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# Common Procedures Manual 11.2 Composting

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IMPORTANT NOTICE: This all species section should not be used as a stand-alone document. For TSE diseases, it is necessary to refer to Disease Procedures.

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## Document Approval

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## Document Control

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# Composting

## 1 About this Document

### 1.1 Purpose

This document is intended to provide information and guidelines for CFIA staff in the use of composting as a method of disposal of animals, animal products and animal by-products that are ordered to be disposed.

### 1.2 Introduction

Composting is a natural biological decomposition process that takes place in the presence of carbon, nitrogen and oxygen, and generates heat. The temperatures achieved in the compost piles during the composting process may be high enough to inactivate certain viruses and bacteria responsible for specific diseases in animals.

Composting is a two-stage process. In the primary phase, the temperature of the compost pile increases, organic materials break down into relatively small compounds, soft tissue decomposes, and bones partially soften. In the secondary phase, the remaining materials, mainly bones, break down fully to a dark brown or black humus, containing primarily non-pathogenic bacteria and plant nutrients.

Composting is used by many farmers for daily mortality disposal, and can also assist as an acceptable disposal method for the management of catastrophic mortality losses in poultry and livestock. The principles for composting catastrophic mortality losses are similar for normal daily mortalities, except that the volume of carcasses for composting in emergency situations may be too large for permanent structures (e.g. composting bins or cells) to contain the carcasses. Accordingly, selecting an appropriate composting site becomes an important issue.

Successful conversion of whole materials into good-quality compost requires daily, and then weekly, control of odour, temperature, and moisture during the primary and secondary phases of composting. Stringent management and control prevents the need for major corrective actions.

Biological heat treatment (BHT) describes the process of treatment that occurs during the primary phase of composting when the temperature rises rapidly, heating materials in the compost pile to such a level that organisms contained in the pile are affected. This process is essential for managing pathogens during composting, as containment and eradication of such pathogens is a primary goal of disease control. The product is non-stable compost that may be free of infective agents, if sufficient temperature has been achieved over time. Further testing may be required to ensure that the pathogen has been inactivated. The partially-composted material requires further composting to achieve a usable end product.

Composting may not be a suitable disposal method for all mass mortality events that result from specific disease agents or contamination. However, the process is suitable for the disposal of animal carcasses resulting from pre-emptive slaughter or welfare situations. Risk assessment is to be utilized for the assessment and development of species specific protocols. Composting may also be suitable as an intermediate method for carcass management until a final disposal option (e.g. biomass reduction) can be finalized.

# 2 Applicability and Scope

This document is intended for CFIA staff members who are responsible for emergency management and response activities during foreign animal disease (FAD) outbreaks and other carcass disposal events.

This document is part of an integrated emergency planning approach used in the CFIA. Therefore, to ensure consistency, it should be used in conjunction with other manuals, plans, and procedural documents.

## 2.1 Legislation

CFIA responsibility for the disposal and treatment of animals and related materials resulting from mandated disease control or toxic substances falls under section 48 of the Health of Animals Act and Regulations.

In addition, each province may have legislation regarding the disposal of animals, animal products and by-products. CFIA staff responsible for disposal is to coordinate with provincial authorities in establishing a disposal plan.

## 2.2 Species

This document is intended for use as a guide with composting terrestrial and aquatic animals, as well as specific animal products, by-products, and related materials (e.g. litter, manure, and feed) together or separately.

## 2.3 Diseases

Although composting has been shown to be effective in reducing many heat inactivated pathogens in animal materials, it may not be applicable as a treatment for every disease situation (e.g. spore-forming organisms such as anthrax or prions). Use of composting as a disposal method should be assessed on a disease-by-disease basis and with the assistance of risk assessment.

Composting may be of use for the C&D of litter and bedding for some diseases, as directed by CFIA Veterinary staff or appropriate disposal technical specialist or strike team.

The BHT stage of composting has been utilized by the CFIA as an effective treatment of materials contaminated with Avian Influenza virus.

For all transmissible spongiform encephalopathies (TSEs) such as bovine spongiform encephalopathy (BSE), scrapie, and chronic wasting disease (CWD), composting alone cannot be considered an adequate method of carcass disposal, but may be used a control and reduction strategy is some cases. In these situations, refer to Disease Control Procedures for information or contact the CFIA's Risk Assessment for guidance

### 2.4 Chemicals

Composting may not be effective for inactivation or mitigation of risks where chemical contamination of animals, products and by-products has occurred. Also, many drugs used for euthanasia are known to remain active through the composting process, and collaboration between various technical specialists is warranted for environmental protection. Risk assessment is to be consulted for assistance.

**Note: For animals euthanized with pentobarbital, it is not recommended to use composting as a disposal method due to the risk of secondary poisoning of scavenging animals.**

### 2.5 Biosecurity and Biocontainment Protocols

The disposal technical specialist is to work collaboratively with the Biocontainment technical specialist for the development of disease response protocols.

## 3 The Composting Process

### 3.1 Definitions

Bin composting: A composting technique in which mixtures of materials are composted in simple structures (bins) rather than freestanding piles.

Biological heat: Inactivation of specific pathogens present in the compost

treatment (BHT): Pile by the heat produced during the composting process. For disease control purposes, bio-heat treatment of carcasses is to occur during the first phase of composting.

Biofilter layer: A top cover layer of carbon source and/or bulking agent materials that maintains proper conditions of moisture, pH, nutrients, and temperature to enhance the microbial activities and that deodorizes the gases released from the piles at ground level.

Bulking agent: A nutrient material for composting that has larger particle sizes than carbon sources and maintains adequate air spaces within the compost pile, e.g. bark chips.

Carbon sources: Various materials may be used as a carbon source provided that they have large C:N ratio, such as sawdust, straw, corn stover, poultry litter, ground corn cobs, baled corn stalks, wheat straw, semi-dried screened manure, hay, shavings, paper, silage, leaves, peat, yard wastes, vermiculite, and a variety of waste materials (e.g. matured compost). The CFIA recommends soft wood shavings.

C: N ratio: The ration of carbon (C) to nitrogen (N).

Comminute: To reduce in size.

Phase I composting: (Primary phase). The period of initial composting following creation of the pile, a length of time of high temperatures followed by a decrease in temperature and turning of the pile.

Phase II composting: (Secondary phase). The period of composting following the primary phase and after the turning of the pile that is accompanied by a secondary increase in temperature. The pile may be moved at this time. The majority of material decomposition occurs during this phase, which may last for months.

## 3.2 Two-Phase Composting

All composting methods require two phases of processing (see Figure 1).

### 3.2.1 Primary Phase

The objective of the primary phase is to provide a suitable environment for the growth of microorganisms, and the generation of heat. In addition the organic materials break down into relatively small compounds, soft tissue decomposes, and bones partially soften. The generation of heat can be utilized to destroy the pathogen responsible for disease in the infected animals through BHT and decrease the biomass in the pile. During this phase, the C:N ratio of the mixture should be > 50:1 to help reduce odours. Internal temperatures are initially non-homogenous during this primary phase (35–70°C) and then become more uniform 4 to 21 days after the building of pile(s).

At the beginning of this phase, a base of new carbon material is laid out, the carcasses and carbon source(s) are mixed or layered into a pile or windrow. Gases and liquids produced from decomposing carcasses diffuse outward toward the surrounding biofilter. This surrounding of new material supports a diverse population of micro-organisms, which form a mechanical and biological filter to contain unwanted gasses and liquids.

### 3.2.2 Secondary Phase

Piles may need to be turned several times throughout the secondary phase. Turning breaks up material that has clumped, increases porosity, redistributes moisture and re-introduces oxygen, which activates microbial activity allowing for the further breakdown of materials. Windrows should not be turned until there has been significant or complete breakdown of soft tissues. If soft tissue remains is necessary to cover the pile for maintenance of scavengers and odour management. The cycle for turning may be weekly or as required by a drop in temperature. Turning can be completed with a loader system by rolling a windrow, or by using specialized compost turners.

After turning, the volume and weight of the piles may be reduced by 50-75%. Turning of the pile will mix and reconstitute the entire compost pile for the secondary phase. In the secondary phase, if required add moisture to the materials to reheat the composting materials until an acceptable product is achieved. The end of the secondary phase is marked by an internal temperature of 25–

30°C, a reduction in bulk density by approximately 25%, a finished product colour of dark brown to black, and the lack of an unpleasant odour upon turning the pile.

This phase is considered finished when pile temperatures no longer increase after turning (minimum of 30 days). After completing the two phases, the finished product may contain small bone fragments. These fragments are usually quite brittle and pose no health risks or danger to equipment when applied to land. Typically, the entire process takes two to eighteen months to complete, depending on the size of the biomass particles at the start of the composting process, the composting method and how the conditions are maintained.

After the secondary phase of composting is complete, the product can be stored, recycled, or if appropriate added to the land as a soil amendment, according to provincial regulations.

> The CFIA is primarily responsible for the destruction of the pathogen, and thus the BHT of the compost pile as a treatment. BHT usually occurs during the primary phase of composting. In the case of Avian Influenza, the CFIA is responsible for the treatment of materials potentially contaminated with Avian Influenza viruses, and not the secondary-phase composting activities, such as the turning and moving of the pile, temperature probing, and monitoring. Exceptionally, if BHT for a specific pathogen does not occur during the primary phase and must be continued in the secondary phase, the CFIA may extend its responsibility to secondary phase composting.

### 3.2.3 Composting methods

#### Static Windrow

Windrow composting consists of placing the mixture of raw materials in long narrow piles called windrows that may be turned on a regular basis. The turning operation mixes the composting materials and enhances passive aeration. Typically, the wind-rows are from 90 cm high for dense materials such as manures to 360 cm high for light, voluminous materials such as leaves. They vary in width from 300 to 600 cm. The equipment used for turning determines the size, shape and spacing of the wind-rows. Bucket loaders with a long reach can build high windrows. Turning machines produce low, wide windrows.

Windrows aerate primarily by natural or passive air movement (convection and gaseous diffusion) from the base up through the material and out the top like a chimney. The rate of air exchange depends on the porosity of the windrow. Therefore, the size of a windrow that can be aerated effectively is determined by its porosity. A windrow of leaves can be much larger than a wet windrow containing manure. Where the windrow is too large, anaerobic zones occur near its centre. These release odours when the windrow is turned. On the other hand, small windrows lose heat quickly and may not achieve temperatures high enough to evaporate moisture and kill pathogens and weed seeds.

CFIA Method for Notifiable Avian Influenza (NAI) – the use of a static window provides an effective method with limited equipment and resources for the treatment of carcasses and litter by the heat generated in the BHT phase of primary composting. It is necessary to assess the premises, materials to be composted and the carbon amendments and to ensure a through mix that will generate adequate temperatures during monitoring for virus inactivation.

## Aerated windrow

Windrows can be passively or actively aerated. A passively aerated window will have a perforated pipe open at both ends through the base material for the added movement of air into the pile. This system may be used to build large secondary piles that may be required due to a limited sized base.

The actively aerated static windrow method involves the addition of a system for aeration and a blower to supply air to the composting materials. The blower provides direct control of the process and allows larger piles. No turning or agitation of the materials occurs once the pile is formed. When the pile has been formed properly and where the air supply is sufficient and the distribution uniform, the active composting period is completed in about three to five weeks.

With the aerated static pile technique, the raw material mixture is piled over a base of wood chips, chopped straw or other very porous material. The porous base material contains a perforated aeration pipe. The pipe is connected to a blower, which either pulls or pushes air through the pile. The pushing of air is recommended due to the corrosive nature of exhaust from the composting process.

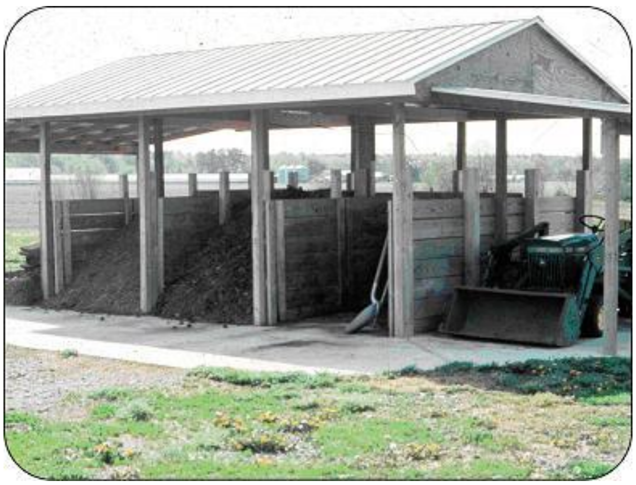
The initial height of the piles should be about 150-245 cm high, depending on: material porosity, weather conditions, and the reach of the equipment used to build the pile. Extra height is advantageous in the wintertime as it helps retain heat. It may be necessary to top off the pile with 15 cm of finished compost or bulking agent. The layer of finished compost protects the surface of the pile from drying, insulates it from heat loss, discourages flies, and filters ammonia and potential odours generated within the pile.

As the pile does not receive additional turnings, the selection and initial mixing of raw materials are critical to avoiding poor air distribution and uneven composting. The pile also needs a good structure in order to maintain porosity throughout the entire composting period. This generally requires a stiff bulking agent such as straw or wood chips. Wood chips are often used for composting sewage sludge by this method. Because of their large size, wood chips pass through the process only partially composted. They are usually screened from the finished compost and reused as bulking agents for another two or three cycle. As straw decomposes during the composting period, a pile with straw as an amendment can lose structure gradually. This is compensated partially by the drying that takes place as composting proceeds. Other possible bulking agents and amendments for static pile composting include: recycled compost, peat moss, corn cobs, crop residues, bark, leaves, shellfish shells, waste paper, and shredded tyres. Uncomposted material such as shredded tires and mollusc shells must be screened from the compost and reused. To obtain good air distribution, manure or sludge must be blended thoroughly with the bulking agent before the pile is established.

## Bin system

Bin composting is perhaps the simplest in-vessel method. The materials are contained by walls and usually a roof. The bin may simply be wooden slatted walls (with or without a roof) or within a bulk storage building. The bins allow higher stacking of materials and better use of floor space than free-standing piles. Bins can also eliminate weather problems, contain odours, and provide better temperature control. Some farms may use a two or three bin method for the composting of mortalities; however it may not be large enough to compost a disease event.

**Figure 1 Three-bin composting system.**



## In-vessel system

In-vessel composting refers to a group of methods that confine the composting materials within a vessel. In-vessel methods rely on a variety of forced aeration and / or mechanical turning techniques to accelerate the composting process. Many methods combine techniques from the windrow and aerated pile methods in an attempt to overcome the deficiencies and exploit the attributes of each method.

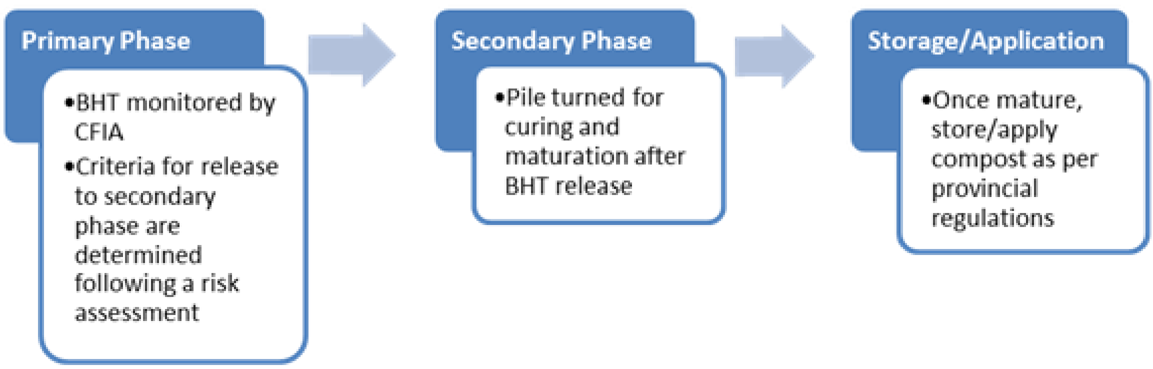
Some farms may use in-vessel system that has a rotating cylinder drum that is divided into sections for the addition of mortalities and carbon amendment, a heating section that is monitored with temperature probes, and an exit for the removal of primarily composted material. The drum is sized for the daily mortalities, and the speed of the process is dictated by the rotation.

## Ag bag method

The Ag Bag system of composting is to aerate the composting material inside of a plastic bag that is traditionally used for the anaerobic fermentation of silage and storage. As the bag is made of polyethylene plastic, it will shed moisture, however to maintain an aerobic environment the addition of forced aeriation pipes and blowers are required.

**Figure 2 Ag Bag System.**

**Figure 3: Phases of Composting for NAI.**




## 3.3 Compost Site Assessment and Selection

Before starting any composting procedure, the disposal team must make an initial assessment of individual farm situations to determine whether composting is applicable and effective, and the use the on-site or off-site method of disposal. Exposure of a pathogen to the environment is expected to be lower with on-farm composting; the potential spread associated with transporting and unloading infectious material at incineration, landfill, or off-farm composting sites will be avoided.

Selecting a suitable composting site is done by assessing numerous factors, such as epidemiologic, geologic, geotechnical, hydrogeological, financial, logistical, social, and environmental.

There may be only a short timeframe available for site selection. Identifying suitable sites prior to the site being needed expedites the composting process. Such site selection would be an important part of an industry's or individual farmer's emergency preparedness plans (or nutrient management plans), and CFIA staff should inquire about the existence of pre-selected sites, equipment, expertise and other helpful information that a producer may possess (e.g. groundwater depths).

The potential impact on groundwater is a key consideration for site suitability. Based on their ecologic and environmental factors, sites can be broadly categorized as secure, variable, or sensitive.

For sites that are not environmentally secure, regulatory agencies will likely require enhanced environmental protection and engineering design. Such sites should be avoided, if possible.

The services of a composting professional may be required to ensure that composting sites are properly evaluated and selected. Required provincial regulatory approvals (which vary by province) must be identified and obtained.

### 3.3.1 Selection Criteria

The following criteria may be considered when selecting an appropriate composting site:

Location:

- inside a barn or structure if possible.
- site has no archeological or historical significance and has no impact on endangered species
- site is away from public view and located downwind of nearby residences to minimize potential odours or dust being carried to neighbouring residences by prevailing wind
- site must be in an area that can be adequately secured
- site has no underground utilities or pipelines, and is an adequate distance from overhead lines
- site has stable ground and will support the equipment used to construct the compost pile
- site is well-drained with year-round access to roads and work areas

Environmental Considerations:

- site is away from areas that are sensitive to groundwater contamination
- site is at least 90 cm above the high water table level
- site is at least 90 m from sensitive water resources (streams, ponds, etc.)
- site is at least 400 m from wells
- site is adequately sloped (1–3%) to allow proper drainage
- site is located at least 600 m from areas that are zoned residential

**NOTE: These standards may be superseded by provincial or regional standards. Consult the local regulatory authorities.**

Size:

- The total area and volume required for the facility depends on the size of the operation, the number of carcasses for composting, and the equipment used.
- Additional estimation for the sizing of compost piles is provided in equation 1.

## 3.4 Disease Agent Considerations

During the primary phase, heat-sensitive pathogenic bacteria or viruses are inactivated by high temperatures. Inactivation is a function of both temperature and length of exposure. Although the heat generated during carcass composting results in some microbial destruction, it is not sufficient to completely sterilize the end product, as some potential exists for survival and growth of pathogens. The levels of pathogenic bacteria remaining in the end product depend on the heating processes of the primary (especially) and secondary phases and on cross-contamination or recontamination of the end product.

To maximize pathogen destruction, it is important to have uniform air flow and temperature throughout the composting process. Because carcass compost is an inconsistent, non-uniform mixture, pathogen survival may vary within different areas of the compost. Proper aeration facilitates temperature uniformity and reduces the probability of microbes escaping the high-temperature zone. In spite of non-uniform temperatures, pathogenic bacterial activity is reduced when the temperature in the middle of the pile reaches >50°C within 1-2 days. That is, a high core temperature provides an increased chance of pathogen destruction (pasteurization). Achieving an average temperature of 55-60°C for 1-2 days is generally sufficient to reduce pathogenic viruses, bacteria, protozoa (including cysts), and helminth ova to an acceptably low level. However, these conditions are not sufficient to inactivate the endospores produced by spore-forming bacteria.

It may be required to test representative samples of finished end product to determine suitability for various end uses, as directed by provincial legislation.

## 3.5 Staging Materials and Mortalities

Quickly remove mortalities from corrals, pens, or housing facilities, and transfer directly to the composting area. If a catastrophic mortality loss occurs, or adequate composting carbon sources and equipment are unavailable, hold carcasses inside the facility or in an area of temporary storage located in a dry area downwind of other animal operations and an adequate distance away from adjacent property lines. This storage time should be minimized.

In hot and warm weather there may be concern with flies, and their associated maggots. Both require control if there is possibility of disease transmission. The incorporation of carcasses and products into a compost pile quickly with the addition of a biofilter is the best method for control.

In cool weather, carcasses can become dehydrated with an extended time in storage. For poultry, it is suggested to mix the birds with available litter to begin a co-composting pile that will cover the birds, generate heat and start the process. When carbon sources and further equipment become available, the co-composting pile can be formed into a proper composting pile.

In freezing temperatures, if the carcasses cannot be immediately loaded into a compost pile, storage in a barn, shed, or other covered space to protect them from freezing temperatures. Frozen mortalities will not compost until thawed and may delay the composting process and BHT.

Carbon sources are to be sourced from clean fresh materials selected by the disposal technical specialist. They are to be ordered for delivery as required due to space limitations and C&D requirements. The staging of carbon sources is necessary for the effective completion of composting, and to maintain a safe and clean site.

**Note: Consult Module 11.5: Transportation of carcasses for the movement of carcases and material off site. RDIMS 8770683.**

## 3.6 Preparing to Build the Compost Piles

Carcass composting systems require a variety of ingredients or amendments and machinery to build the pile. Occasionally, an extra source of water may be required.

### 3.6.1 Carbon source

Composting materials should be mixed and no larger than 2.5-5 cm. Mortality management does not require a precise C:N ratio, however for an effective process, a C:N ration of 30:1 or greater is recommended. The primary nitrogen source in the piles is the carcasses (C:N ratio between 5:1 and 10:1). Some provinces may have requirements for composting and the minimum C:N ratio.

Mortality management requires the addition of a carbon amendment, which serves several key functions:

- surrounds the carcasses, making them less accessible and attractive to pests
- absorbs excess liquids released by decomposing carcasses
- provides structure and porosity, promoting air movement throughout the pile
- provides an important energy source for microbial growth. The rapid growth of thermophilic bacteria (45-70°C) produces heat required for BHT.

The type of carbon material used influences the success of the process. For example, wood chips, saw dust, and straw do not work as well as soft wood shavings due to their sizing. Using these materials requires longer decomposition times, and the leaching of liquids from piles is more likely than with shavings. It is recommended to order a moist carbon source for the mix and a dry source for the base and cover.

**CFIA recommends the use of soft wood shavings as the source of carbon as they are readily available, provide a good mix of small and medium sized particles that support microbiological activity, and have good liquid absorption.**

The final mix should have moisture content between 50–60% (wet weight). A dry mix (< 20%) will not decompose properly and will require additional water. On the other hand, excessively wet compost material will require additional dry amendment. When determining the mix, it is necessary to take into account that the carcasses have moisture content of 80%, however they are enveloped in the hide. It is recommended to order moist shavings for mix, and to open 10% of smaller carcasses or all of larger carcasses to develop a moisture mix and to promote microorganism growth.

The quantity of amendment required may be reduced fourfold if there is comminution of carcass size. Note that with highly infectious diseases, commination or grinding of carcasses is not recommended. To reduce carbon requirements, finished compost material may be used to replace up to 50% of the shavings. Substituting > 50% of the carbon with finished material may limit the carbon availability and decrease the rate of carcass decomposition.

## Equation 1 to calculate the total volume of amendment required:

**Step 1:** Determine the total number of dead animals, their weight, and the inventory of the other animal products or residuals on-site required for composting (e.g. litter, manure, residual feed, hay shavings, eggs).

**Step 2:** Determine the volume of materials that can be used as co-composting material already present on-site (e.g. litter, sawdust, feed, hay).

**Step 3:** Determine the volume of co-composting material to order from an external source. If the volume that is present on-site is insufficient, have fresh carbon delivered to the farm. The total amount of composting material (already on site plus fresh) can be evaluated by using the following equations:

- Poultry - Shavings required (in $m^3$) = ________ kg. death loss x 0.0023
- Swine - Shavings required (in $m^3$) = ________ kg death loss x 0.00625

**Step 4:** Determine the volume of amendment required for the base and biofilter layers using the total volume of material to compost (item 2), then calculate the total length of the compost pile. Once the length of the compost pile is known, the volume required for base and biofilter layer material can be calculated because, depending on the size of carcasses for composting (small, medium, or large), the width and the height of the compost piles and the thickness of the layers are standard known variables.

**Sample calculation:**

There are 10,000, 1-kg broiler birds in a barn that measures 5 m wide by 16 m long. There is 0.05 m (5 cm) of litter on the floor, and the feed bins are empty. The birds will be composted using the piling method (see appendix 1 for poultry-specific composting)

**Step 1:** Weight of materials to be composted

= 10,000 birds x 1 kg

= 10,000 kg

Volume of materials to be composted

= 10,000 kg x 800 kg/$m^3$ (average density of poultry is 800 kg/$m^3$)

= 12.5 $m^3$

**Step 2:** Volume of co-composting material available

= length of barn x width of barn x depth of litter

= 16 m x 5 m x 0.05 m of litter

= 4.0 $m^3$

**Step 3:** Total volume of co-composting material required

= 10,000 kg x 0.0023

= 23 $m^3$

Because 4.0 $m^3$ is available, the actual need for co-composting material is only 19 $m^3$, which can be met by using sawdust.

**NOTE: You can find the C:N ratio on the Cornell Composting website. The values for materials used can be found in various reference books. The values used in this example to determine the appropriate C:N ratio and moisture content were found in the On-Farm Composting Handbook on the Cornell Composting website.**

**Step 4:** The pile can be up to 1.8 m high and a maximum width of 3.6 m at the base. The length depends on volume, which is calculated (based on the windrow being between an oval and trapezoidal shape) using the formula:

V = 0.66 (height x width x length)

Volume of 1-m pile

= 0.66 (1.8 m x 3.6 m x 1 m)

= 4.3 m3

Total volume

= volume of birds + volume of litter + volume of sawdust

= 12.5 m3 + 4.0m3 + 19.0 m3

= 35.5 m3

Length of pile

= total volume / volume for 1 m

= 35.5 m3/4.3 m3

= 8.3 m

The base and cover must be 0.3 m thick, so their volume can be determined by subtracting the volume of the inside of the pile from the total volume of the pile.

Volume inside of pile

= 0.66 x [height – (base + top cover)] x [width – (sides)] x length

= 0.66 x [1.8 m – (0.3 m + 0.3 m)] x [3.6 m – (0.3 m + 0.3 m)] x 8.3 m

= 0.66 x 1.2 m x 3.0 m x 8.3 m

= 19.7 m3

Volume of base and cover

= total volume – volume inside of pile

= 35.5 m3 – 19.7 m3

= 15.8 m3

Volume of cover

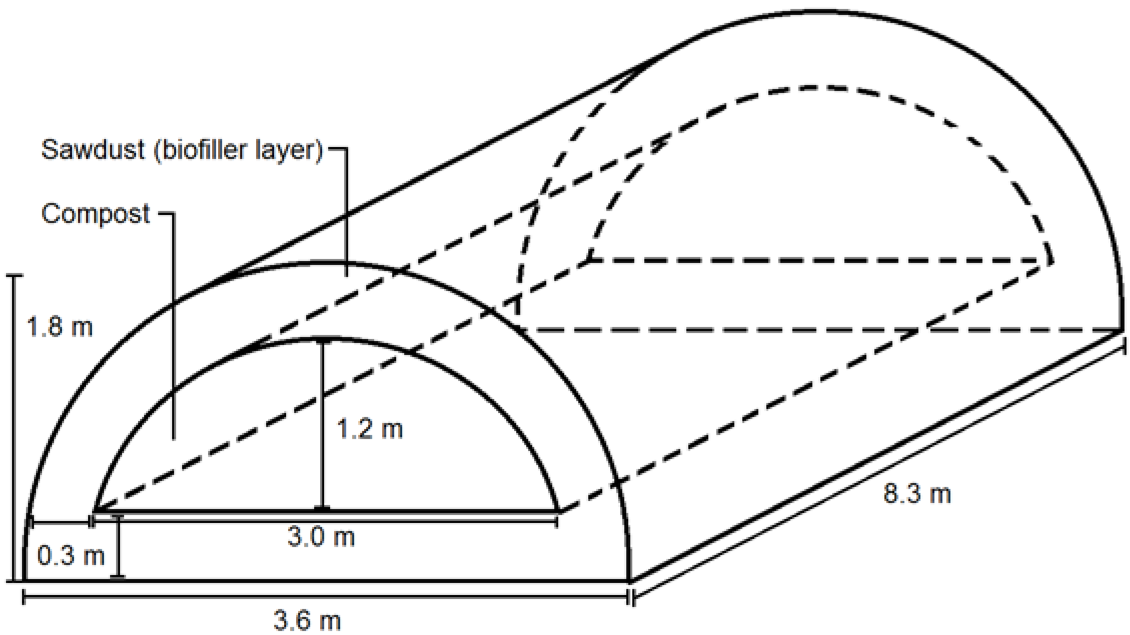
= volume of base and cover – volume of base

= 15.8 m3 – (length x width x height)

= 15.8 m3 – (8.3 m x 3.6 m x 0.3 m)

= 6.8 m3

## Figure 4: Diagram of Compost Pile Dimensions (poultry example)




### Carbon sources

Various materials may be used as a carbon source, such as sawdust, straw, corn stover, poultry litter, ground corn cobs, baled corn stalks, wheat straw, semi-dried screened manure, hay, shavings, paper, silage, leaves, peat, yard wastes, vermiculite, and a variety of waste materials (e.g. matured compost).

A 50:50 (by volume) mixture of separated solids from manure and a carbon source may be used as a base material for carcass composting. Finished compost retains nearly 50% of the original carbon sources.

Using finished compost for recycling heat and bacteria in the compost process minimizes the needed amount of fresh raw materials and reduces the amount of finished compost to be handled. A C:N ratio in the range of 25:1 to 40:1 generates enough energy and produces little odour during the composting process. Depending on the availability of carbon sources, this ratio can sometimes be extended to 50:1. As a general rule, the weight ratio of carbon source materials to mortalities is approximately 1:1 for high C:N materials such as sawdust; 2:1 for medium C:N materials such as litter; and 4:1 for low C:N materials such as straw.

### Bulking agents

Bulking agents are used to increase the porosity of the mix and provide some nutrients for composting. They usually have larger particle sizes than carbon sources, and thus maintain adequate air spaces (around 25–35% porosity) within the compost pile by preventing packing of materials. They should have a three-dimensional matrix of solid particles capable of self-support by particle-to-particle contact. Bulking agents typically include materials such as sludge cake, spent horse bedding, wood chips, refused pellets, rotting hay bales, and tree trimmings.

The ratio of bulking agent to carcasses should result in a bulk density of final compost mixture that does not exceed 600 kg/m3. As a general rule, the weight of compost mixture in a 19-L bucket should not exceed 11.4 kg. Otherwise, the compost mixture will be too compact and lack adequate air space.

**Biofilter**

Biofilters serve to enhance microbial activity by maintaining proper conditions of moisture, pH, nutrients, and temperature. Biofilters also deodorize the gases released at ground level from the compost piles. They also inhibit access by insects, birds, and other scavengers, thus minimizing transmission of disease agents from mortalities to livestock or humans.

### 3.6.2 Water Source

A water source may be required to maintain the moisture content of the carcass compost pile between 40–60% (wet basis). The moisture content can be tested accurately using analytical equipment or approximated using the hand-squeeze method (refer to the Hand-Squeeze Method in section 3.8.2).

## 3.7 Building the Compost Pile

There are three options for designing and building a compost pile: bin systems, static pile systems, and windrows. Sections 3.2.3 evaluate alternatives, and section 3.7.1 describes the best option (windrow composting).

### 3.7.1 Constructing a Windrow

While the procedure for constructing a windrow pile is similar for carcasses of various animal species, carcass size dictates the mixing or layering configuration within the pile. Regardless of mortality size, the length of a windrow can be increased to accommodate more carcasses. Carcasses can be generally categorized as small (e.g. poultry and turkey); medium (e.g. sheep and young swine); large (e.g. mature swine); or very large (e.g. cattle and horses). The major difference between windrow construction and carcasses sizes in that smaller carcass will be mixed with carbon amendment to form the windrow, while larger carcasses will be piled with that addition of carbon amendment to form a windrow.

Windrows can be constructed in-barn if the barn layout and ceiling height permits, or they can be constructed out-of-barn. Outside windrows are built on an all-weather surface, such as low-permeable soil or concrete. Windrows are typically 1-2.5 m high and 3-4 m wide. The pile is capped with a 30-cm carbon amendment (biofilter). Piles are turned when materials have completed the primary phase of composting.

The composting process is similar for all species and can be modified to accommodate different barn management systems:

- Assess barn for disposal and composting,
- Define materials to be composted,

- Order materials and equipment as required, (Ontario Compost Calculations RDIMS # 8979005)
- Assemble carcasses, and other materials to be composted,
- Prepare composting area,
- Lay down base of fresh material (15 to 30 cm, and no wider than 3.6 m),
- Apply mixed or layered materials to be composted,
- Cover pile with fresh material for the biofilter layer (30 cm),
- Maintain the pile,
- Monitor the pile for time and temperature,
- Release the pile.

### 3.7.2 Poultry In-Barn Process:

This section is for the composting of all poultry species in a barn or secure structure on site. There are many different barn sizes and types, and production methods that may be specific to each type of poultry for efficiency and animal welfare. The method of commercial poultry production, barn size and configuration will dictate if in-barn composting is applicable. Typically broilers, game birds, water fowl, pullets, turkeys and turkey breeders are raised on the floor, broiler breeders and layer breeders are raised on slatted floors with nesting boxes, and egg layers may be housed in conventional or enriched cages, aviaries, or raised on the floor. Most floor type systems can accommodate in-barn composting with the movement of welfare equipment. Modern caged egg layers with manure belts to an external storage are the exemption for in-barn composting, as the cages are solid and fixed with narrow isle ways. In this case, an external secure structure on site or out-of-barn composting may be assessed if appropriate biosecure movement occurs. An alternative method of disposal may be necessary. Please note that caged egg layers with a manure pit, there needs to be an assessment that the pit can be accessed safely and that there is adequate space for compost windrow construction.

The process is similar with most poultry; however it may be necessary to modify the process for barn specific situations.

- Site assessment,
- agreement for in-barn composting,
- develop composting team (contracting), loader operator(s), composting lead, labourers,
- order materials for composting,
- empty feeders and waterers onto the floor,
- raise feed and water lines and equipment, and move additional equipment as applicable,

- use loader to clear the central composing area moving litter and carcasses to the side(s) and mixing, ensure complete and consistent mixing,
- mix feed and broken eggs if applicable with carcasses,
- build a maximum 3.6 m wide by 15 to 30 cm deep base of fresh shavings starting at the far end of the barn,
- check the mix and adjust for moisture or carbon, build compost pile of the mixture of carcasses and litter, (it is best to build from the side if possible, if not possible build the base as needed to limit driving on it and compressing it),
- any carcasses that roll off the pile are to be moved and incorporated into the pile, arrange carcasses so that legs and wings do not stick out of the pile,
- clean up sides to incorporate all materials to be composted into the pile,
- cover the compost pile with 30 cm of fresh shavings, it may be possible to cover the pile from the end or side, or it may be necessary to shovel shavings by hand, ensure that all carcasses are covered,
- check that all carcasses are covered,
- mark compost pile for starting point and each monitoring point with marker paint,
- maintain the pile and leachate as required,
- monitor compost pile for temperatures,
- release compost pile when adequate time and temperature has been achieved for inactivation of disease agent.

### 3.7.3 Livestock (Swine, Ruminants, Horses)

Due to the carcass mass and volumes involved, there are some challenges that are specific to composting larger animals. These include the increased time needed for the compost process to work on large masses of tissue. Also, sizeable amounts of carbon source and bulking agents and a greater land base for the compost piles are required. The heavy equipment necessary for the movement of carcasses and materials involved may not be readily available on-site. Evaluate every large animal disposal situation on its own circumstances.

Composting large numbers of carcasses requires large volumes of amendments. Ensure that sufficient volumes are readily available for the projected number of carcasses. Factor into the process a significant reserve of carbon source and bulking agent. These may be required if a pooling of fluids or leachate from a pile were to occur, or if a pile is too hot or too wet. It may also be required if there is extra settling of the pile, allowing exposure of the top of the pile.

#### Opening Large Animal Carcasses Prior to Composting

Although composting of large carcasses can be done without opening the carcass, this action may expedite the process. Consider opening the rumen in ruminants and the cecum in horses to prevent "blow out" situations that may occur if pressure builds up inside these organs. Explosive release of gases can also result in odour problems and, perhaps, blow the cover material off the carcasses. If carcasses are to be opened, open after placing them on the compost pile. This prevents fluid loss as carcasses are being moved to the pile. Take caution, and provide adequate training of personnel who are involved to avoid creating safety issues from improperly using knives and/or sharp objects to open the carcasses. A forklift or front-end loader with a bucket or grapple for placing carcasses may be used to puncture the carcass.

**Pre-processing (Comminuting) the Carcasses**

Comminution of a carcass reduces the size of the individual pieces in the compost and increases the surface area that the composting organisms could act upon. Wood chippers, tub grinder-mixers, or equivalent equipment, might be used for that purpose. Take steps to mitigate the aerosolization of the pathogen during comminution (aerosolization is a biocontainment risk).

**Note:** Pre-processing or Comminution is only recommended with non-infected carcasses, or where adequate biosecurity measures can be instituted that control the risk of airborne transmission.

Where equipment is available for comminution, this action may enhance the speed of the composting process and:

- decrease the length of time required for monitoring and allow the facility into production sooner
- decrease the amount of amendment required
- decrease the size of the equipment required to build the compost piles
- permit the mixing of the carcasses with amendments for proper C:N ratio

Use of the Ag Bag system to compost the material following comminution may be considered especially in areas where soil types are not ideal.

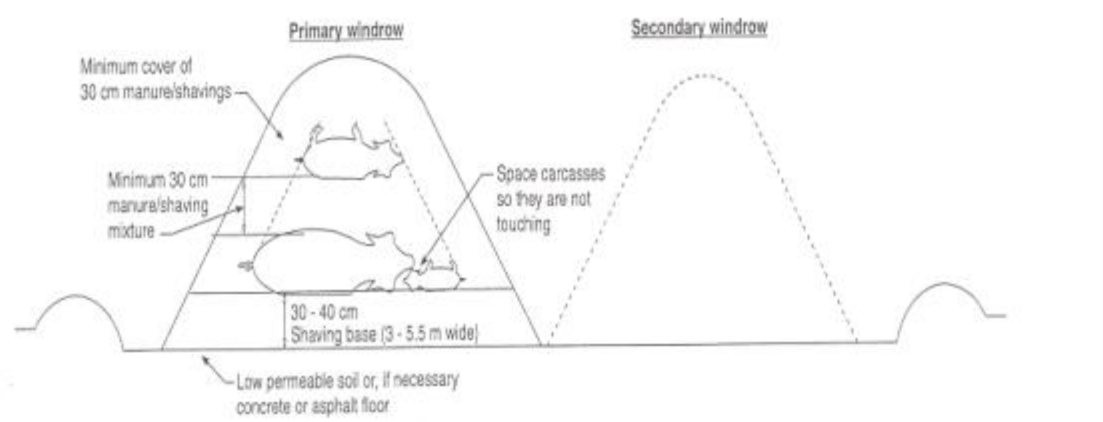
**Building the Compost Pile**

The following is a generic national model. It provides a step-by-step guide for managing livestock composting on-farm:

- Site assessment,
- agreement for the use of composting,
- develop composting team (contracting), loader operator(s), composting lead, labourers,
- order materials for composting,
- the base layer is to be built on suitable soil or a low permeability pad, the use of a plastic liner may be prescribed by provincial requirements or for use with high permeability soils,
- build the base layer of a maximum of 4.0 m wide, and with medium size carcasses 30 to 45-cm depth, and for larger carcasses a depth of 45 to 60 cm of carbon amendment,

- place a layer of dry litter or other materials to be composted onto the base,
- place a layer of carcasses on the base, centred 30 cm from the edges of the pile and evenly spaced and separated by 30 cm of amendment, (large and small carcasses can be layered together provided that there is separation by carbon amendment),
- manure may be mixed with carbon amendment to cover the carcasses,
- additional layers of carcasses and amendment may be added,
- cover the layers of carcasses with 30 to 45 cm of carbon amendment.
- Ensure that piles are mounded for shedding rainfall,
- Monitor the piles for time and temperature.
- Turn the pile as required.
- Release the pile when time and temperature has been achieved.

**Figure 5 Windrow composting of large animal mortalities.**




## 3.8 Managing the Compost Pile

After a compost pile has been constructed, there are several tasks to perform in order to manage it. These include monitoring temperature and moisture content, odour control, time, maturation and other issues.

### 3.8.1 Monitoring Temperature

Measuring the temperature describes temperature patterns and indicates when to turn the pile. When composting for disease control purposes, the CFIA determines whether temperature monitoring is required and decides which procedure to use. Temperature is also an indicator when the material has finished composting.

Temperature monitoring is basically the same for all types of compost pile. In general, high temperatures (> 55 C) are desirable, as they destroy various pathogens, weed seeds, and fly larvae that may be present in the pile.

The temperature monitoring of compost piles will depend upon the rate of decomposition, carcass sizes, the disease agent, available staff and resources, and assistant from risk assessment.

For compost piles containing smaller carcasses, such as poultry, monitor compost pile temperatures daily or every second days for the first 10 to 14 days (ref: Carr, Malone) For piles containing larger carcasses, this may vary, depending on carcass size and ambient temperatures. The initial intention is to ensure that the temperature in the compost pile is increasing or maintaining, which indicates that the compost is "working." In addition, the temperature monitoring ensures that sufficient temperatures have been achieved to inactivate the pathogen(s) involved. The BHT is dependent upon on all of the compost pile achieving specific minimum temperatures for a specific minimum period of time. Therefore, maintain a log of the temperatures recorded during the monitoring, ensuring that the minimum times and temperatures are achieved. Field-release criteria for the compost piles will be determined on a case-by-case basis.

**POULTRY COMPOST TEMPERATURE PROBING AND MONITORING**

NAI POULTRY COMPOST PROBING AND MONITORING PROTOCOL RDIMS # 982056

### 3.8.2 Moisture Content

Ensuring that the pile has sufficient moisture is one of the most important aspects of successful mortality management. A moisture content of 50–60% is optimal for carcass decomposition. If the moisture content is too low, the carcasses decompose at a very slow rate. In general, compost material is too dry if it does not feel moist to the touch.

Low moisture conditions are typically corrected by adding water as needed to obtain a damp feel. A hose is adequate for wetting smaller piles, while larger equipment (e.g. liquid manure-handling or tank trucks) is required for larger piles.

In most cases, the carcasses provide the recommended moisture content and piles will not require any moisture adjustments, provided a moist amendment is used. On a poultry farm, adding eggs to a compost pile increases the moisture content.

The moisture content of the pile fluctuates as water is lost through evaporation and added by precipitation (if uncovered). A pile that produces heat has high evaporative losses, causing the moisture content to decrease with time. On the other hand, a pile that is not protected from heavy precipitation may become excessively wet.

As a rule of thumb, the pile is too wet if water can be squeezed from the material. Moisture content can be accurately tested using analytical equipment, or approximated using the hand-squeeze method.

**The Hand-Squeeze Method**

1. Squeeze a handful of compost firmly several times to form a ball.
2. Evaluate the ball of compost:
    - If the ball is crumbly or breaks into fragments, the moisture content is much less than 50%. Add water to the compost pile. If water is not accessible on-site, identify an external source.
    - Bounce the ball on your hand 3-4 times. If the ball remains intact, the moisture content is approximately 50%. This is within the desired range.
    - If the ball feels slimy and has a musty, soil-like odour, the moisture content is much more than 50%. Add a dry amendment to the compost pile.

If excessive moisture is a problem, use a loader to add a dry amendment. Once the carcasses have decomposed, turning the pile reduces excess moisture. Covering the pile with a roof or plastic tarp protects the pile from precipitation.

Collect and redistribute any runoff onto the pile when moisture is needed. If this is impossible, use alternative systems to manage these contaminated liquids.

### 3.8.3 Preventing Scavenging by Animals (Odour Control)

Scavenging animals may become a problem if the pile is not adequately covered. If this occurs, correct the problem to maintain biosecurity and a positive public perception. The easiest way to keep scavenging animals from the pile is to keep the carcasses covered. Never allow the carcasses to become exposed. It may be necessary to build a structure (e.g. fence) to prevent scavenging animals from accessing to the pile. Maintaining adequate cover with an amendment (such as sawdust) is less expensive than building a fence. Operation and management will determine the needs of the compost system.

### 3.8.4 Time

The length of time required for the decomposition of on-farm mortalities depends on the temperature and moisture content of the pile and the mass of the carcasses.

It may be necessary to extend these periods under the following circumstances:

- the pile contains a large number of large carcasses,
- a suitable moisture content was not maintained,
- cold temperatures may slow the composting process.

### 3.8.5 Other Pile Management Issues

It is important at all times to maintain a sufficient layer of biofilter. The settling of carcasses may cause exposure, resulting in an important heat loss and/or odour. Extra amendment should always be kept on hand for such instances.

**Leachate**

If liquids leach out of the pile, spread an absorbent carbon source material around the pile to soak up the liquids and increase the base depth of the pile.

**Improper Moisture Content**

If the pile appears damp or wet and is marked by a strong offensive odour and a brown "gooey" appearance, it should be transferred onto a fresh layer of bulking agent in a new location. During the first phase, if the moisture content is low (< 40%) and the internal pile temperature is high (> 65°C), rake back the compost pile coverage, or its cap, and add water at several locations. Conversely, if the internal pile temperature is very low (< 55°C), the compost pile may have been too moist and/or lacked oxygen, resulting in anaerobic, rather than aerobic conditions. Collect samples and determine the moisture content using a measuring device or the hand squeeze method (see The Hand-Squeeze Method in section 3.7.2).

**Compost Temperature Not Elevated**

If the compost temperature does not rise to expected levels within the expected timeframe after the pile has been covered and capped, evaluate the initial pile formulation for proper C:N ratio and mixture of co-composting materials and mortalities. See Table 1: Troubleshooting Guide.

### 3.8.6 Maturation of Compost Material

After the primary and secondary phases of composting are complete, the compost may be stored for maturation.

To evaluate compost maturity:

1. Place two handfuls of compost into a re-sealable plastic bag. Close the bag.
2. Allow the compost in the bag to remain undisturbed for approximately 1 hour, or 5-10 minutes in direct sunlight.
3. Open the bag and smell the contents.
   - If the compost has a musty soil odour (like a dirt cellar), the compost has matured.
   - If the compost has a sweetish odour (like slightly burned cookies), the compost is almost mature, but requires 2-3 more weeks.
   - If the compost has a strong unpleasant smell (like rotting meat/flesh, manure, ammonia), the compost is not mature.

Once the maturation process is complete, consider the compost a finished product and dispose of it in accordance with provincial legislation.

## 3.9 Finished Product

The finished product resulting from composting mortalities has an organic matter content of approximately 35-70%, a pH of approximately 5.5-8.0, and a bulk density of about 474-592 kg/m3.

Little or no trace of the carcass should be detectable in the finished product. Some bones (i.e. skull parts, teeth) may be visible in the material, but they should be soft and easily crumbled. Remove larger bones and bury them or place them into a primary phase compost pile for further decomposition.

The finished product may be a suitable soil amendment (if provincial and territorial legislation permits) and have the following characteristics:

- crumbly texture that allows air to penetrate yet holds moisture, while allowing excess moisture to drain away
- raw materials are not detectable
- brown to dark brown in colour
- “earthy” odour

Provincial regulations must be consulted prior to land application of finished compost.

## 3.10 Release Criteria

The criteria for the release of a compost pile will depend upon the material to be composted, the disease agent, response requirements, the sizes of the carcasses, rate of decomposition, time and temperatures reached for inactivation (treatment) or reduction of mass, and federal or provincial regulations.

Contact the disease technical specialist or risk assessment for assistance.

# Table 1: Troubleshooting Guide:

Sourced from the Saskatchewan Agriculture, Food, and Rural Revitalization document Composting Animal Mortalities: a Producers Guide

| Problem | Probable Cause | Other Clues | Solution |
|---|---|---|---|
| Pile fails to heat | Materials too dry | Cannot squeeze water from material; moisture reading is below 20 per cent | Add water, liquid manure or wet bulking agent |
| | Materials too wet | Materials look and feel soggy; pile slumps; moisture reading is more than 60 per cent | Add dry bulking agent |
| | Slow decaying or not enough nitrogen | C:N ratio greater than 50:1; large amount of woody materials | Add more carcasses; perhaps cut or poke holes in the carcasses |
| | Poor pile structure or bulking agent used is too porous | Pile settles quickly while not excessively wet | Add/mix existing bulking agent with sawdust |
| | Cold weather and/or small pile size | Pile height less than four feet | Enlarge or combine piles; add highly degradable materials (manure) |
| Failure to maintain temperature<br>Failure to decompose carcass tissues | Compost has dried out | Looks very dry; wind is blowing materials | Open pile and add water or liquid manure |
| | Cold weather | | Ensure adequate cover with bulking agent and avoid frozen carcasses |
| | Too much moisture | Looks soggy; moisture reading is above 60 per cent | Add fresh bulking agent to absorb moisture |
| | Improper C:N ratio | | Improper mix of ingredients or very old sawdust or straw |
| | Carcasses layered on top of each other | Carcass is intact even after two to three weeks from adding to the primary pile | Make sure 1 foot of bulking material between layers |

| | | | |
|---|---|---|---|
| | Carcasses placed on the outside edge of the pile. | Maintain at least 1 foot of space between carcass and outside edge of bin | |
| **Problem** | **Probable Cause** | **Other Clues** | **Solution** |
| Smell of decaying flesh | Inadequate cover of bulking material over the carcass | | Cover the carcass with at least 1 foot of bulking material |
| | Extended period of low temperature | | Add manure and partially cut up the carcasses and cover with 2 feet of bulking material |
| Pile overheating: temperature greater than 160 F (71 C) | Insufficient aeration in the bulking material over the carcass | Pile is too moist | Add drier material and mix with the moist material. |
| | Pile is too large | Height is greater than 7 feet | Decrease pile size |
| | Low moisture | | Add water or liquid manure |
| Extremely high temperature; greater than 170 F (77 C) | Spontaneous combustion | Low moisture content; pile interior looks and/or smells charred | Decrease pile size; add water to charred or smoldering sections; break down pile |
| High temperatures or odours in the curing (secondary) pile | Compost is not stable | | Turn and mix pile until temperature and moisture are within limits |
| | Pile is too large | Higher than 7 feet | Decrease pile size |
| Ammonia odours coming from pile | High nitrogen level | | Add more bulking agent |
| | High pH level | | Add manure |
| Rotten-egg odour coming | Anaerobic conditions | Low pile temperatures | Add dry bulking agent and mix top layer (if in primary |

| | | | |
|---|---|---|---|
| from pile | | | bin) or the whole pile (if in secondary bin) |
| | Materials too wet; poor pile structure; pile compacted | | |
| **Problem** | **Probable Cause** | **Other Clues** | **Solution** |
| Run-off and/or leaching problems | Heavy rainfall | | Cover the pile, make sure you have a curb on the base to catch run-off |
| | Too much moisture | Looks soggy; moisture reading is above 60 per cent | Add fresh bulking agent to absorb moisture |
| Fly problems | Inadequate cover over the carcasses | Maintain 1-foot layer on top of carcass | Maintain 1-foot layer on top of carcass |
| | Poor sanitation conditions | | Avoid having standing water around the facility; keep the surrounding site clean and free of garbage or debris |
| | Moisture too high | Looks and feels soggy | Add more cover of bulking material |
| Scavenging animals | Inadequate cover over the carcasses | | Maintain 1 foot of cover on top of the carcasses; keep gates closed at all times |
| Pile doesn’t reheat after turning in the secondary bin | Low moisture | Cannot squeeze water from material; moisture reading is below 20 per cent | Add water and mix |
| | Composting near completion | Approaching expected composting time period | None required |
| Compost contains lumps of materials and large bones<br>Texture is not | Poor mixing of materials or insufficient mixing/ turning in the secondary bin | Visible raw material; lumps of compost | You should have mixed the pile in the secondary bin as frequently and as thoroughly as possible |

| | | | |
|---|---|---|---|
| generally uniform | Active composting not complete | Curing pile heats or develops odours | Increase secondary composting time or improve composting conditions |

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