Summary of Composting Techniques

	Piles	Turned Windrows	Aerated Static Piles	Bays, Beds, Tunnels	In-Vessel
General	Low technology Quality problems	Most common on farms	Effective for farm and municipal use	Effective for municipal/commercial waste	Large-scale benefits for commercial applications
Labour	Low	Increases with turning frequency	System design and planning important. Monitoring required	Requires knowledgeable mgmt and operators	Consistent high level of maintenance and management
Site Requirements	Large	Large	Slightly smaller than turned windrows	Medium	Limited land required
Active Period	6-24 months	21-40 days	21-40 days	21-35+ days	21-35+ days
Curing	N/A	30+ days	30+ days	30+ days	30+ days
Size: Height Width Length	1-4m 3-7m variable	1-3m 3-6m variable	3-4.5m variable variable	All dependent on design	All dependent on design
Aeration System	Natural convection	Mechanical turning and natural convection	Forced positive/negative air flow through pile	Extensive mechanical turning. Bed floor may include forced aeration.	Extensive mechanical turning and aeration
Process Control	Initial mix only	Initial mix and turning	Initial mix, aeration, temperature control	Initial mix, aeration, temperature	Initial mix, aeration, temperature, turning
Odour Factors	Likely; the larger the pile, the greater the odours	From open surface area of windrow; greater immediately after/during turning	Can be controlled with pile insulation and biofilters on air system and/or specialty covers	System is enclosed; can be controlled with biofilters or scrubbers.	System is enclosed; can be controlled with biofilters or scrubbers.
General Advantages	Simple system	Flexibility to vary feedstock and capacity Low capital costs Moderate operating costs	Reduced land requirement Limited odour problems Lower maintenance requirements	Moderate capital and O&M costs Lower space requirements	Higher volume capacity Limited odour problems Lower space requirements
General Disadvantages	Not capable of handling complex feedstock without extreme odour Slow process	Large area Odour management can be difficult Difficult to site for political reasons (poor image)	Higher capital cost than windrow Lacks flexibility in dealing with variable feedstocks	Lacks flexibility in dealing with variable feedstocks Large volume of air to be managed by odour control system	Lacks flexibility in dealing with variable feedstocks High capital and O&M costs Large volume of air to be managed by odour control system

1 TYPES OF COMPOSTING SYSTEMS

1.1.1 Piles

Piles are the most rudimentary form of aerobic composting. Optimum pile volume needs to be large enough to hold the heat generated by the biological processes, but be small enough to facilitate aeration by convection. There are no process controls for piles, other than the initial mixing of the feedstock. There are no proprietary systems associated with pile composting.

Composting Pile

1.1.2 Turned Windrows

Windrow composting sites are best suited to processing leaf and yard waste; source separated organics may also be processed, but odour problems are likely to arise.

Turned windrows are generally located outside, although a roof maybe constructed to minimize leachate generation. In particularly cold climates, the process may be indoors. Windrows are the most commonly used form of composting in North America, and can easily be adapted to any size of operation. Windrow composting has been successfully implemented at scales as small as 1000 tonnes/year (tonnes per year), and at scales as large as 100,000 tonnes per year. The differences in scale can be accommodated by the use of different technologies. Small scale operations may use a front end loader to mix the feedstock, whereas a large facility will require the use of a specialized windrow turner.

Windrow Composting

Windrow composting is defined by the formation of long piles, which are regularly and completely turned. Turning serves to aerate the material, reduce the particle size, blend the material to ensure homogeneity, and may also move the materials gradually through the processing area. The length of the pile can vary significantly depending on the facility size and amount of feedstock to be processed, but the height and width of windrows are generally 1-3m and 3-6m respectively. As with piles, smaller windrows do not retain heat, and larger windrows are difficult to move and aerate.

Windrows require a small capital investment and have low operating costs. However, a large land base is required, which may add significant expense. Windrows are usually located in rural areas or adjacent to landfills, as odour generation may be an issue in denser areas. The materials may be turned as frequently as daily or as infrequently as several times per month, depending on the feedstock and stage of the process. Regular turning can result in a fully degraded product in as little as 13 weeks, although facilities commonly reduce operating costs by slowing the process.

Additional water may be required to reach the optimal level of 40-60% moisture.

Capital costs are variable, but tend to be low. A facility of 30,000 tonnes annual capacity costs approximately $2 million, exclusive of land costs. Operating costs typically run at $20-30/tonne, but may be as high as $40/tonne. There are no proprietary systems associated with windrow composting, but there are many competing companies that manufacture windrow turners, both self-propelled and those requiring tractors. Companies include: Wildcat, Scat, Scarab, Frontier and Allu.

Windrow composting is commonly used to complete the composting process after initial composting with channel and in-vessel aerobic technologies, or to achieve pathogen reduction following anaerobic technologies.

1.1.3 Aerated Static Piles

This is a very similar process to that described above, with one important difference. By definition, the piles are not turned, but are aerated by forcing air in or out with fans. The windrows are built on pads or platforms, and the rate of aeration is often controlled by a temperature or oxygen feedback system. Process management can be enhanced by using a cover over the pile, because it achieves better moisture and aeration control. A negatively aerated system involves air being drawn down through the pile and exhausted through a biofilter. The pumps for these systems are generally in the range of 30-50HP, so energy requirements are high. These piles are uncovered and located outdoors. The biofilter is critical to manage odours, and must be sized accurately and maintained well in order to be effective.

Aeration Exhaust on a Static Pile

In a positively aerated system, the fan or blower forces air into the pile, where it is circulated through a diffuser. The diffuser is a pipe with holes to allow the outflow and distribution of air. Controlled air supply allows large piles to be built that would not normally be possible when relying on convection to supply oxygen and cool the pile. Positively aerated piles are often covered with proprietary fabric such as Gore-Tex, which contain odours, reduce vectors, minimize run-off and eliminate the need for a biofilter. Positive aeration requires less force than negative aeration, and therefore a smaller pump can be used (1-5HP).

Covered Static Piles

Once the composting process is almost complete, the piles are broken apart and uncovered piles or windrow composting is used to achieve further stabilization, which may take from several weeks to several months.

Capital costs are higher for aerated static piles than for turned windrows, although staffing needs are lower. As an example, the Gore facility in Edmonton which is a covered, positively aerated system that uses proprietary fabric similar to that used in Gore-Tex jackets, had capital costs of approximately $3 million for a 40,000 tonnes per year plant, and operation and maintenance costs are approximately $22/tonne.

Propriety systems are common for covered positively aerated systems, but less common for uncovered negatively aerated systems. Covered systems can also use finished compost as cover, but it is not as effective as specialty fabrics for odour control. Proprietary covered systems include Gore, AgBag, Texel's Compostex, Dupot's Tyvek and Top-Tex.

1.1.4 Bays, Beds and Tunnels

Bays, beds and tunnels systems are normally constructed inside buildings, and are essentially a variant of the turned windrow system. The feedstock is placed either between 2 long parallel walls, or in a 4 sided reactor bed. The walls of the bay or bed are generally about 2m high, for the same reasons that windrows are normally constructed to that height.

Bed Composting System

The material is turned down the length of the channel by a machine that is suspended above the bed or rides on rails along the top of the bed. Turning aerates the material, and additional aeration may be provided by a forced air system in the floor of the bed.

The turning machine gradually moves the material down the length of the bay or bed, and is timed so that by the time the material reaches the end, the primary composting process is largely completed. The product is cured in turned windrows or aerated static piles.

As with static piles, the mixture must be perfectly balanced when it is added, as there is no further opportunity for amendments to be added. However, odours can be easily controlled, since bays and beds are usually constructed inside buildings.

Bay Composting System

Bays and beds are more expensive than turned windrows and static piles, but less expensive than in-vessel systems. Capital costs can range form $300-700/tonne, depending on the capacity of the facility and the technology used. O&M costs range from $52-160/tonne, depending on if the facility is running at capacity. . Proprietary bed systems include Ebara (Miller Composting Corp) and Longwood Manufacturing Corp. Tunnel composting systems are provided by Double T Equipment, and Browning Ferris Industries (BFI). Manufacturers of channel composting systems include International Process Systems, Consolidated Envirowaste Industries Inc., LH Resource Management Inc., and Farmer Automatic.

1.1.5 In-Vessel

In-vessel systems offer the greatest degree of control over the composting environment. In-vessel systems also have the smallest land requirements, although they are the most expensive technology to design, construct and operate.

An in-vessel system is defined as one in which the composting process is conducted inside some type of sealed container (the vessel) where the environment is highly controlled and access is restricted.

In-vessel systems can be either flow or batch reactors. Larger systems consist of a permanent chamber installed within a building. Mechanisms are in place to load raw waste into the chamber and to remove compost from it. At a minimum, the system includes monitoring systems for temperature and oxygen content and an aeration system.

In-Vessel Aerobic Composting

Smaller systems involve the use of portable containers. Modular vessels, similar in appearance to international shipping containers, are filled with raw organic waste, sealed, and attached to aeration manifolds and monitoring equipment. At the end of the primary composting process, the container is disconnected, emptied and the material is formed into turned windrows or static piles to complete the composting process (curing). The vessel is then available for the next batch of feedstock.

Modular In-Vessel Composting System

These modular systems offer several advantages, such as ease of expansion, and decreased health and safety concerns as a result of the complete enclosure of all operations. A variation of this system is a custom built container that includes internal and agitators

Disadvantages of modular systems include limited control over mixing. Once a module is filled with organics, there is also little opportunity to alter the proportions of carbon and nitrogen.

Proprietary systems include the Containerized Compost System™, the Herhof Biocell system, and the Wright In-Vessel Composting Technology.

2 APPLICATIONS OF AEROBIC PROCESSES

Examples of the application of each of the aerobic organics management process described above are listed below. Information regarding volumes, type of feedstock and costs has been provided. The information is primarily taken from North American examples, although some information comes from European facilities.

2.1.1 Piles

1. Emerald Coast, the current operator of the City's composting facility at the Valley Road site uses a pile system to compost yard and wood waste.
2. Spade Holdings in Cloverdale, BC uses a pile system to compost yard waste. This is a small operation that takes yard trimmings primarily from landscape contractors, food waste from Safeway and some fruit pulp from Oceanspray. The facility employs a turned windrow system. Spade Holdings mixes the compost product with horse manure, lime and mushroom stalks to form a soil amendment product. The mixing of the amendment components is also undertaken at the site. The product is sold primarily to nurseries but is also used to develop neighboring land for use as a tree plantation.

2.1.2 Turned Windrows

1. East Prince County in Prince Edward Island composts 10,000 tonnes of organic wastes each year, including ICI wastes, plus 1000 tonnes of biosolids. Waste is collected bi-weekly by Island Waste Management Corporation.
2. EcoWaste is a private composting company operating in Richmond, BC. The composting site accepts yard waste from a variety of sources, although primarily from landscape contractors. There is also a small drop off area for residential yard trimmings to be deposited. No food waste is processed at this facility. The waste is stockpiled on site until sufficient volume is accumulated to justify bringing in a grinder. Typically a grinder is brought in twice a year. Ground waste is deposited in windrows. A full time employee with a backhoe fitted with a rake scoop turns the windrows in a continuous sequence. Each windrow has documentation which contains records of when it was formed and turned and also temperature readings from the sides and center of the material taken at regular intervals. The final compost product is combined on site with river sand that is pumped from the Fraser River to produce high quality topsoil. A separate company runs this operation. The soil product is used on site as part of the landfill capping efforts. It is also sold for agricultural needs.

2.1.3 Aerated Static Piles

1. The Fundy Region of Nova Scotia, which includes St. John, uses covered windrows to compost organic materials including food scraps, yard trimmings, sawdust and wood chips. In its first nine months of operation, 4800 tonnes were processed. Compostable materials can be dropped off at the Crane Mountain Landfill Compost Plant for a tipping fee of $50/tonne in any container. The operation is managed by the Fundy Region Solid Waste Commission.

2. As part of its Composting Centre, the City of Edmonton operates a covered aerated static pile system, which can process 40,000 tonnes/year of MSW. It is currently used for biosolids. This facility uses technology from WL Gore & Associates, which is described in greater detail in the following examples of its applications in Germany.
3. WL Gore & Associates GmbH has numerous sites across Europe, three of which are outlined below:
   - The Murten facility is located Switzerland, and accepts up to 30,000 tonnes per year of manure, source segregated organics from markets, and yard and garden wastes. The facility used to be an open window operation with daily turning. It was slated for mandated closure due to strong odours. Since implementation of the Gore system and use of the Gore membrane, there have been no odour complaints.
   - There are two sites in Baden Baden. The first is an older, 25,000 tonne per year facility located on a 1 hectare site. It accepts anaerobic digestion residue from a BTA facility (30%) and local yard and garden wastes (70%). Neighbours live very close to this facility but there are no odour problems and good local acceptance.
   - The second site in Baden Baden is a newer facility, about one year old, that accepts up to 20,000 tonnes per year of horse manure and yard and garden waste. The footprint is about 1 hectare. This facility uses 42,000 kW hours of power and 54,000 litres of diesel fuel per year.
4. Cedar Grove Composting is located in Maple Valley, Washington. It is currently using a standard aerated static pile with negative aeration and biofilters to process primarily yard waste originating in the Seattle area. The facility accepts over 200,000 tons of green waste per year. Management at Cedar Grove is currently converting 40,000 tons per year capacity to the positively aerated covered Gore System due to the better economics and process control offered by Gore, and also because the Gore system allows them to compost food waste mixed with yard waste. The balance of the system will be converted to a Gore system in subsequent years.
5. Fraser Richmond Bio-cycle operates a yard waste processing facility in Richmond, BC on a former landfill site. The piles are uncovered and negatively aerated and treat 16,000 tonnes per year. A biofilter is successfully used to control odours.

   Fraser Richmond Bio-cycle uses negatively aerated static piles to compost yard waste, horse manure and a small amount of select vegetable and fruit waste from local produce shops. The facility takes the majority of the yard waste collected by municipalities in the GVRD, with the exception of City of Vancouver and Corporation of Delta, which process their yard waste at the Vancouver Landfill. Municipal yard waste comes primarily in clear bags, which have to be debagged at the site. This adds significant cost to the process, and Fraser Richmond Biocycle is attempting to encourage municipalities to use a can system to reduce costs and the potential for plastic contamination in the compost.

   The raw material is ground on site, and spends 12-16 weeks on the negatively aerated pad. Air is passed through a biofilter, which provides very good odour control, as noted by Earth Tech staff during a site visit. The compost is then cured, processed and stock piled.

The finished compost is mixed with river sand on site to produce high quality soil product that is sold in bulk to the agricultural industry, municipalities and private bagging companies.

The composting operation is located on a former landfill and an interceptor drain to the north controls leachate migration. Surface water on site and contaminated water collected in this drain are treated on site before discharge.

2.1.4 Bays, Beds and Tunnels

1. Lunenburg County in Prince Edward Island utilizes Ebara technology, as designed by Acres International and constructed by Rideau Construction. It is an open bed technology, which has been processing waste since 1994. The facility is housed in a 44,000 square foot building, which includes separation and sorting equipment for dry recyclables, processing equipment for incoming organics (food scraps and yard waste) and mixed waste and the Ebara wide bed vessel composting system. The facility handles in excess of 25,000 tons of municipal solid waste annually.
2. Halifax, Nova Scotia also uses an Ebara system. The system has a capacity of 27,500 tonnes per year, and the feedstock comes from a bi-weekly residential collection of food waste, yard waste, sawdust & wood shavings. No ashes or plastics of any type are collected.
3. The City of Guelph, Ontario, operates a materials recovery facility, which includes a composting system made by Longwood Manufacturing Corp. This is an in-channel system, which uses a turner made by Transform Systems. The feedstock is composted in-channel for 4 weeks, followed by covered windrows
4. The City of Moncton uses a bed system, consisting of primary and secondary silos, to process wet waste (including all food and yard waste as well as any soiled items that would contaminate recyclables). Waste is put into a primary silo, or channel. Compost turners run along the top of the channel, and move the feedstock along a few meters every day. Once the feedstock reaches the end of the primary silo, it is ready to be transferred to a secondary silo. After 21 days in a secondary silo, the waste is refined and to a maturing pad for three to six months where it is regularly turned and monitored.

2.1.5 In-vessel

1. The Region of Peel has adopted in vessel aerobic Herhof Biocell composters, with a current capacity of 3200 tonnes per year, 70% of which is yard waste. Since the original installation in 1994, the Region has increased capacity at least once, which is fairly simple with the modular concrete vessels. Herhof Biocell reactors are more common in Germany (34 in Germany, 8 in Austria, 1 in Canada, 1 in Luxembourg, 1 in Belgium).
2. In addition to its Ebara bed system, Halifax also uses an in-vessel process designed by Stinnes-Enerco. This process, located at a facility known as New Era Farms, can process 33,000 tonnes per year, and has been in operation since 1999. There are 24

containers (30x10x8 feet), and the feedstock remains in vessel for 10 days. It is then moved to a building with a fabric roof for further composting and curing.

3. A Wright in-vessel composting system has just been put into service in Squamish. It is designed to accept all types of organics, wood waste and biosolids from the SLRD. Wright systems are compact units that require very little space, but a significant degree of O&M. Operational reports are not yet available.

4. The Edmonton Compost Facility is the largest co-composting facility in North America. It receives both MSW and biosolids, for a total feedstock capacity of well over 200,000 tonnes per year. The process used in this facility is based on the Bedminster system, but is not proprietary. Materials are “digested” in drums for up to three days, achieving temperatures as high as 70^{o}C. They are then screened and composted in aerated bays for a further 18 to 28 days, Following this, the compost is screened again and cured outdoors for 3 to 6 months