using a smaller footprint.

In general, most residential organics programs in the U.S., with the exception of San Francisco and San Jose that are investigating anaerobic digesters, are primarily still using windrows. The more developed Canadian programs are widely using several in-vessel technologies, and, in the case of Toronto, anaerobic digesters. See TABLE 1.

MAJOR GROUPS OF ORGANIC PROCESSING SYSTEMS			
	Aerobic		Anaerobic
	Windrows	In-Vessel	Digesters
Types	➢ Open turned piles ➢ Static aerated piles ➢ Covered -Pod ➢ Covered - Fabric	➢ Shipping container ➢ Silo ➢ Tunnel ➢ Channel ➢ Rotating drum	➢ Sewage plant digesters ➢ Wet digesters ➢ Dry digesters
General Description	Elongated piles of organics, usually yard trimmings and sometimes sludge, laid out on the ground, or on concrete slabs. The piles can be either open or covered, and aerated manually with end loaders by turning or with forced aeration through piping.	Organics, more often including food scraps and soiled paper, are placed in either shipping containers, in rotating drums, or, in an enclosed building, in tunnels or channels where forced aeration or moving paddles are used to bring oxygen to the material.	The part of the organics primarily consisting of food scraps and soiled paper are first placed in an enclosed anaerobic digestor to generate methane for energy, and then the remaining digestate is composted using conventional aerobic processes

TABLE 1

Existing Windrow Composting Capabilities

Almost all existing composting operations in the U.S. are windrows-based systems. In these facilities, the organic material is laid out into elongated piles, monitored for temperature and sometimes for oxygen content, watered periodically, and turned mechanically or aerated in static piles.

Photo Credit: San Francisco

Covered windrows at Recology's Jepson Prairie

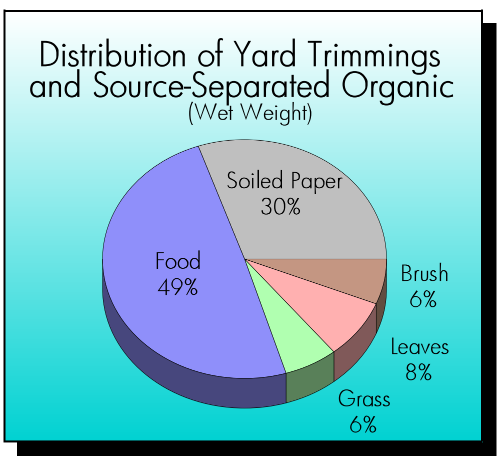
Windrow operators are usually quite skilled at their jobs. For years, they have successfully balanced piles of yard trimmings, with its grass, leaves and brush components, and each stream's different C/N ratios and seasonal characteristics, by calibrating the mixture to be balanced.

These strategies have involved mixing in the correct proportions of grass, which is high in nitrogen, with leaves and brush, which are high in carbon and naturally include bulking material. Sometimes sawdust or sludge may be added to tune the mix, and one or the other material might be stockpiled during seasons when it is plentiful for later seasons when it is not. When more recycling programs expand to include high nitrogen food scraps, however. traditional windrow operations will tend to face these challenges from food scraps that:

> WHERE WINDROW COMPOSTERS CAN FIND BEST PRACTICES TO PROCESS FOOD SCRAPS
>
> Go on-line to Best Practices, which was prepared by the U.S. Composting Council to assist traditional windrow composters of yard trimmings in adding food scraps.

- Have very high nitrogen content that may decompose so rapidly that they will loose their nutrient value, outgas VOCs and ammonia and smell before there is time to finish composting
- Is also dense and moist without any natural bulking material, which means its porosity, essential to permit thorough aeration, is very low
- Can contain volatile fatty acids (VFA), which impedes composting

Fortunately, composters have developed more sophisticated mixing strategies for phasing in food diversion programs. These involve a combination of mixing one community's nitrogen rich food scraps with another's leaves to add carbon, accompanied by the introduction of bulking agents to add porosity. This strategy has been able to produce an appropriate C/N balance that can be adequately aerated. Composters report that a mixture consisting of approximately 75% leaves and brush and up to 25% food scraps, along with bulking agents, can be managed in windrows.



Source: Center for Competitive Waste Industry

FIGURE 1

However, once the number of SSO programs in an area served by a windrow facility ramp up, the mixing strategy among communities with and without SSO programs will become significantly more challenging. Eventually, the leaves from those other communities, which had been used to mix with the food scraps from the programs of the early adopters, will be called back in an attempt to balance the organic material from the later adopting programs. As illustrated by FIGURE 1, there is not sufficient high carbon leaves and brush relative to the high nitrogen food in order to meet all of the surrounding communities' carbon requirements if several of them expand their organics diversion efforts.[1]

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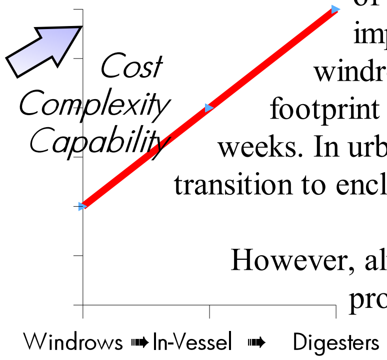
[1] EPA, *MSW Generation, Recycling and Disposal in the U.S.* (2009), TABLE 3. The breakdown between soiled paper and the *un*contaminated fiber fraction not shown, is 50%/50% based upon waste composition studies performed by the Center for a Competitive Waste Industry. The breakdown of yard trimmings between grass, leaves and brush is from Cary Oshins, "Feedstock Composition at Composting Sites," *Biocycle* (September 2000), TABLE 2 at p. 33. Note that this breakdown of organic discards adds back yard trimming generation to illustrate the relative distribution of all separated organics destined for composters.



Program managers will then have to give enclosed systems more serious consideration out of necessity, notwithstanding the greater costs those systems entail. Adding impetus for more advanced processing is the fact that the curing period for windrows, with their months' long residence time, requires a much larger site footprint than more advanced systems with more rapid throughputs of just a few weeks. In urban areas, space constraints may also ultimately add the impetus for a transition to enclosed models.

However, although odor and air quality issues are always looming if open sites are not properly managed, the release of the greenhouse gas methane into the atmosphere does not tend to be significant among the byproducts of aerobic composting, even if in improperly managed sites the center of the piles sometimes become oxygen-starved, for the following reasons:

- Not enough water is usually added to windrows to provide sufficient moisture for methanogenesis
- There is usually insufficient time to pass through the two phases to reach methanogenesis
- The surrounding organic mass will tend to oxidize any methane from the localized pockets where the necessary biological and chemical process that produces methane might intermittently occur

Concerns with Enclosed Systems

At the same time that there is an understanding of the strengths windrow systems in the short-term, and limitations in the long-term, the more advanced processed systems also have concerns that need to be recognized. They ought not be considered a panacea.

In-Vessel Composting Systems

The next level of organics processing systems are the enclosed operations that can be nearly double the cost of windrows. In essence, they combine two features. The first is a fixed enclosure to better control processing and odors using negative pressures and biofilters. While they have the technical capability to control odors when operated within their design parameters, actual performance depends upon proper and careful management.

The other feature of in-vessel systems is some mechanism intended to provide better aeration than has been feasible in windrow operations. These aerating strategies primarily include several variations on forced aeration and bulking agents to slowly moving paddles in a

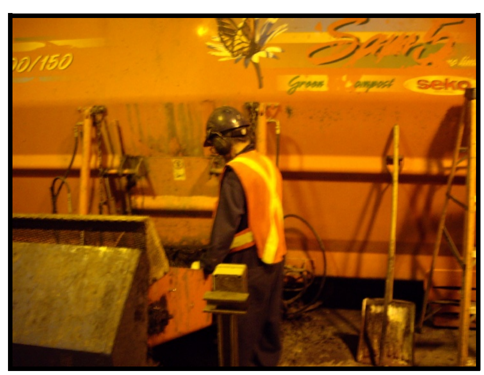


Photo Credit: Center for a Competitive Waste Industry

Enclosed container

channel to shift the loads.

While there is little doubt but in-vessel systems do aerate food rich loads better than most windrow facilities, a question that is hotly disputed is whether one or the other provides adequate thorough aeration to prevent anaerobic hot spots, and how serious an issue that is.

For that reason, some argue that only in vessel continuously rotating drums are adequate to the task to completely compost food scraps. The controversy is so intertwined in the profitability of the vendors offering the different systems that an objective conclusion is elusive.

7.6.4.2 Anaerobic Digesters

The most advanced system for processing source separated organics is anaerobic digesters (AD), that are as much as triple the cost of windrows (before accounting for the potentially large collection cost savings described in the collection discussion. Like the other in-vessel systems, ADs are enclosed. They are also the only processing system that handles the organic material anaerobically in a digester to produce energy, before the residual digestate is later composted conventionally in windrows or silos so that both the energy value in nitrogen rich organic streams and residuals are recovered.

Photo Credit: Center for a Competitive Waste Industry

Anaerobic digester

However, odors are inherently a significantly greater problem with anaerobic than aerobic decomposition. While European AD facilities are reported to function as designed without odors, the first efforts to import them to North America in Toronto have had operational problems. Securing competent management for an AD facility is even more critical than for the aerobic in-vessel systems. In 2009, three cities in North America are actively pursuing development of AD projects: Toronto, San Francisco's private hauler, Recology, and San Jose's hauler, Green Waste Recovery.

<u>Technologies for Processing</u>

The following three tables provide more details about the three broad groupings of compost technology available to handle source separated organics from households that include food scraps and soiled paper, in addition to yard trimmings. The first two, windrows and in-vessel systems compost aerobically, and the last, digesters, generate electricity anaerobically followed by aerobic composting of the digestate that remains.

TABLE 2 describes the four types of windrow based systems, two of which are open piles (turned piles and static aerated piles) and the other two are covered piles (pods and fabric).

Composing systems

Windrows

	Open		Covered	
	No aeration/Turned	Aeration/Static		
	Manually Turned Piles	Static Aerated Piles	Pod	Fabric
Description	Feedstocks are formed into piles, monitored for temperature and sometimes for oxygen content, watered periodically, and turned mechanically based on a regular schedule or on review of temperature and/or oxygen readings. The most common shape is a windrow (elongated pile); another configuration for the composting mass is a trapezoid.	Active aerated static piles achieve air circulation through the use of passive or active aeration using perforated piping. In municipal-scale systems, active aeration, by which air is forced through the composting mass, is more common than the passive method. Active aeration often depends on computerized monitoring systems, which control the amount, frequency, and duration of oxygen to be delivered to the composting mass.	The pod system of covering piles is essentially a static aerated pile encased in a tub or sock made of LDPE plastic, typically 5-12 feet in diameter and about 200 feet long. The tube is "stuffed" with a hopper or mixer using a ram or auger. Upon filling both ends are closed and blowers provide positive aeration with vents for exhaust air.	The fabric system for covering piles uses a plastic sheet pulled over windrowed material approximately 40 feet wide and 175 feet long.
Costs	$15-$40/ton	$25-$60/ton	$55-$65/ton	$55-$65/ton

Composing systems

Windrows

	Open		Covered	
	No aeration/Turned	Aeration/Static		
	Manually Turned Piles	Static Aerated Piles	Pod	Fabric
Pros	Relatively simple to operate; lowest cost; greatest operational experience; and if minor volumes of food scraps and soiled paper are involved and can be mixed with yard trimmings from other communities, existing facilities may be able to handle some additional residential organics during field testing without major upgrades.	More controlled environment, during initial phase of composting; low water input; relatively rapid throughput time; may meet more easily with community and regulatory approval than adding residential organics to existing outdoor turned pile systems. Less space consumed for wide aisles to facilitate turning piles.	Somewhat greater, but not significantly more complex than uncovered piles, and simple way to reduce vector attaction and emissions, and, to a lesser extent, odors, though possibly not sufficiently in states with strict air quality rules. Less space consumed for wide aisles to facilitate turning piles.	Low complexity, and simple way to reduce vector attaction and emissions, and, to a lesser extent, odors, though possibly not sufficiently in states with strict air quality rules. Also, cover can be retracted and the material turned to a limited extent that does not impact the aeration pipes to hasten degradation. Less space consumed for wide aisles to facilitate turning piles.

Composting systems

Windrows

	Open		Covered	
	No aeration/Turned	Aeration/Static		
	Manually Turned Piles	Static Aerated Piles	Pod	Fabric
Cons	Least likely to be able to properly manage any serious volumes or proportions of food scrap and soiled paper, in terms of keeping the material adequate aerated for thorough aerobic decomposition. Questions have been raised whether the oxygen from occasional manual turning is quickly consumed long before the next time the pile is turned. Also, may have difficulty complying with states that have strict air quality programs.	May encounter anaerobic pockets within the composting mass, resulting in incomplete or insufficient processing; may involve a second stage of composting using an outdoor turned pile method, which could result in similar challenges as presented by the outdoor turned pile method itself. While aeration is usually better than turned piles, questions remain about its ability to cope with significant volumes of food and soiled paper and air emissions, although less so than turned piles.	Because there is no agitation from turning, decomposition may be slower in colder climates. Also, water cannot be easily added to optimize decomposition. Again, aeration is usually better than turned piles, but questions remain about its ability to cope with significant volumes of food and soiled paper and air emissions, although less so than turned piles.	Again, aeration is usually better than turned piles, but questions remain about its ability to cope with significant volumes of food and soiled paper and air emissions, although less so than turned piles.

Composting systems Windrows				
	Open		Covered	
	No aeration/Turned	Aeration/Static		
	Manually Turned Piles	Static Aerated Piles	Pod	Fabric
Time	Three months	Three months	Three months	Two to three months
Supplier	N/A	N/A	Ag Bag, CTI	Gore Cover

TABLE 2

TABLE 3 describes the five forms of in-vessel composting systems in which the composting operation is contained inside a rigid physical structure. The first two, silos and containers, are static systems in which the piles are not moved, and the other three involve some continuous mechanical form of agitation. Agitation physically moves the organic material by a variety of means more thoroughly, frequently and regularly than occasional manual turning of piles and is intended to achieve more aeration than forcing air through a static pile.

Composting systems

In-Vessel

	Aeration/Static			Agitation	
	Silos	Containers	Tunnel	Channels	Drums
Description	Similar to those used on the farm, silos are usually used for composting when space is at a premium. Aeration is usually done passively with hot air rising, and the units are usually 6 feet around at the base and about 25 feet high. Material is fed from the top with a conveyor and harvested out the bottom.	Closed intermodal shipping containers holding from 20 to 55 tons container, modified with temperature probes, forced aeration and biofilters.	Enclosed version similar to container in the form of a tunnel running across a building. Sizes range from 12' H x 9' W x 25' D to 18' x 21' x 100'. Also uses temperature probes, aeration and biofilters.	Channels in enclosed building ranging in size from 3' to 8' H and 200' to 300' long separated by concrete walls. A turner that resembles a paddle rides each channel kicking the material back as it slowly progresses from the beginning to the end of the channel and discharging a 5' to 10' at the head to provide room for more material.	A cylindrical drum ranging from 4' to 12' in diameter and 50' to 175' in length that very slowly rotates continuously.
Costs	$95-$105/ton	$95-$105/ton	$95-$105/ton	$80-$100/ton	$90-$110/ton

Composing systems

In-Vessel

	Aeration/Static			Agitation	
	Silos	Containers	Tunnel	Channels	Drums
Pros	Can be sited on small sites when space is at a premium and residence is less than windrows and passive aeration provides energy savings.	Not excessively complex. The same container can be used to compost and ship organics	Also not excessively complex. Easier to move material through system.	Greatly improved aeration especially important with dense food scraps without as much bulking agents. Separate channels enable specialized treatment for different types of organic streams.	Provides for the most complete decomposition of the aerobic systems and shortest residence time.
Cons	Aeration is not as effective as agitation	More cumbersome to load and unload and may require bulking agents such as shredded tires or car bumpers to provide adequate pathways for air to flow especially when processing wet and dense food scraps.	Also may require bulking agents to provide adequate pathways for air when processing food. High head space increases the air flow to be biofiltered.	Least scalable. Watering system may be required. Large buildings increase volume of air to be biofiltered.	Highest capital costs for in-vessel systems

Composting systems In-Vessel					
	Aeration/Static			Agitation	
	Silos	Containers	Tunnel	Channels	Drums
Time	7 to 14 days	14-28 days	10-21 days	14 to 21 days	5 to 10 days
Supplier	Teg Environmental	Naturetech Green Mountain ECS	Christian Bros. Orgaworld	Transform Composting Systems IPS Siemens Longwoods	Hot-Rot ICC X-Act

TABLE 3

TABLE 4 shows the three types of anaerobic digestion in which the significant energy value in nitrogen rich food streams is recovered, and then the remaining digestate is composted. Because digesters optimize energy generation with the food fraction of organics, and because digesters are relatively expensive, they are optimized when processing only the food, soiled paper and, if collected, grass fraction of organic discards, and not leaves and brush. There are Publicly Owned Treatment Works (POTW) Digesters and anaerobic digestors designed to process solid organics, which can be operated dry or by adding moisture and at lower or higher temperatures.

<table>
<tr><th colspan="6"><u>Composting systems</u>
Anaerobic Digesters</th></tr>
<tr><th rowspan="2"></th><th rowspan="2">Digesters for POTWs</th><th colspan="4">Digesters for Solid Organic Discards</th></tr>
<tr><th>Wet</th><th>Dry</th><th>Low Temp</th><th>High Temp</th></tr>
<tr><td rowspan="2">Description</td><td rowspan="2">Many POTW, or sewage treatment plants, have previously installed digesters to process and sometimes recover the energy from the biosolid effluents that they manage. In some cities, these digesters in POTWs had been sized long ago for a larger number of industrial users than remain today after several decades of manufacturing losses in the U.S. Some cities with ROPs, such as San Francisco, are exploring whether this provides a lower cost entry point into digesting their food and soiled paper fractions.</td><td colspan="4">Digesters have four phases –
❶A hydropulper is usually used to remove contaminants, including the significant level of plastics.
❷ The actual digester where a methane forming seed is added to the liquified organics to produced methane from anaerobic digestion in an enclosed vessel that is all captured.
❸ The methane is typically used to power an engine that generates electricity.
❹ The solid organic residual that remains, called digestate, is composted aerobically using standard windrows or silos.</td></tr>
<tr><td>Moisture is added in order to facilitate operation of the hyrdropulper to separate out contaminants (total solids <5%), but at the loss of organic volatile solids that reduces energy value, and also the imposition of more parasitic load losses.</td><td>Similar to wet digesters, but, by using less moisture (total solids <20%), lose less organic volatile solids and require less parasitic loads for pumping, all of which increases useful energy generation but at the cost of less effective removal of contaminants</td><td>Lower temperatures (mesophillic) can be used, with longer residence times and lower energy production.</td><td>Higher temperatures (thermopillic) can be used, with shorter residence times and greater energy production.</td></tr>
<tr><td>Costs</td><td>Not yet determined</td><td colspan="4">$110-$150/ton</td></tr>
</table>

Composting systems

Anaerobic Digesters

	Digesters for POTWs	Digesters for Solid Organic Discards			
		Wet	Dry	Low Temp	High Temp
Pros	Provides a low cost opportunity for cities to investigate and test the feasibility of digesting. Where there are idled digesters, then capital costs may be minimal.	In addition to the subtleties of the different varieties of digesters noted above, digesters as a class require less space, produce green energy and have the greatest capacity to remove contaminants.			
Cons	POTW digesters are optimized for higher liquid ratios and do not include hydropulpers, which are necessary to remove feedstocks from communities that produce significant levels of contamination	Digesters are the most costly, less flexible and experience challenging odor requirements.			
Time			See ➜	15-30 days	12-14 days
Supplier	N/A	Most vendors are European. BTA from Germany is the one used to date in North America. Others include Kompogas, Dranco, Linde, Biopercolat, ISKA, Valorga, APS, Biocoverter, Arrowbio, Waasa, Line, Enec, RosRoca and Hasse.[2]			

TABLE 4

[2] The California Integrated Waste Management Board has commissioned a study of digesters to serve as the basis for transferring the European technologies to the U.S. Department of Biological and Agricultural Engineering, University of California at Davis, *Current Anaerobic Digestion Technologies Used for Treatment of Municipal Organic Solid Waste* (March 2008).