On-Farm Composting

IN BRITISH COLUMBIA

A STEP-BY-STEP GUIDE FOR SMALL TO MEDIUM-SIZED FARM OPERATIONS

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for the BC Ministry of Agriculture

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Disclaimer

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Acronyms

AEM Code __ The Code of Practice for Agricultural Environmental Management

AGRI __ BC Ministry of Agriculture

ALC __ Agricultural Land Commission

ALR __ Agricultural Land Reserve

ALRR __ Agricultural Land Reserve Regulation

BMP __ Best Management Practices

CFIA __ Canadian Food Inspection Agency

EC __ Electrical Conductivity

EFP __ Environmental Farm Plan

EMA __ BC Environmental Management Act

ENV __ BC Ministry of Environment and Climate Change

FIRB __ Farm Industry Review Board

FLNRORD __ BC Ministry of Forestry, Land, Natural Resources, Operations, and Rural Development

FPPA __ Farm Practices Protection Act

OMAFRA __ Ontario Ministry of Agriculture, Food, and Rural Affairs

OMRR __ Organic Matter Recycling Regulation

SRM __ Specified Risk Materials

The Purpose of this Guide

This composting guide is intended to help farmers choose a suitable system that will produce high quality compost in a cost-effective way, in order to minimize waste and maximize nutrient recapture on their farm. The methods and processes discussed are best described as small and medium-sized compost systems.

The guide helps to answer the following questions:

- What is composting and what opportunities can it offer my farm?
- How does the composting process work?
- What materials can I compost on my farm and how do I get my compost system started?
- What methods for composting exist, and which system is best for my farm?
- What do I need to do once the compost process has started?
- Where should my compost system be situated on my farm?
- What building materials do I need and how much will this cost?
- What rules and regulations do I need to be aware of?

The answers to these questions are presented in the following sections. Whenever possible, case studies of actual compost systems from BC farms are included. The Appendix includes lists of resources, equipment dealers, as well as calculation examples for further information.

1.0 What is composting and what opportunities can it offer my farm?

Composting is the decomposition of organic materials by microorganisms under controlled, aerobic conditions to a relatively stable humus-like product suitable for growing plants, which poses no hazard to human health or the environment[1]. Composting can be done in many ways using a variety of systems, materials, equipment, and scales of operation.

While some farmers allow manure and/or plant material to pile up and decompose, this is not the same as composting. Composting is a well-managed process to obtain specific positive end results with a minimum of negative environmental impacts. If done properly, finished compost is a high quality soil amendment with a variety of beneficial end uses and can even be sold to generate income for the farm.

Composting has the potential to manage most of the organic material in the farm waste stream including crop waste, animal manure, and animal mortalities, and can be easily incorporated into any farm waste management plan. Table 1 summarizes the key benefits and challenges associated with composting. Here are four clear reasons why farmers should incorporate composting into their farm operation:[2]

LEGAL DEFINITIONS OF COMPOST AND COMPOSTING

According to BC's *Code of Practice for Agricultural Environmental Management* (AEM Code), an "agricultural composting process is a process whereby agricultural by-products, wood residue, mortalities or processing waste, or a combination of any of them are mixed or layered and managed to decompose aerobically with either periodic turning or forced aeration".

The *Agricultural Land Reserve Regulation and the Organic Matter Recycling Regulation* define compost as a product that is:

1. A stabilized earthly matter having the properties and structure of humus,
2. Beneficial to plant growth when used as a soil amendment,
3. Produced by composting, and
4. Derived only from organic matter.

1. Composting reduces farm waste

Every farm accumulates organic waste, which is rich in nutrients. Composting will drastically reduce what needs to be hauled off site. The finished volume of the compost is frequently 40-60% of the original compost feedstock volume.[3] This translates into lower hauling and spreading costs for the producer. Composting also concentrates many of the nutrients in the compost material compared to the nutrient levels in the original materials. Well-managed compost has minimal odour and leachate potential, thereby reducing potential environmental hazards.

2. Composting is good for soil

Composting takes organic waste from the farm and turns it into soil amendments and fertilizers, which can be put back into the farm by spreading onto pasture land and crops. Some nitrogen will be lost during composting and some will convert to more stable organic forms that are released more slowly to crops. It has been estimated that less than 15% of the nitrogen in compost applied to soil will be released in the first year, meaning that the compost provides a long-term source of nutrients[4]. Composting can also help restore soil structure by adding organic matter, which in turn supports the rooting environment and prevents soil erosion.

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[1] Paul, J. and D. Geesing. 2009. Compost Facility Operator Manual: A compost facility operator training course reference and guide. Abbotsford Printing Inc., Abbotsford, BC, Canada.

[2] This list has been adapted from the University of Northern Iowa's Waste Reduction Centre's 5 Reasons Farmers Should Compost. J. Trent, 2015.

[3] Martin, H. 2005 (reviewed 2019). Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA). Agricultural composting basics: Factsheet. Agdex# 720/400.

[4] Ibid

3. Composting kills pests and pathogens

If high temperatures are reached and maintained during composting, it can efficiently kill pathogens that otherwise pose a health hazard to humans, animals, and plants. The high temperatures can also destroy weed seeds and the eggs of worms and insects. This reduces the need for pesticides and other pest management strategies. Compost also contains beneficial microorganisms that help restore soil nutrients and stimulate plant growth.

> Nitrogen is released as ammonia and nitrous oxide from the compost pile into the atmosphere. Some release of nitrogen is unavoidable during the composting process. However, a well-managed operation can substantially reduce nitrogen losses and keep the nitrogen in the finished compost product. Attention should be paid to the optimal C:N ratio in compost feedstock and ensuring adequate oxygen supply.

4. Good compost can be sold and contribute to the bottom line

In some instances, material from other farms or food waste can be composted with on-farm materials. A high-quality end product can be sold as an amendment to other farms, therefore, it can cover the costs of the compost process and contribute to the bottom line of the farm operation.

Table 1. Benefits and Challenges of Composting[5].

Benefits	Challenges
Reduces and/or eliminates pathogens	Pathogen control requires high temperatures
Reduces volume of waste and moisture content	Often requires additional bulking material
Reduces viable weed seeds	The processing time may take several months
Reduces insect larvae (fly problems)	Requires good aeration to ensure a good end product
Reduces odours	Land is required for composting and storage areas
Stabilizes organic components and nutrients	May require initial financial investment
Produces a soil amendment and/or fertilizer	Requires regular maintenance

[5] Martin, H. 2005 (reviewed 2019). Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA). Agricultural composting basics: Factsheet. Agdex# 720/400..

2.0 How does the composting process work?

A basic understanding of the composting process is important for producing a high-quality product, and for preventing operational and environmental problems such as odour and leachate[6]. During the composting process, heat, water, carbon dioxide (CO_2) and, to a far lesser extent ammonia (NH_3) and nitrous gas (N_2O) are released into the air as the microorganisms break down the raw organic material (Figure 1).

To optimize this process, there are 5 key requirements, as follows:

1. **Feedstock mix:** The composting process requires carbon (C), nitrogen (N), oxygen and water.
2. **C:N Ratio:** The feedstock material must be well-mixed and have an optimum ratio of carbon and nitrogen.
3. **Oxygen:** The composting process must be aerobic (have access to oxygen). This minimizes the release of gases (other than CO_2) and is required for the most time-efficient process and to produce high quality material.
4. **Particle size:** The particle size of the input materials must allow for a good mix and maintain good airflow through the pile or windrow (too small results in not enough air pockets, too large takes too long to decompose). This can be achieved by adding bulking agents.
5. **Water:** Water is required to maintain the life functions of the microorganisms in the compost, however, excess moisture will reduce the airflow and the compost will cease to be aerobic.

If any of these elements are lacking, or if they are not provided in the proper amount and proportion, the microorganisms will not flourish, resulting in low temperatures. The materials will not be composted.

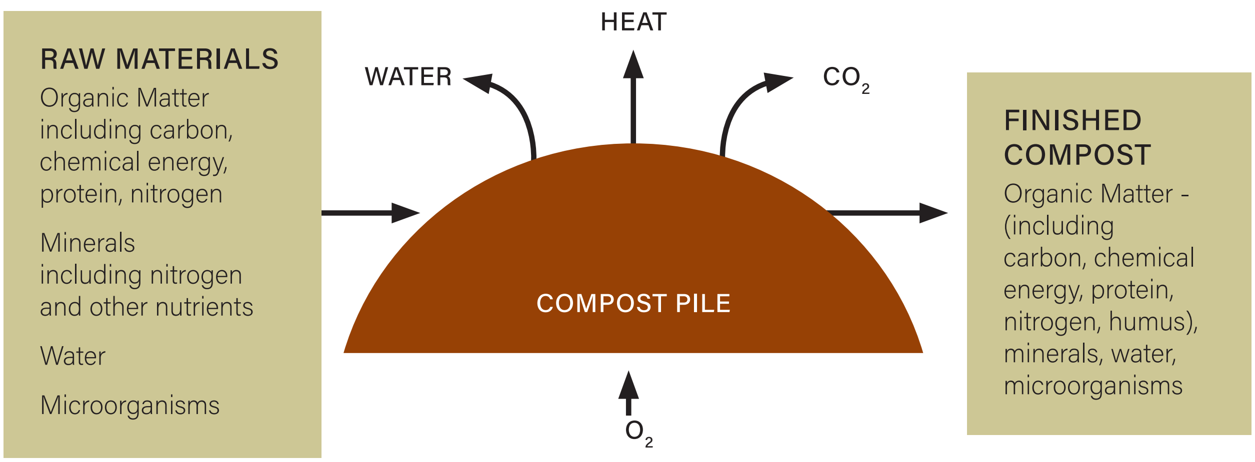

Figure 1. Inputs and Outputs of the composting process[7]

2.1. THE FOUR STAGES OF COMPOSTING

The goal is to create environmental conditions that are optimal for the beneficial microorganisms critical to the composting process. There are four stages of composting, which are described below. Additional information regarding how to manage the compost during these stages can be found in Section 5.

2.1.1 Stage 1. Feedstock preparation: Mesophilic

Mesophilic refers to the type of microorganisms that are active in breaking down the organic matter in the compost pile at lower temperatures. Once organic material has been pre-mixed and added to the compost system, the mesophilic stage of the compost process begins. Temperature increases may be noticeable within a few hours of forming a pile. This stage may last a few days.

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[6] Martin, H. 2015. Agricultural Composting Basics Factsheet. Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA).
[7] Gamroth, Mike. 2015. Composting: An Alternative for Livestock Manure Management and Disposal of Dead Animals. Oregon State University.

2.1.2 Stage 2. Composting: Thermophilic

This stage is the biologically active composting stage, creating high temperatures, and therefore it is important to monitor for conditions to enable efficient breakdown of the organic material. During this stage, the decomposition is being undertaken by microorganisms including bacteria and protozoa. The microorganisms use oxygen to consume the feedstock materials and produce CO_2. Temperatures of composting materials characteristically follow a pattern of rapid increase and can reach levels 45°C to 70°C. The active stage of composting may take several months to complete.

2.1.3 Stage 3. Curing and Cooling

The main thermophilic phase ends when most materials have broken down and are not recognizable from their original form. Woody debris may still be intact. Temperatures are lower and more stable (usually less than 40°C) even after the pile is turned and/or aerated. In this stage there is a shift in the microorganism populations back to those which prefer lower temperatures. Turning is not usually required during the cooling stage but is recommended (for example, once every 2 weeks) to increase compost quality and to avoid dry and wet pockets. The compost is still not 'mature' enough to be considered finished compost at this stage. The material will still have higher levels of organic acids, high C:N ratios, extreme pH values or high salt contents all of which can damage or kill plants. This stage can take 1 to 2 months.

2.1.4 Stage 4. Storing and Maturation

Compost needs time in storage to mature. Maturity is an indication of the degree of humification or the conversion of organic compounds to humic substances that are resistant to microbial breakdown. There are various tests for compost maturity. Lab tests can be used or germination tests using lettuce seeds, which will be injured and not survive if compost is immature. During the maturation phase the pile size is less critical than during the active or curing phases. No substantial reheating of the pile will occur.

3.0 What materials can I compost on my farm and how do I get my compost system started?

All farms produce organic materials that can be composted. To compost successfully, different material types must be mixed together to provide the proper conditions for microorganisms to break down the raw materials. This chapter will discuss common on-farm feedstocks and how to prepare the feedstock materials for the composting process.

3.1 STEP 1: UNDERSTANDING COMPOST FEEDSTOCKS

Compostable farm materials (feedstocks) include:

- Raw animal manures such as pig, goat, poultry, horse, cow and sheep.
- Crop wastes, grass clippings, tree foliage.
- Waste from aquaculture operations (e.g. fish).
- Food scraps, grease and food grade oils.
- Bedding, sawdust, cardboard, straw.
- Spent mushroom compost.
- Carcasses of farm animals (e.g. poultry, sheep, pigs, cows, horses, goats).

Feedstock material that should NOT be composted (due to existing regulations) include:[8]

- Pressure-treated wood or wood exposed to salt water.
- Human waste and septic waste.
- Chemicals (e.g. liquid fertilizers, pesticides).
- Construction debris (e.g. gypsum).
- Plastics and sharp foreign matter.
- Slaughter waste containing specified risk material (SRM).

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[8] Paul, J. and D. Geesing. 2009. Compost Facility Operator Manual: A compost facility operator training course reference and guide. Abbotsford Printing Inc., Abbotsford, BC, Canada.

CAUTION: PESTICIDE RESIDUES

The presence of pesticide residues in compost feedstock may reduce the effectiveness of microorganism activity levels. Pesticide residues can be found in both plant and manure inputs. The break-down of most pesticides is accelerated during the composting process.

There are, however, exceptions like organo-chlorides including DDT, chlordane and chlorpyrifos, which are resistant to composting. Although many organo-chlorides are banned for use in Canada, they are still found in soils and are sometimes used illegally.

Another category resistant to composting are picolinc acids (aminipyralid, picloram, triclopyr, etc) that are used to control broadleaf weeds, vines and woody plants – including blackberries.

Instructions and best practices for composting deadstock (mortalities) are provided in Section 3.3.

Certified organic producers must use additional caution regarding composting feedstocks (see text box, following page)[9]

3.1.1 Livestock Manure as Feedstock

Livestock manure is a common material to be composted on the farm. The moisture content and the C:N ratio of manure is highly variable, depending on the animal type, feed, bedding material, and duration of manure storage. Livestock manure is often already mixed with the bedding material used on the farm (e.g. wood shavings or wood chips, straw, pellets). Farmers should analyze their manure and bedding mixture to determine the C:N ratio and moisture content. Bedding can be used to help absorb some moisture from the manure, but too much bedding will add more carbon to the compost feedstock than desirable. Other feedstocks can be added to the manure if the C:N ratio is not optimal. For more information on C:N ratios see Section 3.2.1.

- **Cattle manure** – decomposes quickly, and the odour risk is low if composted within a few weeks. Moisture content is relatively high, depending on bedding used.
- **Poultry manure** – has a high N content but may be dry and dusty. Layer manure typically contains more moisture and N than broiler manure. Due to the high N content, there may be a significant loss of ammonia gas.
- **Horse manure** – drier than many manures and has a high C:N ratio as it usually contains large amounts of bedding.
- **Swine manure** – is typically a liquid (if no bedding is used) which means a dry bulking agent must be added. Odour potential of this manure is high.

[9] Government of Canada, Canadian General Standards Board, 2018. Organic production systems: General principles and management standards. CAN/CGSB-32.310-2015.

NOTE: FEEDSTOCKS FOR CERTIFIED ORGANIC FARMS

According to the *Federal Organic Production Systems General Principles and Management Standards* (CAN/CGSB-32.310), the following feedstocks are permitted for use for composting systems on certified organic farms:

a) animal manures conforming to criteria specified in 5.5.1 of CAN/CGSB-32.310;
b) animals, animal products and by-products (including fishery);
c) plants and plant by-products (including forestry and source-separated yard debris, such as grass clippings and leaves), pomaces and cannery wastes;
d) soils and minerals that conform to the requirements of this standard and of CAN/CGSB-32.310; and
e) paper yard waste bags which contain coloured ink.

When evidence indicates that compost feedstocks could contain a substance prohibited by 1.4 of CAN/CGSB-32.310 known to be persistent in compost, documentation or testing of the final product is required.

The following composting feedstocks are prohibited: sewage sludge; compost starter and feedstocks fortified with substances not included in this standard; leather byproducts; glossy paper; waxed cardboard; paper containing coloured ink other than paper yard waste bags; and animals, animal products and animal by-products not guaranteed free of the risk materials specified in Table 4.2; bone meal.

3.1.2 Plant Material as a Feedstock

The moisture content, C:N ratio, and particle size of plant materials is highly variable depending on the type of plant material, origin, season and age.

- **Spoiled hay and silage** – provide a very good and easily degradable C source with a typically moderate C:N ratio. They range in moisture from dry to wet, depending on where and how they were stored.
- **Leaves** – high in C and readily degradable, N content is moderate but often relatively rich in minerals. Tends to compact and needs bulking agent.
- **Grass clippings** – low C:N ratio, decompose quickly and can be a good N source. Nitrogen may be lost quickly during storage and composting. Fresh grass clippings are often relatively wet, tend to compact and may contain chemicals. Clippings need to be mixed with a bulking agent for an effective composting process.
- **Fruit and vegetable wastes** – the C:N ratio is low to moderate and often have high moisture content (if wastes are fresh). Vegetable wastes such as potato waste, legume wastes, and hops are rich in N.

3.2 STEP 2: GETTING TO THE RIGHT BALANCE

Finding the ideal compost recipe for your operation will shorten the production cycle and limit the emissions of unwanted odour and leachate substantially. An effective initial compost recipe means balancing moisture, C:N ratio and particle size. Most farmers find that it takes a short time to experiment with the feedstocks entering into their composting process to achieve the right balance.

Often farms will have one or two main feedstock inputs readily available, such as crop wastes or manure, which may need to be supplemented with materials called “bulking agents” to ensure an optimal C:N ratio, moisture and particle size. Bulking agents are typically high porosity, low moisture content and high in C. Examples of bulking agents include wood shavings, straw, cardboard and corn stalks, as described below:

- **Wood shavings and sawdust** – high in C, low (shavings) to moderate (sawdust) degradability. Can be used to absorb excess moisture.
- **Straw** – high in C and readily degradable, usually dry with good structure. If straw is wet, the structure is lost faster and other bulking agents are necessary (e.g. woodchips).
- **Cardboard** – high in C, good degradability and structure, when dry it can absorb moisture. May require pre-shredding.
- **Corn Stalks** – moderate C with varying moisture content, good structure and degradability.

A general rule is to keep the mix of feedstocks within the recommended ranges shown in **Table 2**. Key considerations and common feedstocks are discussed in this section.

Table 2. Recommended ranges of initial feedstock material.[10]

Compost Material Characteristics	Optimal Range
C:N ratio	25:1 – 35:1
Moisture	45% – 60%
Particle size	6 mm – 75 mm

3.2.1 C:N Ratio

The optimum C:N ratio needs to be achieved for an efficient composting process and odor control. If the ratio is greater than 35:1 there is not enough N available for the microorganisms to properly degrade the organic material. On the other hand, if the ratio is less than 25:1 the organic material will be broken down too fast, resulting in anaerobic conditions, and slowing the composting process. Material with a high C:N ratio are often woody materials or straw while materials with low C:N ratio are often manure, food waste or fresh grass clippings (see Table 3). Materials high in N may need to be mixed with materials high in C, to better balance the C:N ratio.

TIP:
TARGET C:N RATIO
The ideal C:N ratio for composting is within the range of 25:1 to 35:1

Table 3. Carbon-to-Nitrogen ranges for common raw organic materials[11,12].

Compost Input Materials	C:N
Grass clippings	9:1 to 25:1
Vegetable crop waste	12:1 to 20:1
Poultry manure with litter	13:1 to 18:1
Sheep manure	13:1 to 20:1
Pig manure	15:1 to 25:1
Dairy manure	18:1 to 20:1
Peat moss	18:1 to 36:1
Fruit waste	20:1 to 49:1
Horse manure	22:1 to 50:1
Foliage	30:1 to 80:1
Leaves	40:1 to 80:1
Straw	40:1 to 100:1
Cardboard	150:1 to 600:1
Sawdust	200:1 to 750:1

3.2.2 Temperature

Reaching and maintaining an optimal temperature range is necessary for the feedstock materials to degrade efficiently. During the active composting process temperatures will fluctuate slightly within the optimal range and materials should be turned if the temperatures dip below 45°C or above 65°C (Figure 2[13]). Turning two to three times a week during the initial month of composting is advisable.

[10] Gamroth, Mike. 2015. Composting: An Alternative for Livestock Manure Management and Disposal of Dead Animals. Oregon State University.
[11] Note that these are examples and that the C:N ratio will vary with the specific material. An analysis of materials will help achieve the correct ratio. Composting calculators are useful tools to use that help determine the C:N ratio of organic materials on your farm and any additional materials that may need to be added to meet the optimal C:N ratio. Links to calculators can be found in the Appendix of this document.
[12] Paul, J. and D. Geesing. 2009. Compost Facility Operator Manual: A compost facility operator training course reference and guide. Abbotsford Printing Inc., Abbotsford, BC, Canada.
[13] Ibid..

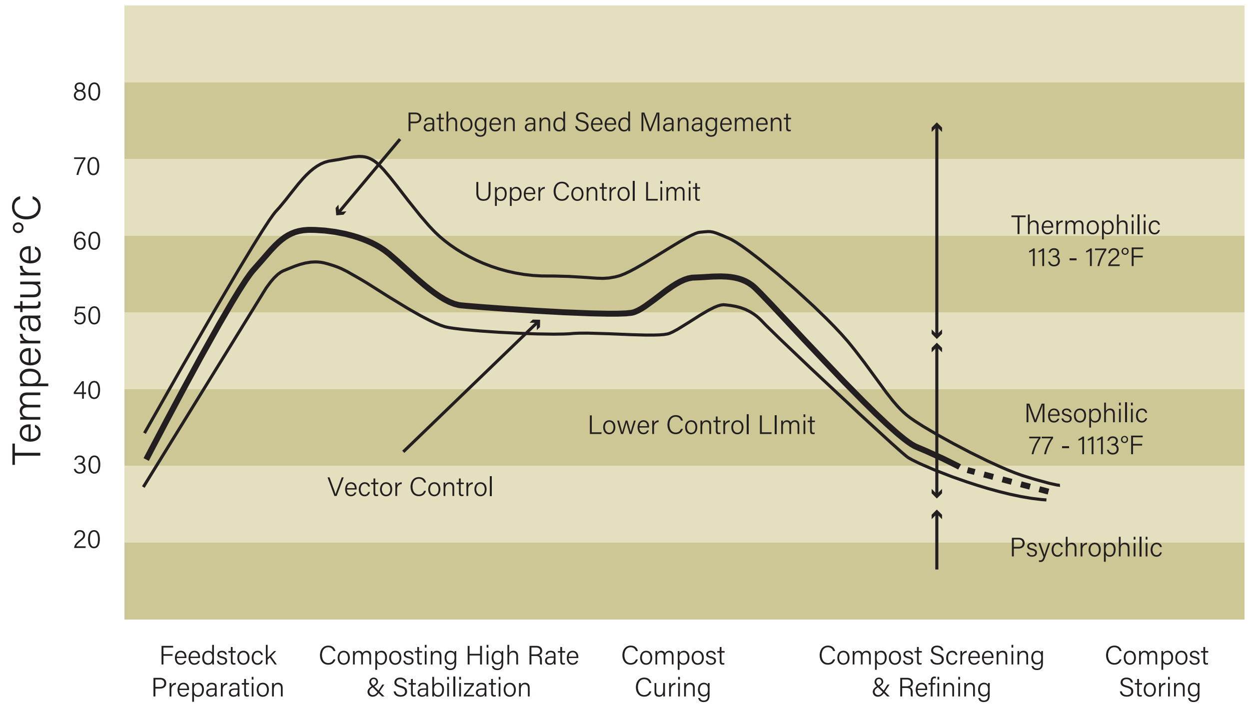


Figure 2. Temperatures during the four phases of composting.

The necessary temperature range to kill pathogens is 55°C – 65°C for at least 3 consecutive days in a forced aeration system (see Section 4.5 for more information) and at least 15 days, with at least 5 turnings, for tractor-turned piles and windrows. In compost piles with temperatures above 65-70°C and a moisture content less than 45% there is an increased risk of spontaneous combustion.

To prevent and reduce vectors (e.g. flies and mosquitoes), the average temperature of the static pile should not be less than 45°C over 2 weeks. A steady decrease in temperature after 3-4 weeks of turning may indicate the end of the active composting stage. Once the temperature stops reheating to above 45°C the active stage of composting is complete.

A thermometer probe is the most important tool for monitoring compost piles and can be either a digital or dial type. Sources of thermometer resources are provided in the Appendix. Temperatures should be taken at different locations within the pile to ensure adequate heat is reached throughout. Thermometers must be long enough to reach the middle of the composting pile - the ideal length of the probe is 2 – 3 m (6 – 8 ft).

NOTE: CERTIFIED ORGANIC STANDARDS AND TEMPERATURE REQUIREMENTS:

According to the *Federal Organic Production Systems General Principles and Management Standards* (CAN/CGSB-32.310), if compost on an organic farm includes animal manures or other likely sources of human pathogens, the compost process must:

a) reach a temperature of 55°C for a period of four consecutive days or more. The compost piles shall be mixed or managed to ensure that all of the feedstock heats to the required temperature for the minimum time; or

b) meet limits for acceptable levels of human pathogens specified in Guidelines for Compost Quality; or

c) be considered as aged or raw manure rather than compost, that is, meeting requirements specified in 5.5.2.5 of CAN/CGSB-32.310.

3.2.3 Moisture Content

Optimal target moisture content of composting material is 40-60% on a wet-weight basis. This range provides adequate moisture without limiting aeration. If below 40%, the microorganism population may not be as active as possible. Water may need to be added during mixing if moisture content is too low, or at times of the year when the relative humidity of the air is very low, such as during the middle of summer. If moisture content is above 60%, air pores may become saturated with water, creating anaerobic conditions. Bulking agents may need to be added if moisture content is too high. However, caution should be taken in adding a large volume of bulking agents to wet material, because it can alter the C:N ratio. Calculation worksheets and online calculators are available to help determine the approximate moisture levels in initial feedstock materials, and if it is necessary to add water to the initial mix (see Appendix for examples of these calculators).

The simplest way to determine the moisture level of compost is by using the squeeze test (**Figure 3**)[14]. This is done by obtaining a handful of material from the centre of the compost pile that is well mixed. The material should feel damp, not dripping wet. If the material drips without being squeezed, it is too wet. If the material appears dry and crumbles after squeezing, it is too dry. If the material retains its clumped shape after squeezing without releasing excess water, then it is just right for the active composting stage.

Figure 3. Squeeze test.

Another way to determine moisture level is by filling a 20 L bucket full of the composting material and tapping it a couple times on the ground during filling. Once filled, if the bucket weighs less than 15 kg then more moisture is needed, if more than 15 kg, moisture of the pile should be reduced by increasing aeration (e.g. turning frequency) or adding a dry amendment.

If moisture needs to be added to the compost it is recommended to add liquids during turning. If liquid wastes (e.g. liquid manure/sludge) are added during composting they should be given enough time in the composting process to destroy any pathogens.

3.2.4 Particle Size and Porosity

Porosity refers to the spaces between particles in the compost pile. These spaces are partially filled with air that can supply oxygen to microorganisms and provide a path for air circulation. Factors that impede porosity include: water saturation, compaction, and excessive shredding of materials in the initial mixing steps. Factors that improve porosity include: turning the material, and adding coarse materials, such as woodchips. Straw can also be used to improve porosity but additional coarse materials such as woodchips must be added since straw loses structure quickly, especially when wet. As the compost process proceeds, the porosity decreases, and aeration is further restricted, which highlights the need for turning the materials to increase oxygen for a faster composting process.

It is best if the particle size of feedstocks range from 6 mm to 75 mm. Increased surface area of materials accelerates the composting process, but some larger particle size material is needed to provide enough porosity and oxygen movement through the composting material. Many feedstocks such as food wastes, manure, woodchips and wood shavings fall within the optimal particle size range. Equipment such as chippers and grinders can reduce particle size of large wood wastes and yard wastes. Chippers are often used to cut woody material into smaller wood chips. Grinders can be used for wood waste and yard waste; however these may be expensive to purchase. Some operators may choose to purchase this equipment collectively to share amongst several farms.

[14] Peace River Forage Association of British Columbia. 2009. Compost Moisture.

CASE STUDY: SHEEP FARM WITH 300 EWES USING WINDROW COMPOSTING

A sheep farm on Vancouver Island uses a turned windrow composting system to manage their sheep manure and bedding. For most of the year, the 300 ewes (and varying numbers of lambs) are out on pasture but during lambing season the 300 ewes are in the barn for two months.

The manure and bedding (straw and hay) is removed from the barn during that two-month period and placed into two windrows in a field nearby. Woodchips are occasionally added as a bulking agent. The material takes a few months to compost and is regularly turned with a front-end loader. If the piles become too dry, sprinklers are placed on the piles to increase moisture content.

A separate area of the windrow is reserved for sheep carcasses, which take approximately 2 years to fully decompose.

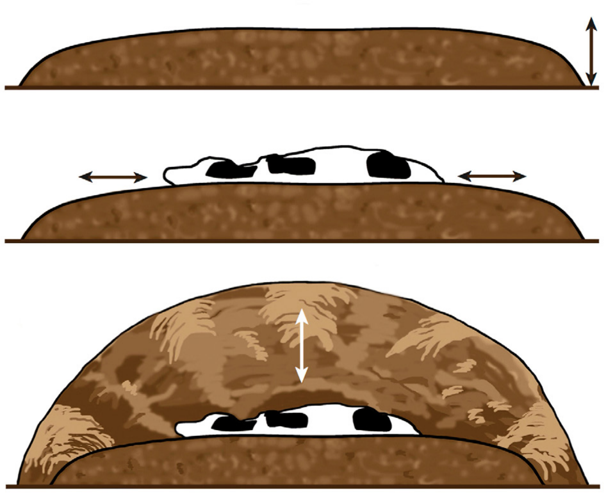
This farm produces approximately 75 m^3 of their own compost annually, to spread on their fields, which is not enough to meet their nutrient needs. They purchase additional compost from off the farm for spreading onto hay and grain fields.

3.3 COMPOSTING DEADSTOCK (MORTALITIES)

On-farm livestock mortalities, commonly referred to as "deadstock", are a normal part of farm practices. While livestock and poultry producers strive to minimize mortalities, a clear disposal plan is required. Groundwater or surface water can be contaminated by improperly sited and poorly managed deadstock disposal systems.

Increasingly, livestock and poultry farmers are composting mortalities and slaughter waste generated from on-farm slaughter operations. Proper management of such wastes is critical in ensuring that pathogens are destroyed and odours are minimized. In addition to provincial regulations, farmers must be aware of stringent federal regulations governing the transportation and processing of wastes containing specified risk materials (SRM)[15] . One important exception, is that the federal regulations do not apply to on-farm SRM management for cattle, if it does not leave the farm on which the cows have died.

The biggest difference in composting mortalities over other feedstock is that animal carcasses are very dense and high in N and moisture content. Therefore, the C:N ratio of animal carcasses is very low, approximately 5:1, and a carbon source will be required. Approximately 10 – 12 yards of straw, wood shavings, or other high C:N ratio feedstock are required to compost a full-size cow (**Figure 4**)[16], slightly less depending on size of the animal carcass(es) (**Figure 5** and **Figure 6**). It is especially important to monitor the temperature of the compost process when composting deadstock.



1 Start with a two to three foot base of absorbent compost material.

2 Add carcass in the middle. Place at least two feet of material on all sides of carcass.

3 Cover with another two or three feet of compost material. This is very important!

Too little material covering the carcass will slow decomposition and attract pests.

Figure 4. Building a compost pile for large animal mortalities[17].

[15] BC Ministry of Agriculture, 2019. Composting and agriculture webpage.
[16] Washington State University Extension. 2008. On-farm composting of large animal mortalities. EB2031E.
[17] Ibid.

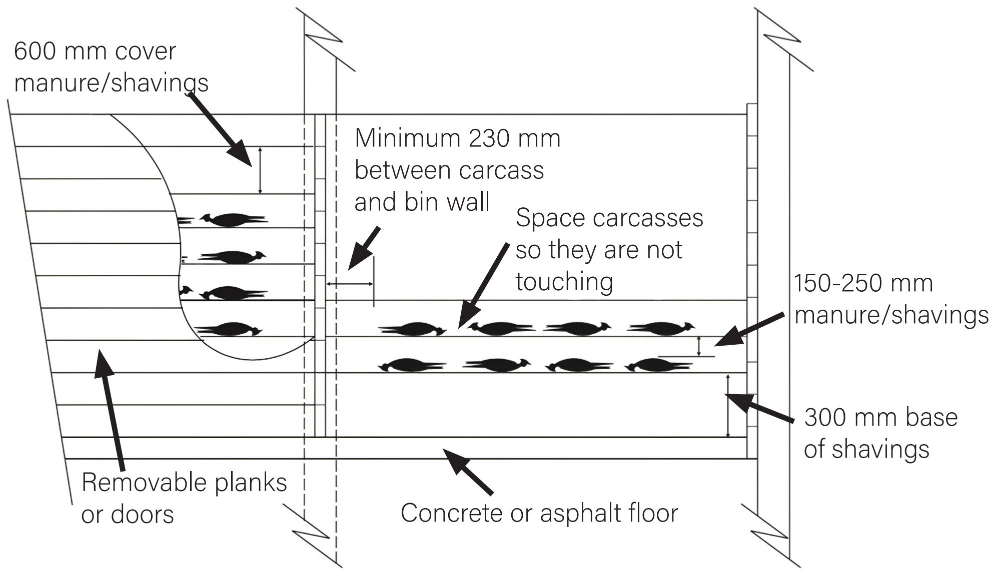


Figure 5. Poultry carcass composting in bins[18]

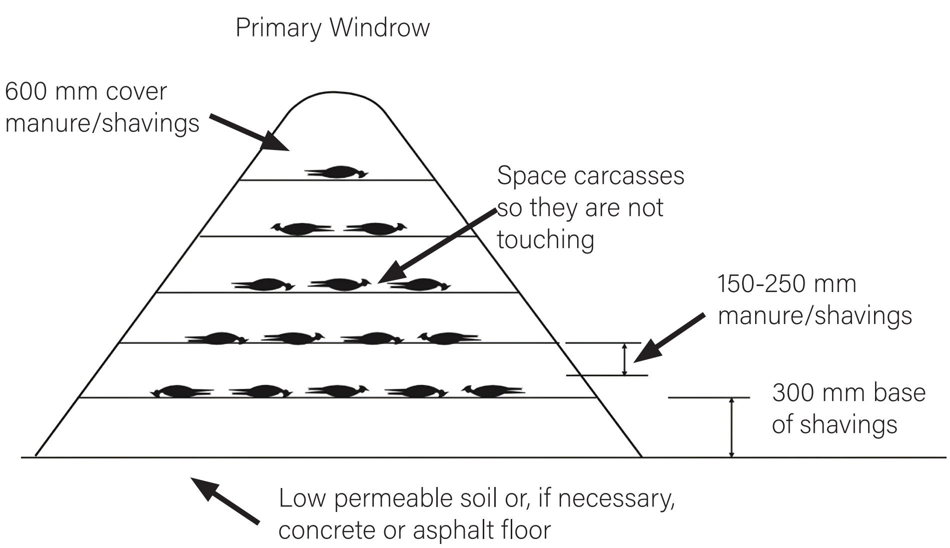


Figure 6. Poultry carcass composting in windrows.

[18] Alberta Department of Agriculture. 2015. Poultry mortality composting. AGDEX: 450/29-1.

The basic steps for composting animal carcasses, include the following:[19]

1. Add a base of absorbent feedstock, such as wood shavings or straw, about 1 m deep for large animals, 0.3 m for poultry.
2. Place the animal carcass(es) on this base of material, such that no part of the carcass is close to any edge (provide approximately 0.2 – 0.6 m of space between the carcass and the edge, depending on the size of the carcass).
3. Puncture the stomach to prevent bloating and to speed up decomposition.
4. Add another 0.6 – 1.0 m of feedstock material. Poultry carcasses can be layered between 0.3 m of additional feedstock material, until a pile height of 1.5 – 1.8 m is reached.
5. Observe the pile carefully over the ensuing days and weeks for settling, movement from wind, or disturbance from animals. Add more feedstock material to the pile as needed.
6. Monitor temperature to ensure that it reaches a range between 40°C and 70°C. Guidelines for mortality composting suggest that temperatures above 55°C be reached at points all around the carcass, at a 0.6 m depth from the surface, for at least 3 days. This ensures that potentially pathogenic bacteria and viruses in the carcass or compost materials are killed.
7. The pile should be allowed to remain in the active stage of composting for several weeks (at least 12-16 weeks for cows and horses, 8 weeks for sheep and goats, and about 4 weeks for poultry) prior to turning and mixing to aerate the materials. Some large bones may still remain, and can be left to continue to compost.
8. Most compost operations will turn a pile three times or until internal temperatures no longer exceed 40°C, indicating that the compost has reached the finishing stage.
9. There should be no traces of tissue or unpleasant odour in the finished compost.

The BC *Environmental Management Act's Code of Practice of Agricultural Environmental Management* (AEM Code) allows the burial or disposal of mortalities that died on the farm. Burial requires a large area, and therefore composting may be an attractive alternative. By following the beneficial management practices (BMPs) referred to in BC's Environmental Farm Plan (EFP)[20] Reference Guide for on-farm disposal of any livestock species, producers should not contravene the Canadian Food Inspection Agency (CFIA) or BC Ministry of Environment regulatory requirements. A CFIA SRM Transport Permit is required to move cattle mortality compost offsite.

The AEM Code contains the following regulations regarding the composting of on-farm animal mortalities:

- May only dispose of animals that died on the farm;
- Mortality composting must occur in a composting structure or in an outdoor agricultural composting pile;
- Mortalities and processing waste must be completely decomposed before land application;
- Mortalities must be prevented from entering a watercourse;
- If a mortality enters a watercourse, it must be removed immediately;
- Contaminated runoff, leachate, solids, and air contaminants[21] from the activity must not enter a watercourse, cross a property boundary, or enter groundwater;
- The activity must deter the attraction of, and access by, domestic pets, wildlife, and vectors;
- The composted livestock mortalities must be applied to land only, and are not to be removed from the agricultural land base on which the composting occurred;
- A person must not dispose of more than 5 tonnes of mortalities through composting processes in any 30-day period unless a director is notified; and
- A person who applies the product of an agricultural composting process to land must, if the product contains SRM, ensure that the product is not applied to land used to grow crops for human consumption or to graze domestic ruminants (Ontario suggests a minimum of 5 years).

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[19] Glanville, T. 1999. Composting dead livestock: a new solution to an old problem. Iowa State University, The Leopold Center for Sustainable Agriculture and the Iowa Department of Natural Resources.
[20] BC Environmental Farm Plan Program.
[21] Air contaminants, as defined by the Environmental Management Act includes: a substance that is introduced into the air and that (a) injures or is capable of injuring the health or safety of a person, (b) injures or is capable of injuring property or any life form, (c) interferes with or is capable of interfering with visibility, (d) interferes with or is capable of interfering with the normal conduct of business, (e) causes or is capable of causing material physical discomfort to a person, or (f) damages or is capable of damaging the environment.

Outdoor agricultural composting piles used to dispose of mortalities must be in piles that are not located in an area in which there is standing water, or water-saturated soil, or on any low-lying area of a field prone to seasonal flooding. The pile must not remain for a period of more than 15 months and no other pile must be erected in the same location for 3 years.

The following videos published by the BC Ministry of Agriculture provide guidance and best practices for disposing of routine mortalities:

Composting Large Animal Mortalities on Farm

Composting Small and Medium Hoofstock Mortalities on Farm

Composting Routine Mortalities from Backyard Poultry Flocks

Composting Poultry Mortalities: Backyard Poultry Flocks

Many good resources exist online regarding the composting of livestock mortalities. These include the following factsheets by the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA):

On-Farm Bin Composting of Deadstock: AGDEX #725/400

Best Management Practices: Deadstock Disposal, 2009 (book) Order No. BMP22

Composting of Cattle On-Farm – Order No. 10-063 AGDEX 729/400

Deadstock Disposal Options for On-Farm – Order No. 09-025

On-Farm Bin Composting of Deadstock – Order No. 09-031

Windrow Composting of Poultry Carcasses – Order No. 09-017

Resources from other jurisdictions include:

On-Farm Composting of Large Animal Mortalities: Washington State: EB2031E

Composting Dead Sheep: State of Maryland Extension.

Composting Poultry: Virginia Department of Environmental Quality.

Poultry Mortality Composting: Province of Alberta: AGDEX: 450/29-1

Swine Mortality Composting: Province of Alberta: AGDEX: 440/29-1

4.0 What methods for composting exist, and which system is right for my farm?

There are several types of compost systems that are used in agriculture. Some, such as channelized systems and in-vessel composting, may be more appropriate for larger composting operations or co-composting operations on farms (including large volumes off-site waste), and these are not included in this discussion.

There are essentially two types of composting that are appropriate for small and medium-scale farms:

1. Piles (may be placed in bays or bins)
2. Windrows

Each composting system requires the addition of air, and this can be accomplished through turning or through forced aeration. These are further described below.

NOTE: PASSIVE PILES OR WINDROWS – NOT RECOMMENDED

Passive composting involves the production of compost in piles or windrows through natural aeration over long periods of time, with no mixing or turning. This system is not recommended for efficient composting. It is a low technology and low labour approach and can generate odour, leachate and must be stored for long periods of time. It also often results in a considerable loss of nutrients and is frequent cause of complaints by neighbors.

4.1 PRE-MIXING OF FEEDSTOCK MATERIALS

Once the initial composting materials (feedstocks) have been selected and the optimal C:N ratio has been determined, the moisture content is optimal, and materials have been prepared for composting (e.g. ensuring adequate particle size) the materials need to be uniformly mixed. This pre-mixing is typically accomplished through a front-end loader or a compost turner. The active stage of the composting process will begin once the feedstock has been piled and mixed.

DID YOU KNOW:

Once the compost system is up and running, most farm operators only spend a couple of hours a week tending to their compost process.

4.2 PILES IN BAYS

This pile system involves the production of compost within a bay, usually in a structure on a protective base, using aeration methods such as tractor-turning or forced aeration (see Sections 4.4 and 4.5). This is a low technology, medium labour approach and is the most common method for small lot farmers as it produces compost fairly quickly and does not require a large amount of space. The bays can be considered as a form of in-vessel composting; however, they are not usually totally enclosed. Piles are generally more appropriate for smaller quantities of materials. At a farm scale, the volume of organic material should be no smaller than 10 m^3 to maintain the high temperatures needed for the composting process. Common designs include two or three bays in which material from one bay is transferred into the next bay during the turning process. While piles can be turned in place, it is often easier to transfer the materials to an empty bay area to ensure materials from the outside of the pile are now in the middle of the pile for more uniform composting.

CASE STUDY: THREE BAY COMPOSTING ON A 27 ACRE FARM WITH 15 HORSES

This horse farm has 15 horses on 27 acres and uses a 3 bay system. The structure has a concrete floor, with extra space at the front, drainage ditches and a metal roof with wooden rafters (Figure 7). The whole structure is 7.5 m wide by 15 m long. Each of the three bays contains materials at different stages of composting:

Bay 1: Fresh manure (includes everything from the stalls: bedding, manure, urine, some hay)

Bay 2: Active composting

Bay 3: Finished compost (still needs to be cured)

While the materials are being loaded into the bays, water is added using sprinklers to reach desired moisture levels if necessary. A forklift is used to turn and aerate the piles once a week while it's composting which takes 1-2 hours of labour at a time. The temperature of the piles is measured using a long temperature probe to reach the middle of the pile. A manure spreader is used to spread the compost onto pasture fields and mixed into vegetable beds.

The cost of the system was offset by donations of the concrete blocks and volunteer labour. The concrete slab cost around $5,000 and the roof also around $5,000.

Figure 7. A three bay compost system for horse manure and bedding

4.3 PILES IN WINDROWS

A windrow is simply an elongated pile of composting material with a more or less triangular cross-section shape. Windrows can be aerated using mechanical turning (Figure 8) or forced aeration (see Sections 4.4 and 4.5). As a general rule, windrows should not be higher than 2.5 m (8 ft) or wider than 3.6 m (12 ft) without forced air. Any larger and air movement into the windrows will be reduced. Windrow size may be influenced by the size of turning equipment (e.g. tractor or windrow turner (Figure 8)).

Windrows should be turned frequently at first and then at longer intervals by the end of the first month (Table 4).

Table 4. Recommended windrow turning Frequency.

Week	Number of Turnings
1	3
2	2 to 3
3	2
4 - 6	Once a week
After 6 weeks	Once every 2 weeks

Figure 8. Windrow composting[22]

[22] Photo is from Geoengineer.org.

4.4 THE IMPORTANCE OF TURNING COMPOST

Turning is the agitation and mixing of the compost pile or windrow to mix materials from the surface into the centre (**Figure 9**). There are several advantages of turning compost:

- Allows an opportunity for moisture management.
- Ensures that there is a uniform mix of the materials throughout the windrow or pile, which enables pathogen kill temperatures to reach all materials.
- Replenishes oxygen, increases porosity, breaks up clods, and interrupts preferential air flow.
- Improves end product quality and homogeneity.

How often a pile or windrow should be turned depends on the properties of the material in the pile, the decomposition rate, and the size of the piles or windrows. Moist material needs more turning than dry materials. However, turning too frequently can make the material too dry and will decrease internal temperature of the pile. Low temperatures will inhibit the degradation of materials. Dry material also becomes hydrophobic, which makes it difficult for re-wetting of materials.

> "We turn the compost pile at least once a week during the start of the process, which takes 1-2 hours of labour time."
> – Farmer managing horse manure

Figure 9. Mixing compost with a tractor[23]

Materials with high odour potential should be turned less often than materials with little odour potential. Dense material of smaller particle sizes may require more frequent turning to maintain oxygen supply for microbes. During the early stages of the active composting process, the decomposition rate is high, and therefore, turning should happen more frequently. Larger piles or windrows will need to be turned more often to replenish oxygen supply to the centre of the materials.

Turning of the compost can be done by one of three equipment systems, which are described below:

- Tractor and front end loader
- Tractor and front end loader and spreader
- Tractor and windrow turner

[23] Photo is from Campus Extension, an online video and training website.

4.4.1 Tractor and Front-End Loader

The tractor and front-end loader (or "tractor-loader") is the simplest system for most farm operations. The disadvantage is that there is frequently less than adequate mixing and large pieces of materials may not be broken up, thereby reducing the amount of aeration. Depending on the size of the operation, a 135-horsepower tractor with a 3 yard bucket should suffice. Using a tractor-loader can be time consuming for large quantities of compost. There are extra space requirements to use a tractor and loader and may require windrows to be located endwise instead of side by side. In general, turned windrow compost operations producing less than 400 m^3 per year can use front-end loaders to be time and resource efficient. A front-end loader is usually sufficient for the bay and bin composting methods.

Some farms use a forklift to mix and aerate small piles of compost. The tines of the forklift can be useful in getting into the corners of a bay or bin system.

4.4.2 Tractor-Loader with Additional Spreader

The tractor-loader plus a second tractor with a manure spreader can be used to get better mixing and aeration of the compost and works well with larger volumes and windrows. The loader fills the spreader, which is used to discharge the material to create a new windrow or pile, therefore mixing and aerating it in the process. The main disadvantages are extra equipment and labour costs.

4.4.3 Tractor and Windrow Turner

For larger volumes, specialized windrow turning equipment can be used that is designed to turn windrows efficiently and moves material from the outside of the windrow to the centre. Compost turners have the capacity to turn compost up to ten times faster than a tractor loader system. The main disadvantage is the cost of the equipment. The cost of equipment is a worthwhile investment in a farm producing over 1,500 m^3 per year of compost. Another strategy involves moving material from one windrow to another and using that opportunity for mixing. A tractor mounted conveyer or slanted surface can be used.

CASE STUDY: 1 ACRE MIXED HOBBY FARM WITH A 3 BAY COMPOST SYSTEM

A mixed farm located on 1 acre uses a 3-bay compost system (**Figure 10**). Materials composted on the farm include vegetable green waste and on-farm pony, pig and chicken manure.

Materials in bays are mixed using a tractor with a front-end loader to assist with aeration and maintain desired temperatures. The farm operator submits samples of the compost to a laboratory for nutrient and salt (electrical conductivity) level analysis. Any test results that are outside the optimal range will trigger changes to the management of the compost operation, such as increasing water, additional turning, or adjusting the C:N ratio. Often, the farm buys oyster shells or chicken manure from another farm to add to the system to increase calcium and nitrogen content.

Summer months are too busy for constant maintenance but when hot/dry conditions occur the compost will be watered with hose or sprinkler. Farmers manage the compost system more closely during the fall and winter seasons. The farm operator decided on the location of establishing the compost structure with the help of an Environmental Farm Plan planning advisor.

The average time for decomposition of materials is 16-18 months. The final product is incorporated back into their growing fields.

System design: Each bay is 3 m wide by 2.5 m deep built from wood. The concrete pad is approximately 60 m^2.

Estimated costs for additional inputs (e.g chicken manure) around $600-700 per year.

Figure 10. Three bay pile system turned with a tractor loader.

4.5 FORCED AERATION – AN ALTERNATIVE TO TURNING

Forced aeration involves using a combination of perforated pipes under the composting material (or embedded into the floor) and a vacuum or fan blower system to move the air through the compost (Figure 11).

4.5.1 Negative Aeration

In negative aeration, air is drawn down through the composting material from the outer surface of the pile using vacuum suction, moves through the pile into the piping, and is discharged through a blower out of the pile. The exhaust can be odourous, and the air flow can be directed into a biofilter in order to treat odours if need be.

Disadvantages of negative aeration include:

- Moisture and fine particles are drawn into the aeration pipes and blowers increasing clogging potential;
- Air is highly-corrosive which increases stress on piping and blower; and
- If a biofilter is used, it is important to ensure additional air is added to the exhausted air to reduce the overall air temperature.

The main advantage of negative aeration is a better control over odour if combined with a biofilter than positive aeration.

4.5.2 Positive Aeration

In positive aeration, air is pushed into the pile or windrow from below the materials and flows out the top, exiting over the entire composting surface. Advantages of positive aeration over negative aeration are that it provides better air flow, better distributes air in the pile, and requires less energy consumption. Positive aeration is also more effective at cooling the composting pile overall.

Figure 11. Example of forced aeration piping and blower system[24]

4.5.3 MANAGING AIR FLOW IN FORCED AERATION COMPOST SYSTEMS

It is recommended that aeration occurs intermittently and is managed by either a timer or a temperature control. In a timer-controlled system, the blower "off" time should normally not exceed 60 minutes and the best aeration schedules are usually determined by observing compost pile characteristics (e.g. temperature, moisture). A temperature-controlled system uses temperature sensors (usually thermocouples) coupled with a timer to automate the on/off cycle of blower. The temperature sensors are set to provide enough oxygen to meet the requirements of the microorganisms based on the temperature of the pile. Temperature-controlled systems are often hybrid systems: an on/off timer (30 min on/30 min off) that can be overridden when temperature exceeds a certain threshold.

4.5.4 Designing Forced Aeration Compost Systems

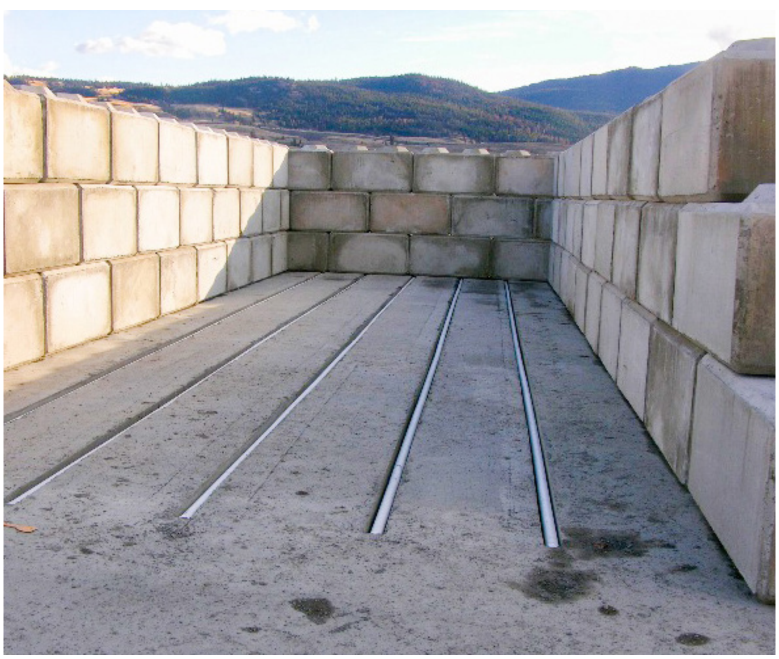

Figure 12. Force aeration composting using ventilated floors.

Forced aeration systems can be used in the pile method or in the windrow composting method. Forced aeration of piles and windrows requires more careful design for appropriate airflows and is usually more expensive than tractor-turned systems. Piles will still need to be turned to ensure that all material is composted consistently but less frequently, resulting in some cost savings. Piles can be higher, and the composting process is completed faster overall.

Proper pre-mixing of the feedstock materials and optimal moisture contents are critical to success. If forced aeration systems are used, the moisture content should be closely monitored, as the pile may dry out faster.

[24] O2 compost systems, 2019. Blower system with piping.

If positive forced aeration is used, piles or windrows must be covered with 15-30 cm of an insulated blanket of material (such as mature compost) for odour control. A cover is also recommended when negative aeration is used.

An alternative design of forced aeration systems involves a pile or windrow placed upon a concrete pad with a ventilated floor and air holes down the length of the centre of the pad (**Figure 12**). The ventilated floor can be set up as either a positive or negative forced aeration system. This reduces problems with removing and setting up air pipes, when emptying the bins and allows the option of tractor-turning of the pile to enhance mixing and temperature/moisture management when required. Well-designed floors can also catch and collect leachate for reuse to add moisture to the pile.

4.6 COMPARING COMPOST SYSTEM OPERATIONS

Once the compost system is running the overall labour inputs are quite low. This includes a couple of hours a week to remove manure and bedding from barns and put it into the compost bins, one hour a week to turn the compost or check PVC piping if using forced aeration, an hour a week to conduct temperature checks and other housekeeping, and about a full day every month during the growing season to spread the finished compost onto fields. The first run-through may require additional time allocated to general troubleshooting and maintenance. Section 7 provides a more detailed analysis of system design and cost requirements for different compost systems. Table 5 summarizes the differences between turned piles or windrows and forced aeration piles or windrows.

Table 5. Differences in turned vs. forced aeration systems.

Characteristics	Turned piles or windrows	Forced aeration piles or windrows
General	Effective for small and medium scale farms, more common on small farms.	Effective for small and medium scale farms.
Labour	Tractor turning required.	High labour for system design and planning. Specialized turning equipment may be needed.
Site design	Piles typically in 2 or 3 bays. Windrows can take up larger areas of space.	Total area can be smaller than turned system due to faster processing times.
Bulking agent	Higher volume of bulking agents needed. More turning would result in less bulking agents required.	Lower volume of bulking agents needed
Period of active composting	4 to 6 months	3 to 4 months
Curing	1 to 2 months	1 to 2 months
Size and Volume	Windrows: ▪ Up to 2 m high ▪ 3 – 6 m wide ▪ Length is variable *These dimensions will depend on windrow turning equipment Piles: ▪ Up to 2 m high ▪ Width and length will depend on desired size of bay structure	Windrows: ▪ Up to 3 m high ▪ 3 – 6 m wide ▪ Length is variable *These dimensions will depend on windrow turning equipment Piles: ▪ Up to 3 m high ▪ Width and length will depend on desired size of bay structure
Aeration	Mechanical (tractor turning).	Forced positive or negative air flow through the pile.
Odour consideration	Turning can create odours especially in the initial weeks.	A cover of mature compost or wood shavings (biofilter) can help to mitigate odours.

4.7 REGIONAL CONSIDERATIONS

Regional considerations, particularly annual precipitation and temperature patterns may influence the choice and design of the system. Windrows are typically more impacted by weather than piles and bins, primarily because it is more difficult to protect windrows from the elements. These conditions are further described below.

4.7.1 Wet Conditions

High levels of precipitation create site management issues, because saturated soils can make it difficult to operate equipment. Standing water (e.g. puddles) can lead to anaerobic conditions around the base of a windrow or pile. Wet conditions can also lead to flies, insects, and odours. Leaching from compost piles must be controlled and collected for future reuse, otherwise it will transport organic, inorganic and nutrient contaminants into soil or watercourses. In the soil, these contaminants may contribute to ground water pollution. Therefore, composting in high precipitation areas must be conducted under cover and on impervious surfaces with leachate collection, as per the AEM Code[25] (see text box). Covering windrows with tarps also allows windrow composting to become more feasible in regions with high precipitation, such as the Lower Mainland and parts of Vancouver Island.

> **NOTE:**
> **COMPOSTING PRACTICES AND THE LAW**
>
> As per the AEM Code, compost structures must be placed on a protective base with leachate collection and control.
>
> Furthermore, outdoor compost piles need to be covered between October 1 and April 1 in high precipitation areas. High precipitation areas are defined as areas that receive at least 600 mm of precipitation from October 1 to April 30. This area includes the South Coast of BC.

4.7.2 Dry Conditions

In low rainfall areas (less than 600 mm of precipitation between October 1 and April 30), compost may be produced outside on uncovered concrete slabs. More attention should be paid to providing adequate moisture to the composting process. Sprinklers may be a necessary addition to compost structures and a water license may be required to access water. Care should be taken to prevent dry material on the outside of the piles and temperatures over 65-70°C inside the pile as this can lead to spontaneous ignition of the materials.

4.7.3 Cold Conditions

Cold weather will increase the heat loss from piles and windrows and will decrease the microbial activity levels. Prolonged freezing temperatures can halt composting completely in smaller piles, but the process will resume once the weather warms up. If composting begins before cold weather sets in, temperatures of 45-65°C may be reached in the centre of the piles and continue to compost. In this case, the outer few inches will need to be turned into the pile once the weather warms, to ensure complete composting of materials. Tarps or roof structures can be used to place over the piles to ensure that snow is not getting into the compost, as snow will affect the moisture content and temperature of the pile. Covering the piles with mature compost can provide an insulated barrier to allow the composting process to proceed. If snow falls directly onto the actively composting materials, it can also act as an insulating layer, allowing the composting process to continue. Turning should be avoided if snow accumulates on the pile, as it will decrease the internal temperature[26]. Surrounding the piles with straw bales can also act as an insulating mechanism to maintain higher temperatures.

4.7.4 Hot Conditions

Warm weather enhances water loss of the outside layers, and water can be added to windrows and piles if they become too dry. Automated sprinklers and other watering devices can be integrated into the system design to facilitate moisture control. Some pre-wetting may be required to avoid excessive run-off from the pile because dry compost can become water-repellent. A water license may be required. Care should be taken to prevent temperatures rising to over 65-70°C inside the pile as this can lead to spontaneous ignition of the materials.

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[25] BC's Code of Practice for Agricultural Environmental Management regulates the siting and practices associated with agricultural composting. Special conditions apply to high precipitation areas (regions receiving more than 600 mm of precipitation from October 1 to April 30).
See the Code for more information.

[26] Land Management Guide for Horse Owners and Small-Lot Farmers. 2007.Langley Environmental Partner's Society.

5.0 What do I need to do once the composting process has started?

During the active, thermophilic stage, it is important to monitor the organic material to ensure efficient composting. Temperature is the most practical parameter to monitor and can be measured fairly easily using affordable temperature probes. Temperature is a useful indicator, whereby if the temperature is too high or too low then it is a sign that something about the compost process is not working as intended. Monitoring and maintaining the desired temperatures at each stage of the compost process is good practice which leads to an increased chance of successful composting. Other characteristics to be aware of and manage for are moisture content and aeration. Optimal ranges are presented in Table 6 and additional information about each factor is provided in Section 3 of this guidebook.

Table 6. Optimal ranges of composting material conditions during the active stage of composting.

Factor	Optimal Range
Temperature	45°C - 65°C
Moisture content	40% - 60%
Percent oxygen (aeration)	> 10%

CASE STUDY: 5 ACRE FARM WITH 7 HORSES USING A 2-BAY COMPOST SYSTEM

A horse farm on 5 acres of land has an average of 7 horses boarding at a time, providing a constant stream of manure and bedding.

The composting structure is placed close to the barn for easy access to the manure source. The structure has two bays for feedstock, a concrete pad with a 1% slope to the back of the structure for leachate control, and leachate pipe that drains into a collection area in the nearby garden. There are 2 m high concrete side walls and a metal roof with wooden rafters. The roof is high enough so that the loader can scoop and turn the manure without hitting the roof (Figure 13).

Piles are turned every couple of weeks. A concrete pad was built in front of the structure making it easier for the tractor to maneuver, especially during wet conditions. The operators perform the "squeeze test" for moisture content and take the temperature of the piles regularly using a long probe. Manure coming into the structures is wet and does not need additional water. Sometimes wood shavings are added to the piles as a bulking agent to reduce moisture content. After 2-3 months the material is ready to be cured and then spread onto fields. Composted material is spread onto pasture lands several times a year with a manure spreader, which takes approximately 1 day of labour each time.

The cost to build the structure was around $5,000. Construction labour was performed in-kind, and concrete forms were rented. In the future, they would like to add a third bay to increase efficiency.

Figure 13.
Two bin pile system using tractor turning.

5.1 TROUBLESHOOTING COMMON PROBLEMS

Being able to identify problems early-on will increase management success. Problems and solutions to common issues associated with composting are described in Table 7.

Table 7. Common composting problems, possible causes, and solutions [27] [28] [29] [30] [31].

Problem	Possible Causes	Solutions
	TEMPERATURE	
Pile does not heat up	Pile too dry	Add water to the pile
	Pile too wet	Turn and/or cover the pile, add dry material
	Small pile size	Enlarge or combine piles
	Insufficient aeration	Turn windrow more frequently to increase airflow
	Too much aeration	Reduce turning frequency to allow more time for materials to decompose
	Low pH	Add lime or wood ash and remix
	Low nitrogen	Add high nitrogen ingredients Reduce bedding materials
	Material is too coarse or too fine	Re-grind bulking agent or add coarser bulking agent
Pile does not stay hot	Low oxygen	Turn pile, add bulkier material
	Low moisture	Turn pile and add water
	Piles are too small	Add more material to pile
	Piles are too porous	Add smaller particle size feedstock
Temperature is too high	Low to moderate moisture	Add more water and continue turning pile
	Pile is too big, dense, and/or compacted	Decrease size of pile, turn pile, add bulkier materials
	Nitrogen content in pile is too high	Add high carbon ingredients
The inside of the pile is cool and the outside is hot	The pile is either too wet, lacking oxygen, or materials are too compacted	Turn pile
	MOISTURE	
Pile is dry throughout	Relative humidity is too low	Add water while turning pile
	Pile is too small	Enlarge the pile
	Aeration is occurring too often	Reduce frequency of turning pile and aeration time
Pile is damp and sweet-smelling but still not breaking down	Relative humidity is high	Turn pile to evaporate water
	PESTS	
Rodents and/or birds	Rodents and/or birds are in and around the compost	Use concrete block siding rather than wood Cover pile with tarp or layer of finished compost Handle material promptly
Flies	Flies are breeding in uncovered, un-composted manure	Cover pile with a tarp or a layer of finished compost to prevent access to breeding grounds Handle material promptly
	Flies breeding in standing water or in puddles of leachate around piles	Drain all puddles from around compost area

[27] New Brunswick, Agriculture, Aquaculture and Fisheries. 2015. Compost – Basics of On-Farm Composting
[28] Langley Environmental Partner's Society 2007. Land Management Guide for Horse Owners and Small-Lot Farmers.
[29] USDA Natural Resources Conservation Service. Whatcom County Small Farm Composting Guide.
[30] Backyard Composting, Factsheet Series #1. Compost Education Centre.
[31] Alberta Agriculture, Food and Rural Development. 2005. Manure Composting Manual.

5.1.1 Odour Management

Most organic wastes will generate some odour during the composting process. Odour problems, causes, and solutions are summarized in Table 8. Odour increases when the composting material is allowed to become anaerobic (i.e. is deprived of oxygen). Therefore, odours can generally be minimized with proper aeration.

The primary sources of odour at a composting site are:

1. Anaerobic conditions;
2. Ammonia lost from high-N materials;
3. Poor initial mixing of raw materials;
4. Bad housekeeping; and
5. High odor potential (fish waste, meat, etc.)

Odour control starts with good feedstock preparation: rapid mixing with bulking agents, control of moisture content and porosity, and an optimal C:N ratio. Planning composting activities in accordance with the weather is also an important operational strategy to reduce odour impact beyond the property lines. Prevailing wind direction and proximity to residential areas are important factors to take into consideration in selecting sites for composting.

WARNING:

The *Environmental Management Act* defines "air contaminants" as a substance that is introduced into the air and that:

a) Injures or is capable of injuring the health or safety of a person,

b) Injures or is capable of injuring property or any life form,

c) Interferes with or is capable of interfering with visibility,

d) Interferes with or is capable of interfering with the normal conduct of business,

e) Causes or is capable of causing material physical discomfort to a person, or

f) Damages or is capable of damaging the environment.

Odour may be considered an air contaminant. The AEM Code requires that air contaminants do not cross property boundaries.

Table 8. Common problems, causes and solutions associated with odour during composting [32 33 34].

Odour Problem	Possible Causes	Solutions
Ammonia	C:N ratio less than 20:1	Add high carbon materials
Hydrogen sulphide	Material is too wet High sulphur feedstock (high protein feedstock)	Add dry bulking material Increase mixing or forced aeration Cover pile Use negative aeration with biofilter Increase layer on top of pile and keep that layer moist (not wet)
General foul smell	Anaerobic conditions Material is too wet Temperature is low Bad housekeeping	Increase mixing or forced aeration Incorporate bulkier materials to increase porosity Lower the height of piles or windrows to reduce compaction Ensure good pile drainage Keep moisture content 40 – 60% and temperature 45 - 65°C Drain standing water Clean cracks in walls and floor regularly

[32] On-farm Manure Management Through Composting. Nova Scotia's Adaptation Council.
[33] Langley Environmental Partner's Society. 2007. Land Management Guide for Horse Owners and Small-Lot Farmers.
[34] Manure Composting Manual. 2005. Alberta Agriculture, Food and Rural Development.

6.0 How do I know when my compost is finished, and can I sell it off-farm?

The main steps involved in the finishing process involves curing and screening. If the compost will be sold off farm, then it is important to understand the rules and regulations surrounding compost sales. These are described in this chapter.

6.1 THE CURING AND FINISHING PROCESS

Once the active phase of composting has completed, the compost must be matured or cured for a period of time before the product can be used. This timeline will vary depending on the feedstocks, the system and aeration method selected, and the time spent managing the process. For example, using a windrow composting method but turning infrequently may result in a timeline of six months for adequate curing time of the compost. On the other hand, using a windrow with frequent turning or an aerated pile method may require a curing period of only 2 – 3 months[35].

The three best indicators that compost is ready for curing are:

1. After a period of sustained optimal temperatures there is a gradual decline in pile or windrow temperature;
2. When the pile is turned it does not re-heat to high temperatures[36]; or
3. When a sample is placed in sealed bag, there is no trace of unpleasant odour after 24 hours.

> **TIP:**
> Germination tests using lettuce seeds can be used to test for compost maturity. If compost is immature the germinating seeds and plants will not survive.

If space allows, compost should be brought to a final curing area, away from any actively composting materials. It is recommended to cure piles under a roof or shelter and in a well-drained area for optimal moisture control[37].

- The final compost product will have the following, easy-to-observe, qualities (Figure 14):
- No recognizable original materials
- Dark brown to black colour
- No objectionable odours, but an 'earthy' smell
- No pathogens and seeds
- A crumbly texture
- Stable ambient temperatures
- A pH between 5.0 and 8.0.

Figure 14. Finished compost.

6.1.1 Screening

Screening is an optional post-processing activity, but it is an important step if compost will be sold off-farm. Screening is usually undertaken after curing the process is finished. It allows a size selection according the final desired use (e.g. spread onto fields or used in vegetable bed preparation), as well as a uniformity of look and feel. Rocks, large pieces of undecomposed woody material, and other unwanted materials will be removed from the final product through screening. Screen openings should be 2 cm. Screening dry product is easier than compost with high moisture content. In some cases, compost that will be used on the farm may not need to be screened, either because some larger-sized material is desired for soil structure purposes, or because the finished material is already fairly uniform. In situations where plastics or other foreign materials are present, then screening is highly recommended.

[35] Gamroth, Mike. 2015. Composting: An Alternative for Livestock Manure Management and Disposal of Dead Animals. Oregon State University.
[36] On-farm Manure Management Through Composting. Nova Scotia's Adaptation Council.
[37] Ibid

6.1.2 Using Finished Compost on the Farm

Mature compost is a valuable input to many scales and types of agricultural operations. As discussed in Section 1, compost increases the aeration and organic matter content of soils, improves nutrient retention and soil structure, and suppresses plant diseases.

When finished compost is used on-farm to enhance plant growth, it is important to know the characteristics of the compost material being incorporated into fields. Samples of compost can be sent for analyses to identify its content, which is useful for nutrient management. Some laboratories will return results along with suggested application rates. Resources regarding sampling, laboratories, and interpretation of results are provided in the Appendix.

> **WARNING:**
>
> When storing finished compost long-term, the storage structure must be sited to meet the following setbacks:
>
> - 30 m from a drinking water source
> - 15 m from watercourse, other than a drinking water source
> - 4.5 m from a property boundary

The characteristics of compost and the receiving soil to consider are:

- **Salt content (Electrical Conductivity or EC):** Elevated levels of salt concentrations above 4 mS/cm can be toxic to plants, and the EC of compost can range from 1.1 to 5.4 mS/cm[38], depending on the feedstocks and the stage of composting. It is not typically recommended to plant seeds or seedlings directly into fresh compost unless that compost has been cured for a long time. However, if the compost is land applied in the fall or 3 – 4 months prior to planting, there are generally no EC problems, particularly in areas with elevated rainfall.
- **Nutrient concentrations (N, P):** In mature compost, most N is in an organic form, so it is released gradually, which decreases the risk of immediate leaching and extends its availability over the growing season. The average annual mineralization rate (the availability of the nutrient) is between 8-12% of the total N in the compost. The ability of compost to supply N to crops will vary depending on the initial composition of the raw wastes, as well as on the type and duration of the composting process. Phosphorus in compost is 40-75% available to plants in the first year.
- **C:N ratio:** Compost materials with C:N ratios less than 20:1 act as fertilizers right away, as the compost will supply nitrogen to the soil. Any compost or other organic waste material which has a C:N ratio greater than 30:1 will still release nitrogen over the longer term, but may cause a temporary reduction in plant-available nitrogen.

6.2 SELLING FINISHED COMPOST OFF THE FARM

Some farmers may find that they have enough compost product to sell off-farm. Several important regulations need to be considered if compost is going to be sold. These include:

- Federal *Fertilizers Act and Regulations* (regulates product safety and labelling)
- AEM Code (regulates record keeping)
- Organic Matter Recycling Regulation (see text box)
- Agricultural Land Reserve Regulation

> **WARNING:**
>
> Agricultural composting for on-farm use is generally exempted from the *Organic Matter Recycling Regulation* (OMRR).
>
> However, if the operation is processing wastes from other farms and selling the finished compost, OMRR Class A compost requirements may be triggered.
>
> In order to comply with permitted farm uses under the *ALR Regulation*, only the production, storage, and application of compost from agricultural wastes produced on the farm for farm purposes is allowed.
>
> Non-agricultural wastes brought onto a farm for composting purposes will require a permit or approval from ENV as outlined in the *Organic Matter Recycling Regulation* (OMRR), unless all of the finished product is used on the farm.

---

[38] Paul, J. and D. Geesing. 2009. Compost Facility Operator Manual: A compost facility operator training course reference and guide. Abbotsford Printing Inc., Abbotsford, BC, Canada.

According to the AEM Code (SECTION 43), if finished compost is being exported off-farm from an operation with 5 or more animal units (one animal unit = 455kg of livestock and/or poultry), the following requirements must be met:

1. If exporting compost in amounts less than 5 m^3, an annual record of the following information must be kept:
   - The total amount of compost distributed in m^3;
   - The dates that distribution began and ended; and
   - The type of agricultural by-product distributed.
2. If finished compost is being exported off-farm in amounts greater than 5 m^3, a signed receipt indicating:
   - The amount distributed in m^3;
   - The date of distribution;
   - The type of agricultural by-product distributed; and
   - The name and business contact information of the receiver.

According to the *Federal Organic Production Systems General Principles and Management Standards* (CAN/CGSB-32.310), certified organic producers must also maintain records and documentation concerning inputs and details of their use, the nature and quantity of products that have left the farm.

7.0 Where should my compost system be situated on my farm?

When siting a compost system, a farm operator must first and foremost consider the legal setback requirements from water sources, septic fields, and property boundaries as set forth in the AEM Code (see Section 7.2 for more information).

Site selection will be based upon: the total volume of feedstock, the composting method and equipment selected, vehicle traffic patterns, space requirements for storing raw materials, curing compost, storing compost, and buffer areas for noise and odour control, predominant wind direction, and access to water.

Usually the most convenient composting site is near the barn or manure storage area. However, convenience must be weighed against environmental concerns and proximity to neighbours. These are further discussed below.

BEFORE YOU BEGIN:

Review the relevant sections of the BC *Environmental Management Act's* AEM Code to make sure you choose a site that meets the regulatory setbacks from drinking water sources, watercourses, and property boundaries.

See Section 10 for more details.

7.1 ESTIMATING FEEDSTOCK VOLUMES AND LAND AREA REQUIRED

Farmers know their farms better than anyone and tend to be the best decision-makers when it comes to estimating manure and crop waste volumes that will be available as inputs into the compost system. As a general rule for windrow composting, 1 m^3 of raw feedstock material will require 0.8 m^2 of active processing area on the ground. Aerated static piles may require less space. For reference, a typical tractor front end loader has a volume of 0.8 - 1.5 m^3. Many case studies of small and medium farm composting systems indicate area dimensions of the protective base for bay system composting activities ranging from 100 – 200 m^2.

Turning requires somewhat more of a land base than forced aeration, due to the tractor's need to maneuver around the site. Forced aeration allows piles to be built higher and in rectangular shapes. Experience has shown that producers tend to underestimate the amount of finished compost that will be produced, and often do not have contingency plan for peak feedstock events. A site design example is provided in Figure 15.

Resources such a feedstock volume and site dimension calculators are included in the Appendix.

Other points to consider include:

- Bulking agents need to be stored, sometimes for several weeks, based on seasonal availability.
- Sufficient space for collection and eventual disposal of foreign non-compostable objects (i.e. rocks, plastics) that are present in the feedstock is required.
- Appropriate coverings as well as leachate controls may be needed for storage areas.
- Equipment maneuverability is also important, and it may be desirable to design the structure so that part of the covered area protects any equipment or inputs.
- Sufficient area for potential future expansion of the composting system.
- Ventilation is an important design consideration, so that the compost structure can provide adequate air flow to minimize condensation, frost build-up and accelerated deterioration of the structure.

Whenever possible, building products should be selected that can withstand the aggressive corrosion caused by condensates of dissolved ammonia and sulphur compounds that develop in most composting operations. For example, concrete blocks will last longer than wood, but may be more expensive (see Section 8 of this guidebook for more details about composting economics).

An Environmental Farm Planning Advisor, as part of the Environmental Farm Plan program, can assist in selecting the best location for the composting system.

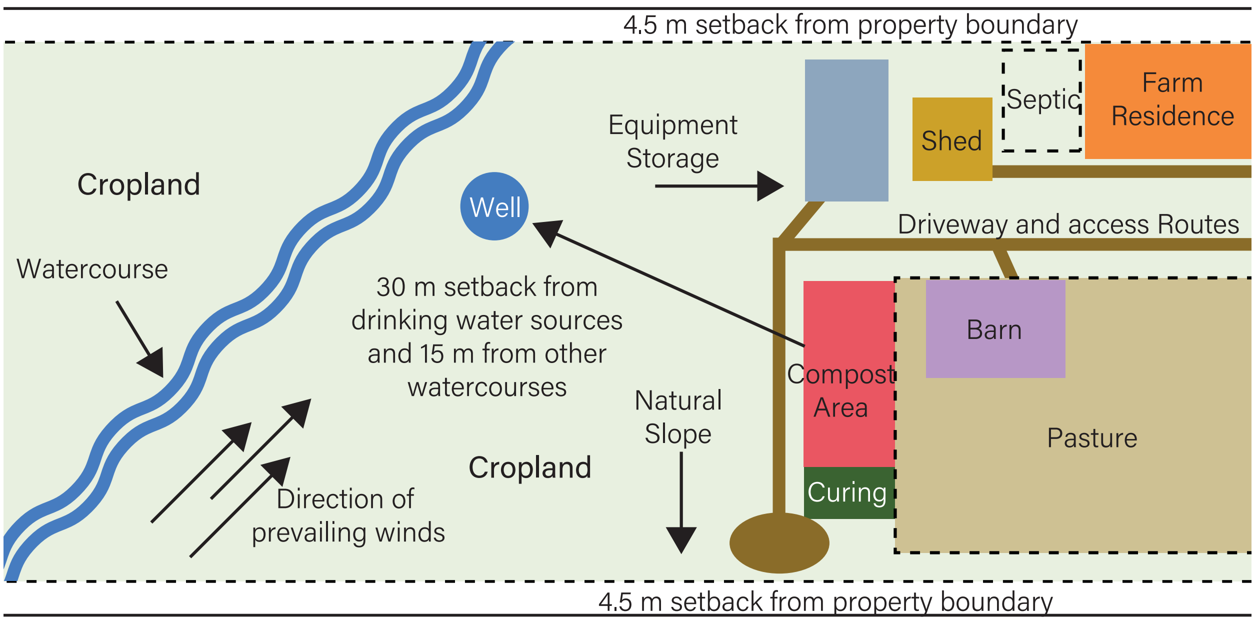


Figure 15. Example of a compost system site plan.

Figure 15 is provided as an example of a small farm operation (could be a 5 to 10 acre lot) with a active compost pad and curing area sited close to the pasture and barn for ease of feedstock movement. Prevailing winds are directing air flow away from the nearest property boundary. The site is within the required AEM Code setbacks from drinking water sources, watercourses, and property boundaries. If leachate control is an issue, the curing area could be moved so leachate does not flow into the cured compost area. Note that this diagram is provided as an example only and is not necessarily to scale.

7.2 ENVIRONMENTAL CONSIDERATIONS

The primary environmental consideration when siting a compost area is the prevention of leachate escapement. Sites must not be located close to wells or other water sources (30 m setback if it is a drinking water source, 15 m setback for watercourses), near tile drains, or on sandy soils.

Outdoor composting (e.g. not under a roof or on a protective base):

- The compost pile must not be located in an area where there is standing water or water-saturated soil, on any low-lying area of a field prone to annual seasonal flooding, during the flood season, or when flooding is imminent.
- If within a vulnerable aquifer recharge area and storing for longer than two weeks, must not be located directly on or over coarse-textured soil (e.g. soil with a saturated hydraulic conductivity of more than 10^{-3} cm/s). This can be ascertained by conducting a percolation test.
- Outdoor agricultural composting piles in high-precipitation areas (e.g. receiving 600 mm or more of precipitation from October 1 to April 30) must be covered from October 1 to April 1.
- Piles and windrows should be located on slightly sloping land (0.5%-2%) with the windrow up and down the slope. This allows for leachate to be managed appropriately. The site must be protected from external run-off with berms or curbs that direct the runoff away from the composting site. Leachate arising from the compost site can be collected in order to be land applied. It should not drain directly into a field, which would be in contravention of the AEM Code (SECTIONS 39-42).
- If a compost pile is managed outdoors (e.g. not within a structure) then it must be monitored at least once a week to ensure compliance with the AEM Code, it must not remain for a period of more than 12 months, and no other pile must be erected in the same location for at least 3 years. Records must be kept of the type and source of materials being composted, the location of the pile, and monitoring results.

Composting occurring within structures:

- Composting structures must be located on protective base, such as a concrete pad, or a layer of soil at least 30 cm thick with a saturated hydraulic conductivity of less than or equal to 10^{-7} cm/s or other material that does not allow leaks or for liquids to soak through.
- Ensure the protective base is maintained to prevent leakage. If in a vulnerable aquifer recharge area, all storages built or modified after February 27, 2019 must be assessed for leaks at least every 6 months. If leaks are found, corrective action must be taken. Document the date and outcome of every assessment and any corrective actions taken.

7.3 NEIGHBOUR CONSIDERATIONS

Odours are usually a primary cause of friction with neighbours. Even well-managed compost systems will result in some odour or ammonia emissions. Sites near sensitive locations such as residential developments, daycares, schools, hospitals, and senior care homes should be avoided. Section 5.1 provides an overview of common compost processing problems and how to solve them.

While the Farm Practices Protection Act (Right to Farm Act) does protect farmers from being charged with nuisance complaints based on normal farm practices, all of the regulations in the AEM Code and other best management practices must be followed in order for the farmer to be protected.

Potential odour nuisance complaints or other conflicts with neighbours, such as noise impacts, may be minimized by using the following practices:

- Locate buildings according to the AEM Code;
- Locate buildings and operations as far as possible from rural residences or residential areas;
- Take advantage of unique topography or microclimate conditions that could affect odour impacts;
- Site buildings and operations so that prevailing winds transport odours away from rural residences or residential areas;
- Keep compost material covered (this is required by the AEM Code in some areas);
- Install and use simple outdoor weather stations with logging capability. These tools are relatively inexpensive (a few hundred dollars) and can support composting management decisions and conflict mitigation;

- If handling material with high odour potential, ensure to pre-stock adequate volumes of bulking agents so material is readily on-hand to mix with odourous materials;
- Try to avoid compost mixing activities on weekends or in evening hours;
- Good housekeeping practices, including frequent clean-up of spilled materials, draining standing water, will reduce the potential for odour problems;
- Log your activities and weather daily. Consult your records in case of complaints to correct future activities; and
- Make sure you follow up diligently on complaints. Neighbors generally like to be taken seriously even though you may be acting within your rights.

8.0 What building materials do I need, and how much will this cost?

Every decision made on the farm involves a cost-benefit assessment. When establishing a compost system, operators will want to know what level of resources (such as time and money) will be required to maintain the process, and how much money it could save them (or earn them) over time.

Farm waste needs to be managed. If composting is not undertaken or managed incorrectly, it may deprive the farm operation of resources (both nutrients and finances), and the process may require more time and money than it gives back in increased crop productivity or reduced spending on amendments.

FARMER QUOTE:

"Compost behaves as a liability during its entire maturation and becomes an asset the instant it hits the field."

8.1 COMPOST SYSTEM BUILDING MATERIALS

This section provides a high-level overview of some of the main cost considerations for compost structure for a 2 or 3 bay pile system design. There are examples of specific calculations and links to online calculators in the Appendix for a more detailed analysis.

8.1.1 Costs Associated with a Concrete Slab Base and Siding

The AEM Code requires that a composting structure must have a protective base. Many farmers address this requirement by designing their system to include concrete slab as a base. The concrete slab both improves insulation and slows down nutrient loss due to leaching. Walls of the compost system can be constructed using cinder blocks or large precast concrete blocks, such as those used for retaining walls (Figure 16). A slight slop of 1-2% can be built into the base so that leachate is collected in a central location.

Depending on the size and scale, rebar may be required. A concrete mixer, forms, and other equipment may also be required during construction (Figure 17). This equipment can be rented or borrowed, and will not need to be purchased outright.

Costs would range from about $1,500 to $6,000 depending on materials used, labour costs and size of the bays. Calculation examples are provided in the Appendix.

Figure 16. Large concrete precast blocks.

Figure 17. Constructing the concrete slab base using forms[39]

8.1.2 Costs Associated with Roofing

As mentioned previously, the AEM Code requires that manure be covered in areas that receive a total precipitation average of over 600 mm between October and April (e.g. Lower Mainland, Vancouver Island, and coastal regions). Tarps are the most simple and inexpensive option, but can be cumbersome when moving material in and out of the system. It can also be difficult to keep a tarp in place when winds are severe.

A permanent roof structure (e.g. metal, hard plastic, or wooden) that is either stationary and high enough for equipment maneuvering or that can be moved out of the way when needed, is preferable. It is important to note that in some municipalities a roofed structure can constitute a new building and a building permit may be required. An alternative option is a temporary roof structure that can be screwed into place.

Corrugated asphalt roofing tiles are a relatively low-cost solution and provide excellent wind and rain protection. It should be noted that, while quite durable, asphalt can become brittle with age, and may not last as long as metal or wood. Sheet metal roofing is perhaps the most long-lasting and stable solution, however it is usually a more expensive option.

8.1.3 Costs Associated with Forced Air Systems

As described in Section 4.5, aeration systems use blowers or vacuums to intermittently or constantly disperse air through the compost pile. Negative aeration may require the addition of a biofilter, but it minimizes odour problems. Reversing systems (enabling both positive and negative aeration) require bidirectional or reversible pumps and are the most effective at dispersing air evenly.

The most common aeration system (whether positive, negative or reversing) is known as a Pipe On Grade (POG) sparger[40]. To install forced aeration in a windrow or bin system using a POG sparger, the required materials include 2.5 - 3.0 m long perforated PVC pipes at a width of 10 cm. In general, there should be one lengthwise pipe for every 0.5 - 1.0 m of pile width and enough length to protrude slightly

TALLYING UP COSTS:

When labour and material costs are both factored in, farmers indicated that the cost of setting up a concrete slab for a 2 or 3 bay compost system costs $1,500 to $6,000.

Metal roofing for a 3-bin system can cost anywhere from $2,000 to $5,000 for materials and labour.

Labour was the biggest cost, and those who were able to secure volunteers saved the most.

[39] Photo is from Manurelink.com
[40] Coker, C., & O'Neill, T., 2017. Aeration Floor Fundamentals. Retrieved from BioCycle.

from the end of the piles. On the blower end, the pipes must be brought together by a manifold and attached securely to the blower. In negative aeration (vacuum) systems, there is an increased expense and complexity due to the need to prevent leachate from passing through the blower. The blower itself needs to be non-corrodible, and the exhaust vent should be covered by a biofilter (e.g. a pile of finished compost material) to capture odour.

For both positive and negative aeration systems, the initial desired airflow through the pile may range from 10 - 13 m^3 of air per hour, for every m^3 of material in the pile. The blower can be operated for a few minutes every hour during the active composting stage, or for a few hours a day total.

For example, a 6.5 horsepower blower is capable of drawing air at over 300 m^3/hour and could provide adequate aeration for a 25 - 30 m^3 sized windrow[41]. This type of unit could be purchased for under $500. By covering a pile or windrow, the allowable ratio of air flow to pile volume can be substantially reduced, because there is minimal air loss due to natural settling and compression. In this case, a smaller blower, in the range of 2 - 3 horsepower, would likely suffice.

Figure 18 provides a schematic of a possible layout for a forced aeration pile or windrow. Additional examples of forced aeration systems and associated costs are provided in the Appendix.

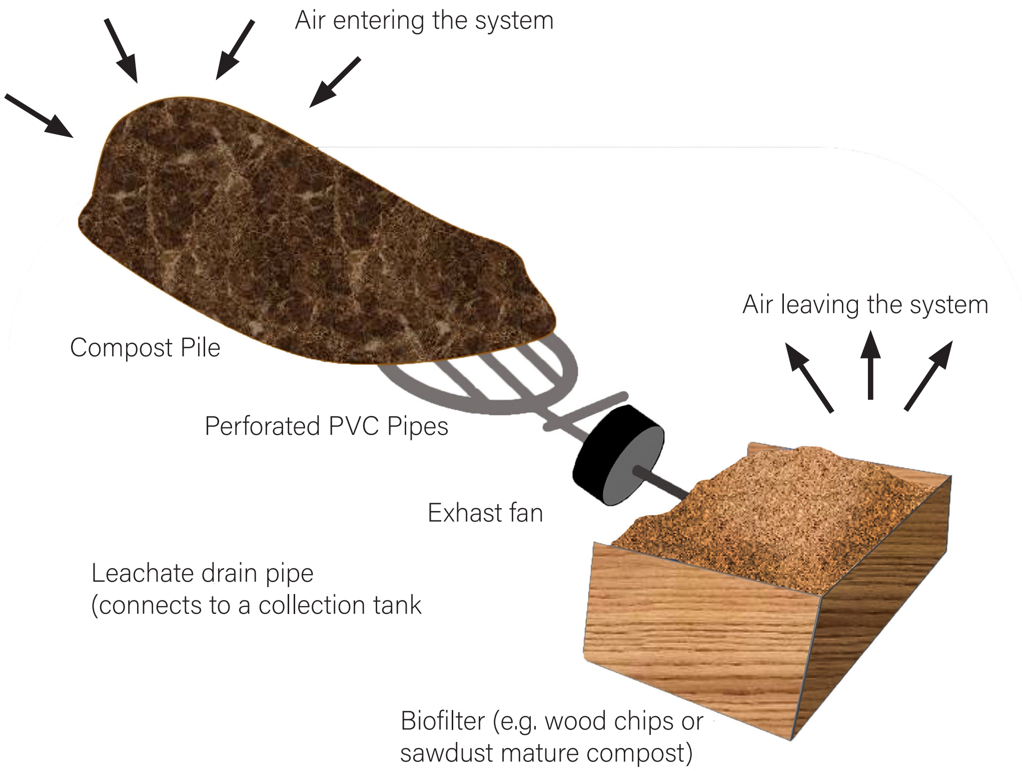


Figure 18. Compost pile or windrow with negative aeration - basic layout.

8.2 COMPOST SYSTEM LABOUR COSTS

Table 9 presents the average amount of time required by farm operators to run their compost system. The data is based on interviews conducted with farmers as well as a literature review. While the labour associated with the collection of feedstocks was considered, it is not included in the table, because it was assumed that the material would need to be managed whether it was going to be composted or not. It is assumed that labour costs are paid at a rate of $15 per hour.

[41] Bryan-Brown, M., & Gage, J., 2010. Lessons Learned in Aerated Static Pile (ASP) Composting.

Table 9. Labour costs for a 3 bay compost system with 200 m^3 of composting material.

Case Study: Farm with 350 hogs using pile compost system under a covered structure

A 350 hog farm on Vancouver Island uses a covered pile compost system to manage its swine manure and straw bedding wastes (Figure 19). The feedstock is added at a ratio of approximately 5 to 1 (manure to bedding on a wet weight basis).

Recently, the farm has invested in an $80,000 compost structure to manage the hog manure: it is 10 m wide by 25 m long (250 m^2 base), with a concrete floor and wooden and metal roof. It is located directly beside the pig pens which allows easy access for the front-end loader to deposit the manure and bedding into the composting structure. Concrete blocks are used as the bottom side walls, the rest of the sides are open.

The concrete floor slopes at about 1% grade to one central point allowing the leachate to flow into a pipe system for collection. A pump is then used to move the liquid leachate up to an outflow, recycling the leachate to the top of the pile to help with moisture content. During hot, dry summers when moisture gets too low, a sprinkler is used 2 days/week to maintain desirable moisture levels.

The organic materials are turned with front end loader several times per week during the active composting stage, which takes 4 months. After another month or so of curing, the compost is ready to be spread onto the fields. Swine carcasses are put into one section of the pile and often can fully compost in about a month due to the high temperatures of the pile.

The compost site can hold approximately 580 m^3 of feedstock. Operating costs are approximately $2,400 a year.

9.0 What rules and regulations do I need to be aware of?

Policies and regulations constantly change, and compost operators should ensure that the information they are using is as up-to-date as possible. The following section provides a brief outline of the main legislation that applies to composting. **Figure 20** provides a flow chart to indicate how a farm operator may navigate through these regulations.

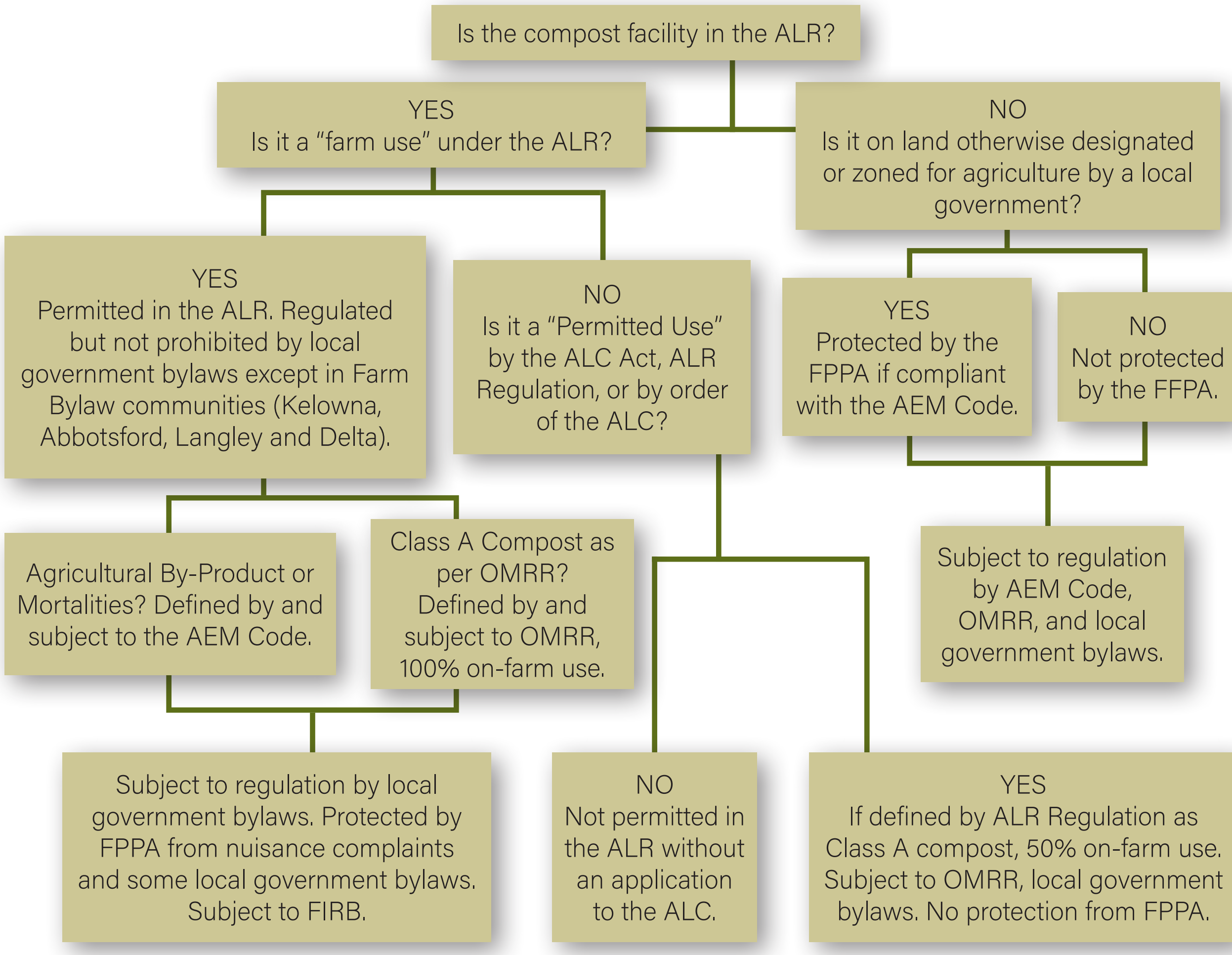


Figure 20. Regulatory decision flow chart for composting[42]

9.1 FEDERAL FERTILIZERS ACT AND REGULATIONS

This Act regulates the requirements for compost for compliance with the safety and labelling standards that must be met in order to legally sell or import compost into Canada. The Act is administered by the Canadian Food Inspection Agency (CFIA).

9.2 FEDERAL FISHERIES ACT

Administered by both Fisheries and Oceans Canada and Environment and Climate Change Canada, this Act is established to manage Canada's fisheries resources, including fish habitat. The Act can also be administered provincially by the Ministry of Forests, Lands, Natural Resources, Operations, and Rural Development (FLNRORD) and BC Ministry of Environment and Climate Change (ENV). The Act applies to all Canadian waters that contain fish, including ditches, channelized streams, creeks, rivers, marshes, lakes, estuaries, coastal waters and marine offshore areas. It also applies to seasonally wetted areas that provide fish habitat such as shorelines, stream

[42] This flowchart was developed by updating a previous version found in: Hulse, M. 2015. Compost regulation in British Columbia: Regulatory overview, best practices, and recommendations for law reform. University of Victoria.

banks, floodplains, intermittent tributaries and privately owned land. Provisions for stiff fines and imprisonment are contained in the Act to ensure compliance.

9.3 FEDERAL HEALTH OF ANIMALS ACT

The Federal Health of Animals Act enables regulatory control over Specified Risk Material (SRM), so that it does not enter the animal feed system. Regulations under this Act (enhanced feed ban) require that producers do not feed any animal products containing SRM to livestock and that abattoirs properly identify SRM to ensure that it is removed from the feed system. A permit from the CFIA is required to handle, transport or dispose of cattle carcasses and certain cattle tissues if they are moved off of the farm of origin. Composting processes do not destroy SRM, therefore composted mortalities must be handled in accordance with CFIA regulations as the compost is still considered to contain SRM.

9.4 PROVINCIAL AGRICULTURAL LAND COMMISSION ACT AND ALR REGULATION

The *Agricultural Land Reserve Regulation* (ALR Regulation) allows the production, storage and application of compost from agricultural wastes produced on the farm for farm purposes if produced on the farm and/or if at least 50% of the compost measured by volume is used on the farm and in compliance with pertinent regulations under the EMA and associated AEM Code. Commercial-scale composting operations, which source a majority of inputs from off-site, are not a permitted used in the ALR and require a Non-Farm Use approval from the ALC. Activities associated with commercial compost, wood residue, and soil conditioning operations require a Non-Farm Use approval from the ALC.

9.5 PROVINCIAL DRINKING WATER PROTECTION ACT

This Act and Regulations have requirements regarding the protection of drinking water quality. SECTION 23(1): subject to subsection (3), a person must not (a) introduce anything or cause or allow anything to be introduced into a domestic water system, a drinking water source, a well recharge zone or an area adjacent to a drinking water source, or (b) do or cause any other thing to be done or to occur if this will result or is likely to result in a drinking water health hazard in relation to a domestic water system.

9.6 PROVINCIAL ENVIRONMENTAL MANAGEMENT ACT

The EMA has three Regulations that address composting on farms. In general, industrial and commercial composting processes fall under the *Organic Matter Recycling Regulation* (OMRR) and the product may be distributed as a compost, whereas on-farm composting of agricultural by-products falls under the *Code of Practice for Agricultural Environmental Management* (AEM Code). The *Spill Reporting Regulation* may also apply under certain circumstances.

9.6.1 The Code of Practice for Agricultural Environmental Management

The AEM Code defines an agricultural composting process distinct from that described in OMRR, where agricultural by-products, wood residue, mortalities, or processing wastes are mixed or layered and managed with either periodic turning or forced aeration. If distributed by an operation, products of an agricultural composting process may not be described as compost or composted (SECTION 43). The AEM Code also sets requirements for setbacks and practices for compost and composting structures, as summarized below:

SECTION 17: composting structures must be 30 m away from drinking water sources and 15 m away from watercourses, whereas outdoor composting piles must be 30 m away from both drinking water sources and watercourses. Both outdoor compost piles and permanent compost storage structures must be 4.5 m away from property boundaries.

SECTION 40: agricultural composting processes must ensure that:

- all leachate is collected and contained, as well as contaminated runoff and solids;
- runoff is diverted away from compost piles;
- if leachate, contaminated runoff and solids do escape, that they do not enter a watercourse, cross a property boundary or enter groundwater; and that
- air contaminants do not cross a property boundary

SECTION 41: a person who carries out a composting process in a structure must ensure that the structure has a protective base and that the protective base is maintained so it does not leak.

SECTION 42: requirements for outdoor composting piles:

- The pile is not located in an area with standing water, saturated soil and/or that is susceptible to seasonal flooding
- The pile is monitored and that composting records, such as material source, temperature, and location are kept
- The pile is not left for more than 12 months
- No additional pile is erected in the same location for 3 years

SECTION 43: of the Code requires those who distribute the product of agricultural composting to:

- If distributing 5 m^3 or less of a product of agricultural composting, keep records of the volume distributed, the date of distribution and type of by-product distributed
- If distributing 5 m^3 or more of a product of agricultural composting, ensure each distribution has a receipt that is signed by the receiver which shows the volume and type of material distributed, the date of distribution, and the name and business contact information of the receiver

If using a storage structure that has been modified or built on or after February 28, 2019 in a vulnerable aquifer recharge area, SECTION 22 and 23 requires the protective base of permanent composting structures be assessed every 6 months for leakage, taking any corrective action necessary to stop the leak. Records must be kept of the assessment and any corrective actions taken. SECTION 25 also requires that outdoor composting piles must not be situated on coarse-textured soil if stored longer than 2 weeks.

If in a high-precipitation area (minimum of 600 mm precipitation from October 1 to April 30), SECTION 25 requires outdoor composting piles be covered from October 1 to April 1.

SECTION 67:

- (1): A person may dispose of mortalities that died on their land through burial, incineration or composting
- (2): A person may only dispose of mortalities that died on the person's agricultural land base
- (3): A person may dispose of processing waste only if it comes from livestock or poultry that were reared, kept or slaughtered on the person's agricultural land base
- (4): A person must not dispose more than 5 tonnes of livestock processing waste or 1.5 tonnes or more of poultry, determined on a live weight basis

SECTION 68: people who dispose of mortalities on their land base must ensure:

- Mortalities are not to enter a watercourse, but if this occurs, the owner must immediately remove said mortality
- Processing waste does not enter a watercourse
- Odours, particulate matter and vector attraction is minimized

SECTION 69: Mortalities must be stored in a manner that prevents putrefaction and the escape of leachate, whereas processing waste must be stored in a completely enclosed structure on the agricultural land base from which processing waste and leachate cannot escape

SECTION 70: Mortalities may be transported in containers in which the mortalities and leachate cannot escape

SECTION 71: A person who disposes of mortalities through composting must ensure

- Composting occurs in a permanent structure or outdoor agricultural composting pile
- Leachate & solids do not enter a watercourse, cross property boundary or enter groundwater
- Air contaminants do not cross a property boundary
- Vectors, wildlife and domestic pets are deterred from the composting pile
- Mortalities and processing waste are completely decomposed before application to land
- Composted livestock mortalities are only applied to land on which the composting occurred
- A person must not dispose of more than 5 tonnes of mortalities in any 30-day period

SECTION 72: Outdoor composting piles must not be located in areas prone to seasonal flooding and that have standing water or saturated soils. The pile cannot be left for more than 15 months and another pile must not be erected in the same spot for 3 years

SECTION 73(4): Compost containing specified risk material cannot be applied to land used to grow crops for human consumption or to graze domestic ruminants

9.6.2 The Organic Matter Recycling Regulation

This Regulation (also under the *Public Health Act*) deals with the production of compost and subsequent land application of recyclable organic matter derived from many non-agricultural (municipal) sources (i.e., sewage biosolids, yard waste and food waste). It is intended to encourage composting and beneficial use of selected organic matter. The regulation contains quality criteria for metals, pathogens and vector attraction reduction. It also covers aspects of land application plans for managed organic matter. It does not typically apply to agricultural waste composting operations that operate in accordance with the AEM Code. Schedule 12 of the *Regulation*, lists suitable organic material for composting under provisions of the *Regulation* and provides some definition of the source and constituents of those organic materials.

The OMRR has requirements related to composting that affect operation, product quality and land application. For instance, the OMRR requires permits for composting facilities that process food waste or biosolids and have a design production capacity of 5,000 or greater tonnes (dry weight) of finished compost per year.

SECTION 12 of the OMRR specifies the requirements for Class A and Class B compost. Compost that is produced solely from yard waste or untreated and unprocessed wood residuals must meet pathogen reduction process and vector attraction reduction requirements and quality criteria (trace elements). Compost that contains any of the other permitted organic materials (Schedule 12) must additionally meet pathogen reduction limits and must meet sampling and record keeping requirements as outlined in Schedules 5 and 6 of the OMRR. If the compost meets these requirements, it is considered Class A compost and it can be distributed freely without volume restriction. To be designated as Class A compost, fecal coliforms must be measured at less than 1000 MPN per gram of total solids (dry weight basis). If compost is made from yard waste alone, determination of fecal coliform levels is not required. Class A compost must also meet the quality criteria as outlined in Schedule 4, column 1.

9.6.3 The Spill Reporting Regulation

The Spill Reporting Regulation requires spills of a polluting substance (including mortalities) be reported immediately to Provincial Emergency Program at 1-800-663-3456 (24 hour service). Report spills of mortalities greater than 200 kg or 200 litres. Or report any amount, if the mortality spill contains organisms that are or that are reasonably believed to be infectious.

9.7 PROVINCIAL FARM PRACTICES PROTECTION ACT (RIGHT TO FARM ACT)

Administered by AGRI, this Act provides that farmers on agricultural land are not liable to legal actions resulting from nuisance complaints regarding farming activities when they meet certain conditions. The Act defines a normal farm practice as an activity "that is conducted by a farm business in a manner consistent with proper and accepted customs and standards as established and followed by similar farm businesses under similar circumstances."

SECTION 2: protects a farmer from liability in lawsuits alleging nuisance for odour, noise, dust or other disturbance resulting from a farm operation if:

- The farmer uses normal farm practices;
- The operation is conducted in the ALR, land zoned for farm use, or, in the case of fish farming, has a valid license under the provincial *Fisheries Act;*
- There is no contravention of other listed legislation, such as the *Environmental Management Act,* the AEM Code and land use regulations (e.g. a zoning bylaw).

In addition, the Act establishes a Farm Industry Review Board (FIRB) to receive complaints regarding odour, noise, dust or other disturbances resulting from farm operations. FIRB will hear complaints and determine whether the complaint issue results from a normal farm practice.

9.8 PROVINCIAL PUBLIC HEALTH ACT

The *Public Health Act* prohibits activities that may cause a health hazard. Administered by the Ministry of Health, this Act has a specific prohibition that "a person must not willingly cause a health hazard, or act in a manner that the person knows, or ought to know, will cause a health hazard". This prohibition would apply to farm practices that may result in a health hazard, such as when nutrients, contaminants or pathogens are discharged to land, water or air to pose a public health problem. Any situation that entails a health hazard will enable health officers to investigate using their powers under the Act. Under the *Public Health Act,* the local Health Authority must investigate any health hazard and has authority to order that a person prevent or stop a health hazard, or mitigate the harm or prevent further harm from a health hazard amongst other powers. Similar regulatory provisions exist for addressing health hazards to drinking water supplies under the *Drinking Water Protection Act.*

The Act also has conditions under the *Health Hazards Regulation,* SECTION 8(1): separation distance from wells to be at least 30 m from any probable source of contamination (probable source of contamination could include compost materials and leachate.

Appendices

APPENDIX I: LIST OF HELPFUL ONLINE CALCULATORS

1. Cornell Composting Calculator (Excel):
   http://compost.css.cornell.edu/download.html
2. Government of Alberta calculator for N input, C input, and desired moisture content:
   http://www.agric.gov.ab.ca/app19/calc/manure/manure.jsp
3. Klickitat County, Washington for total C:N ratio for up to four feedstock inputs
   https://www.klickitatcounty.org/1030/Compost-Mix-Calculator
4. University of Washington: Compost mixture calculator
   https://puyallup.wsu.edu/soils/compost-mix-calculator/
5. New Hampshire Department of Agriculture:
   https://nerc.org/documents/manure_management/manure_generation_calculator.xls
6. Storage and Volume needs: Manurelink BC:
   http://www.manurelink.com/manure-composting/how-to-compost/step-4-calculate-volume/

APPENDIX II: EXAMPLES OF OPTIMAL CARBON: NITROGEN RATIOS IN FEEDSTOCKS

Here are some examples of the typical manure, crop waste, and bedding amounts that will result in a C:N ratio of 30:1. These numbers were determined using the calculators listed in Appendix 1.

Broiler Litter:

- One broiler bird (2 kg) produces around 1.1 kg of litter over its lifetime[43]. If a farm had 300 broiler birds that would mean 340 kg of broiler litter to manage and 180 kg of woodchips would have to be added.

Layer litter:

- For 45 kg of laying hen litter waste, 90 kg of straw are needed.

Swine manure:

- A 90 kg swine produces around 6 kg of litter per day. Over a whole year, 2,150 kg of swine manure are produced, and 360 kg of sawdust is needed.

Sheep manure:

- A 45 kg lamb produces 2 kg of manure a day. Over a whole year 675 kg of manure would be produced requiring 275 kg of straw.

Horse manure:

- One (450 kg) horse produces approximately 8,200 kg of manure per year, approximately 1,360 kg of straw is needed per year or 115 kg of sawdust per year.

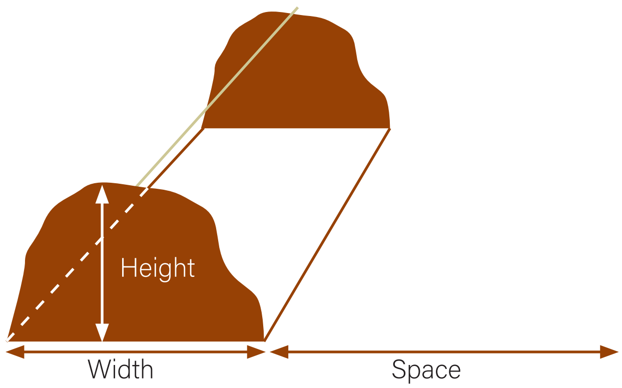
Crop wastes:

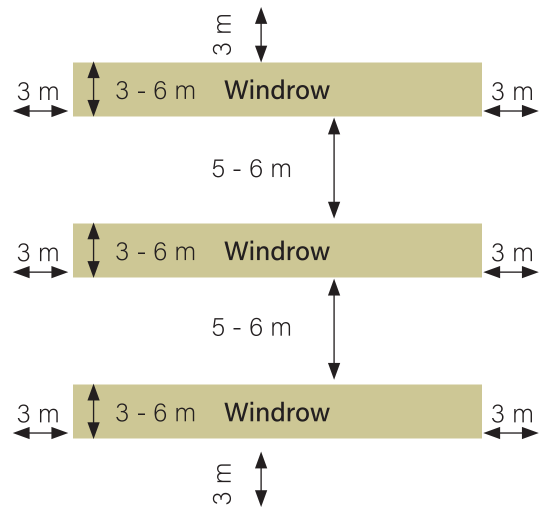
- For 1 m^3 of vegetable wastes, 7 m^3 of straw is needed to obtain the optimal C:N ratio.
- 1 m^3 of vegetable wastes + 0.5 m^3 laying hen manure + 12 m^3 of softwood chips.
- 90 kg of vegetable wastes + 45 kg of fruit wastes + 275 kg of horse manure + 15 kg of dry leaves

[43] Ritz, C.W. and W.C. Merka. 2013. Maximizing Poultry Manure Use Through Nutrient Management Planning. University of Georgia Extension. Bulletin 1245.

APPENDIX III: CALCULATING THE AREA REQUIRED FOR YOUR COMPOST SYSTEM

WINDROW COMPOSTING





The calculations below roughly estimate composting pad area requirements based on daily volumes (in cubic meter, m^3) or weight (in kg) of the compost mix (for example manure mixed with wood shavings). The calculations allow for the separate estimation of the area needed for active composting and the area needed for curing. The combined area of active composting and curing is the total composting area.

In addition to the total composting area, you will also need to account for space at both ends of the windrows for vehicle access and, if applicable, space for mixing, screening, storage of bulking agents and non-compostable waste (stored for a limited time until disposal).

The **width** of windrows is generally determined by machinery used for turning, loading and unloading. It should, however, generally not exceed 6 m. The **height** of windrows is also determined by machinery but should not exceed 3 m (active composting) or 4 m (curing) to avoid anaerobic conditions. If forced aeration is used, the height of the active composting pile can be increased to up to 4 m.

It is not unusual to observe that composting sites run short of space only a few years after the beginning of the operation. This often results in oversized piles and operational challenges which can then cause emissions (e.g. leachate) and result in a poorer quality of the end product. Therefore, it is generally recommended to plan the composting site in a location that allows for expansion, or to design the site with at least 20% more space than area calculations suggest.

Equation (1): Windrow area without space for vehicle access between the windrows:

$$P \times n / (H \times CF) = \text{area } (m^2)$$

Equation (2): Windrow area including space for vehicle access between windrows:

$$P \times n \times (W + S)/(H \times W \times CF) = \text{area } (m^2)$$

where,

P = total daily weight (in kg) OR total volume (in m^3) of compost mix.

n = Number of active composting or curing days. The minimum for active composting should be 30 days (n=30); the minimum for curing should be 60 days (n = 60).

H = Pile height. Maximum 3 m unless forced aeration.

W = Pile width – account for operational restraints such as equipment, vehicle access, compost methods and material flow. Generally, not larger than 6 m.

S = Space between windrows for vehicle access. Minimum 5 m.

CF = Correction factor (rounded) – see table next page.

	Correction Factor (CF)	Formula
DAILY **WEIGHT** OF COMPOSTING MIX IS KNOWN (KG)		
Active Composting	**CF = 500**	CF = bd x sc/sf
Curing	**CF = 700**	CF = bd x sc/(sf x sfc)
DAILY **VOLUME** OF COMPOST MIX IS KNOWN (M^3)		
Active Composting	**CF = 0.8**	CF = sc/sf
Curing	**CF = 1**	CF = sc / (sf x sfc)

where,

bd = Bulk density of the compost mix. Assumption 700 kg/m^3.

sc = Windrow shape correction. Assumption: 0.66.

sf = Average shrink factor for active composting. Assumption: 0.8 for 30 days of composting.

sfc = Average shrink factor for curing. Assumption: 0.8 for 60 days of curing.

OTHER COMPOSTING SYSTEMS

For (active) composting systems using bays, equation (1) can also be used to obtain an estimate of the area requirements. The Correction Factor (CF) in this case is 800 if weight (in kg) of the composting mix that is produced daily is known. Alternatively, a CF of 1.2 can be used if the volume (in m^3) of the composting mix that is produced daily is known. The results can then be further divided by the number of bays (typically 2 or 3) to obtain the area per bay. Pile width should not exceed 3 m unless forced aeration is used, in which case 4 m is acceptable.

Additional resources for sizing a compost area:

Selecting, Siting, Sizing and Constructing Compost Pads. Cornell Waste Management Institute
http://www.manuremanagement.cornell.edu/Pages/General_Docs/Fact_Sheets/compostfs6.pdf

Turned windrow composting: Sizing your compost pad. Vermont Agency of Natural Resources, Department of Environmental Conservation
https://dec.vermont.gov/sites/dec/files/wmp/SolidWaste/Documents/ANR%20Sizing%20Your%20Composting%20Pad.pdf

Composting aeration floor functions and designs. Biocycle.net
https://www.biocycle.net/2017/07/05/composting-aeration-floor-functions-designs/

APPENDIX IV: LIST OF COMPOST EQUIPMENT SPECIALISTS

This is a non-exhaustive list of agricultural and industrial suppliers who service compost systems and sell equipment for monitoring compost (e.g. long thermometers, moisture metres).

Transform Compost Systems, Abbotsford BC
604-856-2722
transform@telus.net
http://www.transformcompostsystems.com/design-aerated-windrow-system.php

Wika Instruments Ltd, Chilliwack, BC
780-463-7035
info@wika.ca
https://www.wika.ca

Huber Farm Equipment, Prince George, BC
250-560-5411
http://www.huberfarmequipment.com

Meinen Brothers Agri Services, Agassiz, BC
604-819-5557
https://www.mbagri.ca

Omega Spectris thermometers, St Eustache, QC
1-888-826-6342
https://www.omega.ca/en/sensors-and-sensing-equipment/temperature/thermometers/p/A12P

ReoTemp Instruments: thermometers and moisture meters, San Diego, CA
1-800-648-7737
https://reotemp.com/compost/heavy-duty-compost-thermometer/
https://reotemp.com/compost/moisture-meters/long-stem-compost-moisture-meter/

APPENDIX V: LABORATORIES, SAMPLING, AND INTERPRETATION OF RESULTS

Taking Samples:

Test methods for the examination of composting and compost (TMECC). US Department of Agriculture and the Composting Council Research and Education Foundation. Adopted in 1995, revised 2001. https://www.compostingcouncil.org/page/tmecc

Best practices on taking compost samples: A&L Laboratories. Compost handbook. Appendix D, pages 1 -5. https://www.alcanada.com/pdf/Compost_Handbook.pdf

List of Laboratories:

List of nutrient testing laboratories in BC, 2010. Revised in 2015. Order reference No. 631-500-8. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/soil-nutrients/600-series/631500-8_nutrient_testing_labs_factsheetno1_may2015.pdf

AGAT Laboratories 120 - 8600 Glenlyon Parkway, Burnaby, BC V5J 0B6 Phone: (778) 452-4000
www.agatlabs.com

Exova #104, 19575 - 55A Avenue, Surrey, BC V3S 8P8
Phone: (604) 514-3322
Toll free: (800) 889-1433
www.exova.com

Maxxam Analytics (formerly Cantest Ltd.) 4606 Canada Way, Burnaby BC V5G 1K5
604-734-7276
info@maxxamanalytics.com
www.maxxam.ca

MB Laboratories Ltd.
By Courier: 4 - 2062 West Henry Ave, Sidney BC V8L 5Y1
By Mail: PO Box 2103, Sidney BC V8L 3S6
250-656-1334
mblabs@pacificcoast.net
www.mblabs.com

Pacific Soil Analysis Inc. 5 – 11720 Voyageur Way, Richmond BC V6X 3G9
604-273-8226
cedora19@telus.net

Plant Science Lab (affiliated with TerraLink Horticulture Inc.) 464 Riverside Road, Abbotsford, BC V2S 7M1
(604) 864-9044 x1602
pwarren@terralink-horticulture.com

Interpretation of Laboratory Results:

Interpreting compost analyses.
2018. Sullivan, D.M., Bary, A. I., Miller, R.O., and L. J. Brewer. Oregon State University Extension Service.
https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9217.pdf

Understanding a compost test report. Nova Scotia Department of Agriculture, 2010.
https://novascotia.ca/agri/documents/lab-services/analytical-lab-manure-compost-report.pdf

Understanding different soil test methods.
Canada – British Columbia Growing Forward program. Nutrient Management Factsheet – No. 3 in Series. 2010. Order reference No. 631.500-9.
https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/soil-nutrients/600-series/631500-9_soil_test_methods_factsheet_no3_sep2010.pdf

APPENDIX VI: CALCULATING COMPOST SYSTEM COSTS

The prices included in these two examples assume new or rented materials (no secondhand) and are current to 2019 Canadian pricing. Actual prices may vary depending on the size of the compost system, materials chosen, and specific design features.

Example 1

A 3-pile system in bays, turned on a 100 m^2 footprint with concrete block walls, a concrete slab and a metal roof

Construction materials:

Concrete slab:

- Concrete mix: 575 x 25 kg bags at $6 per bag = $3,450
- Concrete molds and mixing equipment (rented): $400

Walls:

- Concrete blocks: 2 high x 3 deep x 7 sides = 42 blocks total @ $40 each = $1,680

Roof:

- Lumber and hardware for frame: $250
- Corrugated Galvanized steel roofing panel: sheet sizes 3.6 m x 1 m would require 34 sheets to cover a roof area of 120 m^2 (in order to slightly overhang the concrete base) at $30 per sheet = $1,020
- Roofing screws: $50

Total costs before labour = $6,880

Labour requirements:

- Several full days of high-intensity labour, demanding both physical strength and skill.
- The concrete slab will require the assistance of several people for setting up the forms, and rebar if necessary, and then pouring the concrete.
- The roof construction will also require some basic framing knowledge.
- In general, the construction work for this project is intermediate-to-high in physical demand and technical knowledge.
- It is estimated that it would take 5-7 days with an effort level of 2 people.

Example 2

A forced aeration windrow system (140 m^2 footprint).

Construction materials:

Concrete Slab (note –a protective base other than concrete could be used as an alternative):

- Concrete mix: 1 m^3 x 14 @ $110 = $1,540
- Concrete delivery: $250
- Rebar: 3 m x 131 @ $10 = $3,930
- Formwork: $400

Aeration System:

PVC piping: 17 pipes (3 m x 0.10 m) at $20 each = $340

PVC caps and manifold parts: $40

- PVC cement/solvent: $10
- Airfoil Centrifugal Fan: $400

Total costs before labour = $6,910

Labour requirements:

- Several days work to clear slab site and achieve desired 1-2% slope, build formwork and arrange rebar.
- One day for delivery of concrete, spreading and smoothing, which is best done with several people.
- One day for assembly of piping system and installing the fan (blower) unit properly and ensuring that it is successfully sealed to the PVC manifold will be essential to the success of the aeration system.
- All together, this project involves at least a week of preparation and construction for a crew of at least two people.