Compost Processing Technology Information

**This document provides an overview of the composting technology discussed. It is not intended to be an exhaustive or comprehensive description.*

The term *compost* is based on 'natural' processes in the decomposition of organic materials into a nutrient-rich substance. In our context, we have an unnatural quantity and a material with an increased nutrient dense composition, that in turn, requires an appropriately managed system to rapidly break down the food and yard waste that is collected. Everyone, from backyard composters to large-scale municipal composters, rely on thermophilic organisms, ideal water content, aeration, and a well-balanced recipe of thoroughly mixed materials to speed up that process. This process is called composting, and conditions are created to encourage a high rate of activity within a mass of carbon (C) and nitrogen (N) rich materials. The anticipated result is a product that will provide beneficial end use, is biologically stable, safe to handle and transport, and has an overall positive impact on the environment.

A common concern with composting is the potential for unpleasant odour. Typically, odour is strongest in the collection stage where materials have been stored anaerobically in individual carts and then transported to the processing facility. Odor production is minimized by managing the mix of materials (C:N ratio) and starting the composting process promptly. Typical processing systems for municipal composting vary by type, usually in response to the nutrient loading, overall volume to be processed and the location of the processing facility. Every type of processing will have its merits and usually a benefit of one system can be seen to offset a risk within another type of facility. In some cases, a more rurally located facility will have negligible impact to receptors of odour or other emissions and for that reason the most beneficial system could be open air processing, especially if the materials are received during warmer months only. For efficiency, many cities have sited their facilities very close to residential communities within the suburban landscape; therefore, to minimize impacts, they need to invest in a much more controlled environment to operate all the processes needed.

A chart is located at the end of this document comparing the different processing technologies. Each process has varying pros and cons usually based on location, budget, and nutrient density. Three types of technologies are described in this document.

Open Air Turned Windrow

Open air windrows are suitable for small, medium, and large-scale operations. The technology is simple, the output is predictable, and the end-product is trustworthy. The City's Compost Depot program has been operating with open air windrows for the past 17 seasons, and the information in this section describes the City's operation.

This process is a low cost, low risk method. Organic waste materials from public and commercial drop-off are collected into designated areas at the compost depot. Woody materials are pre-processed to reduce the size and are then blended into the finer components of leaves, grass and curbside collected green bin wastes. Target C:N ratio is 25-35% and the water content is 50-65%. Water is added to the materials, as the composting process slows when the materials dry out. Even with the addition of water, it is common for a windrow to be in place for periods exceeding 21 weeks.

After material is received, it is set aside for processing (logs and branches) or it is immediately stockpiled (grass and leaves, garden waste and curbside collected material). Shredded wood is used as a bulking agent and is thoroughly blended with the leaves and grass. The mixture is later transferred into a 1.8-meter-high x 5-meter-wide windrow that may be 50 to 100 meters long. If needed, water is added and the temperature monitoring starts. As the microorganisms do their work, they generate heat, and the temperature of the windrow determines whether it needs to be turned or have water added. As the microbes' food supply diminishes, the windrow loses heat energy until it is deemed 'finished' whereupon it is transferred into a bulk 'curing' pile to stabilize over a period of a few months.

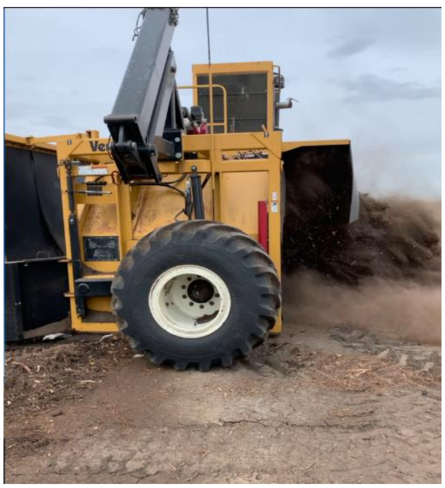

Figure 1 City Owned Compost Turner Aerates and Recombines Composting Materials

As the decomposition progresses, the temperature within each windrow is monitored on an ongoing basis to ensure that they meet the necessary criteria for pathogen reduction. Pathogens may include e. coli, salmonella, fecal coliforms and weed seeds. Further, finished materials are bulk sampled and submitted for testing to see that the physical requirements for minimizing contaminants such as glass and plastic are also met. Materials not meeting those requirements are either re-tested or rejected from use as a Category A compost.

Among the criteria for processing the material, requirements called Pathway to Further Reduce Pathogens (PFRP) must be followed for all composting technologies. This consists of a series of turning and heating cycles over time and is defined in the Alberta Environment Compost Facility Operator Study Guide as follows:

> ***Process to Further Reduce Pathogens (PFRP)*** *is a set of criteria used to define the time and temperature requirements needed to reduce pathogen levels in a material. For in-vessel and ASP composting, PFRP requires that materials be maintained at operating conditions of 55°C or greater for 3 consecutive days. For windrow composting, materials must be maintained at a temperature of 55°C or greater for at least 15 consecutive days, during which time, the windrow must be turned at least five times.*

Once the material is cured, it is screened for end use and samples are taken for compliance analysis. The fine material is sold or donated, and the coarse material is reused on site as inoculant or bedding preparation.

Some of the common issues related to windrow composting are the susceptibility of materials to wind, freezing conditions, drying conditions, large land surfaces required to accommodate materials, laborious efforts for monitoring, and site maintenance. Every windrow needs to be accessible for watering, periodic turning, relocating and ongoing temperature monitoring.

Winter operations, when conducted, are essentially performed understanding that microbes become dormant, waiting until appropriate conditions are present to reactivate. Following spring thaw or any high precipitation events, the site can become wet and requires ongoing efforts to maintain driving surfaces; limiting access to the expansive area needed for processing material in an open windrow configuration.

Drying through exposure to long daylight hours and wind create challenges as well. The exposed surface area of the windrows leads to rapid evaporation of water from those surfaces, and the microbes consume water through the composting process.

Most municipalities that compost leaf and yard waste are employing open air windrows, including Winnipeg, Brandon, North Battleford, and Swift Current.

Covered Aerated Static Pile

An aerated static pile (ASP) is one which allows all the composting to be done within a much smaller footprint than an open-air windrow through increased pile height and slope steepness. Typical pile height can reach 3.6 metres, with the footprint confined to the area served by a forced air distribution system in the floor.

Aerated static piles, once built, breakdown the organic materials with minimal interventions needed. Monitoring stockpile temperature and oxygen is performed to catch any conditions before an upset. Air can be adjusted, and under certain conditions water may be added to the pile.

As with all compost processing, feedstocks and bulking agents must be mixed to some recipe, with a target ratio of 30 C:N and water content of 50-60%. This process does not have the advantage of the periodic remixing of windrows through agitated aeration, so it is vital that the recipe correctly accounts for moisture and the C:N ratio to be distributed evenly throughout the volume of the pile. Any error can lead to upset conditions such as the formation of ammonia and volatile organic compounds contributing negatively to the odour profile and the escape of odours to the wider community.

In-floor aeration systems can apply positive pressure (blowing fresh air into the static pile) or negative pressure (pulling gases from the static pile). In either case, an exchange of fresh air for carbon dioxide rich gases is made, usually on a timed interval.

With a negative aeration system, it is possible to route the gases through a biofilter, reducing the volatile compounds that make up the odour component of the off gases. An indoor, positively aerated pile can also have effective odour controls through frequent air exchanges and utilizing an outdoor biofilter bed.

Aerated floors are built using above-ground or in-ground pipes with regularly spaced holes drilled or embedded emitters installed. The aerated floor with in-ground piping is usually concrete and channels of piping spaced to allow for control zones so materials can be placed in batches and the pile built over a short period of time. Above-ground piping is placed on a hard surface, then deep bedding materials cover the pipe to both protect it from the weight of the feedstock mixture and to distribute the fresh air over the entire surface of the pile base. Air supply for the system may be one or several electric air blowers depending on the flow needs of the design.

These piles are susceptible to compaction under their bulk, and care must be taken to ensure that air does not compromise the system. A heterogenous mix can create differential settlement conditions. This could lead to blinding off some parts of the pile to fresh air and create zones of anaerobic conditions. Careful monitoring of the piles' internal temperatures and oxygen can help identify the best recipe and minimum particle size for the bulking agent, as well as the mixing time, optimizing each piles' conditions for best chance of success.

A covered aerated static pile (CASP) is an ASP with a cover. The cover can be layers of biofilter material such as wood chips and/or a finished compost, or it can be a factory-made cover of special fabric. What sets the fabric cover apart from a simple plastic or canvas tarp is its ability to retain moisture while allowing for gas exchange. For a fabric cover, the size of the pile is limited to the size of the cover being used. The cover is held to the bottom of the pile by using weights or some other anchoring system.

Where natural materials such as wood chips or finished compost are used as a cover, it is placed in thickness not less than 30 cm. Ideally, the natural cover would be consistent thickness from the bottom of each side, up the slope and across the top. This material acts as a biofilter for positively aerated piles. The thickness contributes to more even dispersion of the gases and provides insulation so that the mixture closest to the outside of the pile can reach the necessary temperatures for pathogen destruction. The exposed surface of a natural cover system will be subject to drying. It is important for the surface to be kept moist to ensure that the filtration of odour causing compounds is performed.

Typical residence time within an ASP can be 4-12 weeks with 8 weeks being the typical timeframe. Some two-stage systems, where the pile is built on one pad for 4 weeks then remixed and transferred to another pad for 4 weeks, are preferred as they help ensure reduced compaction and aerobic conditions throughout the entire 8-week period.

To optimize the available surface area for processing materials, the space between stockpiles can be reduced so that adjacent piles share a border at the toe of the slope. If there is adequate space for the cover (if used) they can be very close together. These systems are suitable for small, medium, and large-scale operations and are very scalable for growth over time. The time commitment for handling materials is significantly reduced compared to the open windrow operations.

Municipalities using ASP or covered ASP include Kelowna/Vernon, Mission, Victoria, Edmonton, Montreal, GTA, Barrie, and Peel Region.

Containerized Systems

High up on the technology and cost profile for compost manufacturing, containerized composting using a variety of in-vessel systems are those that completely enclose the operation from initial batch mixing through to finished compost. Only the collection of the materials and the final curing would be subject to exposure to the environment.

The same composting principles apply for containerized systems. Feedstocks are batch blended to achieve optimum water content and C:N ratio and are placed into the holding cell with either a tunnel or container. The door is closed and remote monitoring of water content, air content and other parameters is initiated. To some extent the water can be adjusted within the vessel, but air flow is strictly controlled, so the process can take as little as four weeks. Often an initial cure of the product is done under-cover, but the final cure is often outdoors. Once the material is finished composting in the in-vessel process, it is placed in curing piles. Once cured, the material is screened, and the resulting compost product is ready for use.

In-vessel systems are generally reserved for large scale material reduction of high nutrient organics to compost, although some medium scale processors use in-vessel systems. These systems can be used for low nutrient feedstock alone however the cost of such a system will favour selecting more putrescible wastes and incorporate low nutrient wastes as part of the blend to balance the recipe. As usual, a bulking agent is also required to provide the carbon component and the porosity of the mix.

The higher costs to implement container systems are justified where strict control of environmental impacts is required. Many of these systems are designed to operate within very close proximity to residential areas and/or environmentally sensitive sites.

Ranging in scale from highly modular shipping style containers to elaborate massive concrete and steel structures; these systems have found a place in many large cities in Canada including Calgary, Cold Lake, Banff, Ottawa, Halifax, Montreal, Toronto, and Guelph, to name a few.

Table 7: Compost Processing Technology Comparison Chart

Compost Method	Benefit	Disadvantage
Aerated Open Windrow	• Inexpensive • Low Tech • Low environmental impact • Suitable for seasonal loading • Suitable for remote areas • Tolerates varied recipes (25<C:N>40) • Tolerates varied bulking agent sizes • Repeated turning over time continuously remixes and can reduce maximum particle sizes • Least expensive	• Labour intensive • Powered Mobile Equipment (PME) intensive • Land area intensive • Comparatively slow to other large-scale methods • High surface area to footprint ratio • Weather susceptible • May not fully degrade many certified compostable plastics in one season of operation • Difficult to maintain water content of mixture • Trucking water • Odor control limited to best practices • Limited offsite dust control
Covered Aerated Static Pile	• Short turnaround time to process organics • Relatively low cost compared to higher technology systems • Smaller site size • Durable infrastructure once built (concrete) • Reduced material handling • Small footprint • Year-round potential • Higher internal temperatures are achievable throughout the volume • Low surface area to footprint ratio • Covered systems maintain water content better • Easy to implement wireless monitoring • Can automate aeration • Can utilize more efficient PME to build	• Requires equipment that can reach on to piles without driving on them • Biofilters require constant watering • Requires electricity to site (3Ph) • Feedstocks must be at or near optimum water content prior to placing • Infrastructure/capital costs are high compared to windrows • Less tolerant to deviation from recipe • Constant water supply • Risk of anaerobic pockets within mass • Fabric cover must be replaced periodically due to wear and tear • When ASP is in a building corrosive moisture conditions will reduce building life
Containerized (in-vessel	• Shortest turnaround due to highest level of control (2-4 weeks) • Highest level of technology for compost • Eliminate cool spots within the waste matrix • Can handle high strength (nutrient dense), high moisture organic waste materials • Very little odour and dust produced, leading to most successful outcomes when placed near public spaces and residential neighbourhoods • Long term life for building envelope if all process air is kept to the container and treated with biofiltration • Very long-term option, often under PPP arrangements • Opportunity for air-lock doors to reduce risk of odour escape even further • No limitation on what kind of organics can be composted	• Cost to design • Cost to construct • Cost to operate • Confined space implications • Highly specialized operators • Often require aerated floors for primary curing stage • Biofilter design and operation is critical to maintain low odour concentration from the facility • Most expensive