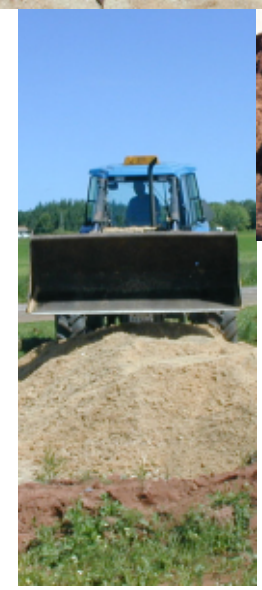
On-Farm Livestock Mortality Management



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Foreword

This manual is intended to provide Nova Scotia livestock producers with an improved understanding of on-farm mortality management. It will be of specific interest to producers seeking alternative on-farm mortality disposal options to burial and rendering. It is intended to serve as a practical guide for establishing and managing on-farm mortality biopiles. The focus is on managing what is considered routine, day-to-day livestock mortalities, and is not recommended for managing diseased carcasses. The methods discussed, however, may also be used for handling catastrophic mortality events if management plans are appropriately scaled to accommodate such events.

Introduction

Above Ground Burial Mortality Management

Proper management of farm dead-stock is an important aspect of sustainable livestock production. Traditional disposal methods have included rendering, burial and incineration. These options, however, are becoming either less acceptable or available due to disease, environmental and economic considerations.

A practical alternative to traditional dead-stock disposal methods is an adaptation of traditional composting best described as burial in an above ground biofilter (biopile).

The goal of the above ground biofilter is to use a carbon (C) amendment to accelerate the breakdown of carcass tissue in an environmentally sound manner. It involves a two-phase process (primary and secondary phases) that uses **composting principles** solely to help breakdown the dead-stock material.

The benefits associated with above ground burial management include:

- prevention of nuisances associated with flies, vermin and odours;
- low operational costs;
- reduced risk to ground and surface water;
- nutrients in dead-stock are recycled; and
- increased on-farm bio-security.

Primary Phase

The goal of the primary phase is to reduce carcasses to bones. During this phase, a biopile is formed (Fig. 1), consisting of both: (i) large carcasses, small carcasses and afterbirth (which have a low C to nitrogen (C:N) ratio, a high moisture content and limited porosity); and (ii) a C amendment such as sawdust (which has a high C:N ratio, moderate moisture content and good porosity). Sawdust is an ideal C amendment due to its small particle size, ease of handling and high C content. During this phase the C:N ratio of the mixture should be >50:1 to help reduce odours.

Fig. 1: Sawdust works well as an amendment for managing on-farm mortalities.

At the beginning of this phase, the carcasses and C amendment are layered in a pile. Gases and liquids produced from decomposing carcasses diffuse outward toward the surrounding C amendment layer. This surrounding material supports a diverse population of microorganisms, which form a biological filter. As gases enter the biofilter layer, they are ingested by microorganisms and degraded to carbon dioxide (CO_2) and water vapour.

This phase requires little management, and pile turning is delayed until carcasses have decomposed. For carcasses such as poultry, mink,

At the beginning of this phase, the carcasses and C amendment are layered in a pile. Gases and liquids produced from decomposing carcasses diffuse outward toward the surrounding C amendment layer. This surrounding material supports a diverse population of microorganisms no longer increase after turning. This phase lasts for a minimum of 30 days.

Secondary Phase

The secondary phase facilitates further decomposition and nutrient stabilization of pile materials. This phase is similar to traditional composting because pile materials are well mixed. For this reason, it is important to monitor the following:

- **nutrient status**: the C:N ratio should be between 25:1 to 30:1;
- **moisture content**: should be between 50% and 60% (wet weight);
- **temperature**: should be monitored weekly; and
- **oxygen**: the pile should be turned on a regular basis (bi-weekly) to ensure that oxygen is supplied.

After completing the primary phase, piles will have a high C content. This requires some consideration if the finished product is intended to be used as a soil amendment. To produce a higher quality finished product, an additional N source should be added at the beginning of the secondary phase to establish a C:N ratio between 25:1 and 30:1.

Since manure is generally available on-farm, it is commonly used as a N source. When adding manure, keep in mind that the pile should contain **1/3 to 1/2 manure**. Inorganic supplemental N sources may also be used such as ammonium nitrate (NH_4N_{O3}). The addition of about 3 kg of granular NH_4NO_3 per 100 kg of material will provide the N necessary to achieve a C:N ratio within the recommended range (BCMAF, 1996).

Piles are turned several times throughout the secondary phase. Turning reintroduces oxygen and this activates microbial activity and allows for further breakdown of pile materials. This phase is considered finished when pile temperatures no longer increase after turning. This phase lasts for a minimum of 30 days.

After completing the two phases, the finished product will contain very small bone fragments, if any. These fragments are usually quite brittle and pose no health risks or danger to equipment when land-applied. Typically, the entire process takes between 8 and 18 months to complete.

Getting Started

Mortality Management Facility

Farm operations typically manage dead-stock using a windrow (static piles) or bin system. The advantage of a bin facility is the ability for more controlled moisture conditions. The initial input and maintenance costs, however, are greater than those for windrows (or static piles).

A mortality management facility must provide the required conditions that allow for all-weather management, water quality protection, reduction of the spread of disease, prevention of nuisances and maintenance of air quality. Therefore, several factors must be considered when siting a mortality management facility. The site should be:

- well-drained with year-round access to roads and work areas;
- away from areas that are sensitive to groundwater contamination;
- located at least **100 m** from wells or water courses;
- located at least **600 m** from areas zoned residential;
- aesthetically pleasing (trees, shrubs, windbreaks can be used to screen site);
- located near available water treatment areas (i.e. vegetative filter strip, infiltration areas, etc.); and
- located on high ground to prevent surface water from entering the management site.

Piles should be conveniently located. Some operations construct piles close to the farm, while others select more remote sites, such as back fields.

The total area and volume requirements for the facility will be dependent on the size of the operation, number of carcasses to be decomposed and equipment used. The daily average weight of mortalities will need to be determined before sizing and establishing a mortality management facility.

Windrows vs. Static Piles

Windrows and static piles are similar in design. Walls and roofs are not required in these designs, making it easier to load, unload and mix pile materials. Piles are constructed on an all weather surface such as low permeable soil or concrete.

With a windrow design, the length of the windrow is extended as mortalities occur. Windrows are ideal for managing catastrophic mortality events. Windrows are typically **1.0 m to 2.5 m high and 3.0 m to 6.0 m wide**.

Static piles, however, are extended in height rather than length. As mortalities occur, carcasses are layered in the static pile with 30 cm of C amendment placed between mortality layers. In both designs the pile is capped with a 60 cm C amendment (biofilter).

Both static and windrow piles are turned when pile materials have completed the primary phase (Fig. 2). With windrows, however, new sections are continually added, and certain sections are turned before others as they complete the primary phase.

Fig. 2: Static piles are turned once the carcasses are almost fully decomposed.

Stakes or markers may be inserted along the length of the windrow to help distinguish newly constructed sections from older sections. In addition, a log book should be used to keep a record of the turning schedule.

Bins

Bins usually consist of three walls (concrete or treated lumber) (Fig. 3) and a roof (to reduce expenses, a roof may be substituted by a plastic tarp).

Fig. 3: Bins are typically constructed as three-sided enclosures.

To make bin contents easily assessable, the open side of the bin should be about twice the width of the bucket on the turning equipment being used. Bins are usually sized to a maximum depth of 1.5 m and an operating width of 3.0 m.

Covered bins are advantageous over open windrows and static piles, as they provide the following:

- greater ability for stacking materials;
- more controlled moisture conditions; and
- improved temperature control.

To prevent leachate, the bin should be constructed on a concrete pad. The area of the pad will depend on the mortality volume and other operational considerations. As a rule of thumb, a capacity of approximately **1.25 m³ is required for each kg of average daily loss** (see example page 4).

Example:

Primary Phase Volume Required:
54 kg (daily death loss) x 1.25 m^3/kg = 67.5 m^3

Bin Dimensions:
1.5 m x 3.0 m x 3.0 m = 13.5 m^3

Number of Bins Required:
67.5 m^3 / 13.5 m^3 = **5 Bins**

Amendment

Unlike traditional composting, mortality management does not require a precise C:N ratio. In fact, many operations have successfully decomposed carcasses in sawdust without adding supplemental N. The primary N source in the biopiles is the carcasses (C:N ratio between 5:1 and 10:1).

Mortality management requires the addition of a C amendment (examples are given in Table 1) 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 which promotes air movement throughout the piles; and
- provides an energy source for microbial growth.

Table 1: C:N ratio and percent moisture values of common carbon sources.

Material	*C:N (weight to weight)*	*% Moisture (wet weight)*
Corn stalks	60-73	12
Corn silage	38-43	65-68
Hay	15-32	8-10
Straw	48-150	4-27
Sawdust	200-750	19-65
Wood chips	451-819	-
Leaves	40-80	-

Source: On-Farm Composting Handbook. 1992. R.Rynk.

The type of C material used will influence the success of the process. For example, wood chips, shavings and straw do not work as well as sawdust due to their larger particle size. With these materials, longer decomposition times are required and leaching of liquids from piles are more likely as compared to sawdust (small particle size).

The amendment should have a moisture content between 50% and 60% (wet weight). A dry amendment (<20%) will not decompose properly and may require the addition of water to obtain the proper moisture content. On the other hand, an excessively wet material may require the addition of a dry amendment to correct the moisture content.

Approximately 2.5 kg of sawdust is required for every kg of carcass that is decomposed. To reduce C requirements, finished material may be used to replace up to 50% of the sawdust. Substituting >50% of the C with finished material may limit C availability and decrease the rate of carcass decomposition.

Starting the Biopile

The following is a step-by-step procedure for managing livestock mortalities on-farm:

- start the primary bin or pile by creating a base. The base should consist of at least 60 cm of C amendment, preferably sawdust;
- place a layer of carcasses on the base, centred 30 cm from the walls of the bin or edges of the pile. Carcasses that are placed directly on the ground, concrete floors or against bin walls will not decompose properly. Carcasses should be evenly spaced and separated by 30 cm of amendment (carcasses should not be stacked);
- try to add carcasses to piles within 24 hours after death, and do not add diseased carcasses;
- in windrow designs, cover carcasses with 60 cm of C amendment. In static piles and bins, cover carcasses with 30 cm of C amendment and continue to layer as necessary;

- once the carcasses are layered (static and bin design), cap the pile with 60 cm of C amendment to provide insulation, retain heat and prevent the release of odours and the attraction of pests to the pile;
- ensure that uncovered piles are mounded for the purpose of shedding rainfall;
- check the pile regularly to ensure that the carcasses are adequately covered (settling of the pile and windy conditions will move the amendment);
- if possible, monitor the temperature once a week, using a long-stem, dial-type thermometer (piles that are started during cold weather may not begin to decompose immediately. If carcasses are buried with the proper amount of amendment, decomposition should begin once air temperatures increase);
- after 3 to 12 months or more, when all of the carcasses have decomposed, transfer the material to a secondary bin or pile (3 to 9 months for smaller carcasses and 9 to 12 for larger carcasses);
- if the pile does not produce heat with turning, additional N should be added. Since manure is generally available, it is commonly used as a N source. When adding manure, keep in mind that the pile should contain **1/3 to 1/2 manure**;
- turn the secondary pile at least twice a month; and
- after **1 to 5 months** in the secondary pile, the material should be finished. Before land-application, a sample of the material should be sent to a laboratory and tested for nutrients (such as N, P and K) and pathogens.

Managing the Pile

Temperature

Primary Phase

In general, high temperatures (>55°C) are desirable, due to their ability to destroy various pathogens, weed seeds and fly larvae that may be present in the pile. According to the Canadian Council of Ministers of the Environment (CCME) guidelines for compost quality, a temperature of 55°C must be maintained for a period of 3 to 15 consecutive days (3 for bins; 15 for windrows) before most pathogens are destroyed (CCME, 1996).

Since mortality management does not require a specific C:N ratio, it may be difficult to obtain high pile temperatures. With a sufficient oxygen supply, a suitable moisture content and a proper C:N ratio, the primary phase will produce elevated temperatures. If optimal conditions are not maintained, the temperature will likely remain within 10°C to 20°C of ambient conditions.

With time, microorganisms will exhaust the pile's oxygen supply, causing the temperature to decrease and indicating the pile should be turned (Fig. 4).

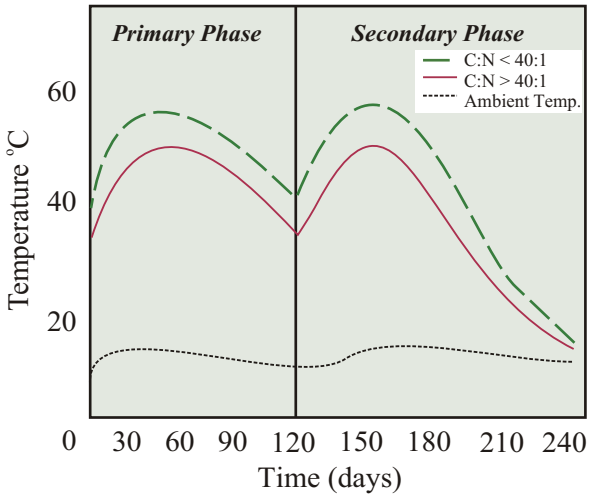

Fig. 4: Typical temperatures produced during the decomposition of mortalities.

Secondary Phase

Once the carcasses have decomposed, the pile is turned and moved to another location to begin the secondary phase. Turning the pile replenishes oxygen supplies, which activates microbial activity and causes pile temperatures to increase.

During this phase, the temperature should be monitored on a weekly basis. Temperature measurements are useful in describing temperature patterns and help indicate when turning should occur.

Temperature is used to determine when the material is finished and is typically monitored by inserting a 60 cm to 90 cm dial thermometer into the centre of the pile, where most of the heat is produced (thermometers may be purchased at local hardware stores). In general, the process is considered to be complete once temperatures no longer increases with turning.

Once several carcasses have been successfully decomposed, a normal temperature pattern should emerge. Deviations from the normal temperature pattern will indicate that one of the conditions for successful decomposition is not being met.

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% to 60% is optimal for carcass decomposition. If the moisture content is too low, the carcasses will decompose at a very slow rate. In general, a handful of material that does not feel moist to the touch is too dry.

Low moisture conditions are typically corrected through the addition of water. Water should be added as needed to obtain a damp feel. Water may be added to smaller piles with a hose, while larger piles will require larger equipment, such as liquid manure handling equipment or tank trucks.

In most cases, the carcasses will provide a moisture content within the recommended range and piles will not require any moisture adjustments, provided a moist amendment is used.

The moisture content of the pile will fluctuate as water is lost through evaporation and added by precipitation. A pile that produces heat will have 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**. If excessive moisture becomes a problem, dry amendment should be added (this may be done using a loader). Once the carcasses have decomposed, excess moisture may be reduced by turning the pile. Covering the pile with a roof or plastic tarp are two effective methods for protecting the pile from becoming too wet.

Any runoff should be collected and redistributed onto the pile when moisture is needed. If this is not possible, alternative systems should be used to manage these contaminated liquids.

On-Farm Moisture Analysis

Moisture content refers to the amount of water in a material and is expressed as a percentage. Although on-farm methods for determining the moisture content tend to be less accurate than laboratory procedures, they are satisfactory for most on-farm situations.

Prior to conducting an analysis on-farm, an empty sample container must be weighed. A sample is collected, placed in a container, re-weighed and dried. Drying is completed in stages. After each stage, the container and sample are weighed. Once the weight remains constant between two consecutive drying stages, the sample is considered to be dry.

The drying time will vary according to the temperature, drying equipment, sample size and initial moisture content of the material. After a

number of drying experiments, typical drying times may be established. On-farm methods for determining moisture include:

1. Air drying: This is the simplest method for determining the moisture content of a sample. Once the sample is weighed, empty it (<1.5 cm thick layer) on paper in a warm room. Allow the sample to dry for 24 to 48 hours and re-weigh. It may be necessary to repeat these steps, weighing every few hours, until the weight loss is negligible.

2. Microwave drying: A microwave oven will reduce the drying time. The microwave should be dedicated to material testing (i.e. not for household use) and located in a well ventilated area. Experimentation is necessary to determine the drying time for a given microwave oven and sample. To begin, spread a 10 g sample of moist material in a thin layer and place in a microwave-safe container. Heat for 8 minutes at full power (at least 600 watts of power). For a less powerful microwave oven, increase the heating time or reduce the sample size.

After the initial heating, remove the sample from the oven and weigh it. Reheat the sample for another 2 minutes. After reheating, re-weigh the sample. Continue the cycle of heating and weighing at 1 minute intervals until the weight change is negligible. If the sample becomes burned or charred, start over using less power and/or shorter heating times. After determining the required drying time for a particular microwave oven, sample size and material, a standard drying period may be used.

3. Oven drying: Samples may be thoroughly dried at 60 to 104°C in a conventional heated-air oven (for material testing use only and located in well ventilated area). For most materials, a temperature of 100°C is adequate. Rough estimates for drying a 10 g sample range from 24 hours (104°C) to 72 hours (60°C). The drying process may be accelerated by spreading the sample in a thin layer.

Once the sample is dry, a final weight is obtained (container included) and the following equation is used to determine the moisture content (MC) of the original material:

$$MC = \frac{\text{wet weight - dry weight}}{\text{wet weight - container weight}} \times 100\%$$

Turning

The primary phase pile should be turned once the carcasses have decomposed. Turning is very important, as it supplies the pile with oxygen, releasing trapped heat, water vapour and gases. Turning allows all of the material to be exposed to any heat that might be produced at the centre of the pile. Furthermore, turning breaks the material into smaller pieces, which facilitates rapid decomposition.

The secondary phase pile should be turned bi-weekly, although the frequency of turning should be dependent on the following factors:

- rate of decomposition;
- temperature decrease;
- moisture content; and
- porosity.

Piles are usually turned using a front-end loader or manure spreader (Fig.5). Commercial compost turners are available for turning windrows, but are not essential for successful decomposition.

Fig. 5: When a pile is turned, trapped heat, water vapour and gases are released.

Time

The length of time required to decompose on-farm mortalities will be dependent on the temperature and moisture content of the pile and the mass of the carcasses (Table 2). It may be necessary to extend these periods under the following circumstances:

- the pile contains a large number of carcasses;
- a suitable moisture content was not maintained;
- the ambient temperature is cold enough to slow the composting process; and
- additional N, such as manure, was added during the secondary phase.

Table 2: Duration of primary and secondary stages (days) according to carcass mass (kg).

Carcass Mass (kg)	*Primary Stage* (days)	*Secondary Stage* (days)
2	10	10
5	16	10
25	35	12
50	50	15
100	75	25
160	95	30
230	115	40
455	160	55
700	195	65

Source: Ohio Livestock and Poultry Mortality Manual (2000).

Finished Product

Little or no trace of the carcass should be detectable in the finished product. Some bones (skull parts, teeth) will be visible in the material, but they should be soft and easily crumbled. Larger bones can be removed and placed into a primary phase pile for further decomposition, or buried.

If the recommendations provided in this manual are followed, the finished product will be suitable for land-application and will 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; and
- earthy odour.

If optimal conditions are not maintained, the finished material will be high in C, and will be more suitable as a mulch or cover to protect exposed soil during the winter.

To determine the precise nutrient content of the finished product, a sample should be sent to an accredited laboratory. Although temperatures for pathogen kill (>55°C) should be reached during the secondary phase, it is advisable to have samples tested for pathogenic organisms (eg. fecal coliforms <1000 MPN/g dry weight basis (CCME, 1996)).

Guidelines for the Management and Use of Animal Manure in Nova Scotia (R-91-2000) (NSDAF, 1991) should be followed if the end-product is land applied. For some crops, it is important to ensure that adequate time between crop application and crop harvest is allowed for (check crop withdrawal times).

Preventing Scavenging Animals

Scavenging animals may become a problem if the pile is not adequately covered. If this occurs, the problem should be corrected to maintain bio-security and a positive public perception. The easiest way to prevent 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 to prevent scavenging animals from entering the unit. Maintaining an adequate cover with an amendment (such as sawdust) is less expensive than incurring the additional cost of a fence. Operation and management will determine the needs of the system.

Frequently Asked Questions

Will a pile containing dead animals produce odours and attract rodents?

As long as the carcasses are properly covered with 60 cm of amendment, odours and rodents should not be a problem.

What happens to the pile during the winter?

Carcasses typically decompose more rapidly when the ambient temperature is warm. Pile temperatures of 50°C or higher, however, may be attained when ambient temperatures are as low as -15°C. Frozen carcasses placed in frozen sawdust will not decompose during cold weather, however, they should begin to breakdown once ambient temperatures increase in the spring. Adding more cover material will help retain heat in the winter, providing warmer material with which to cover carcasses that are added during this period. Avoid turning piles during extremely cold weather.

Should the pile be constructed on a concrete pad?

A concrete pad will reduce the risk of water contamination. Any runoff should be collected and redistributed onto the compost pile. Furthermore, a concrete pad will facilitate turning. If a concrete pad is not economically feasible, the pile should be located on sloped land that drains into a collection area. Any uphill surface water should be diverted from the management site (i.e. berm, terrace).

Will there be any problems with pathogens or flies?

As long as temperatures above 55°C are maintained for 3 to 15 consecutive days (3 for bins; 15 for windrows), most pathogens in the material should be destroyed. Flies should not be a problem, as long as a suitable moisture content is maintained (<60%) and the carcasses are not exposed.

Why do some piles fail?

A pile fails when it does not produce heat or produces runoff and/or odour. These problems commonly result from the following:

- failure to provide enough amendment;
- an excessive moisture content; and
- placing carcasses too close together.

Can wet sawdust be used?

Dry sawdust should be used (50% to 60% moisture content), as it can absorb more water and contains more air space. Excessively wet sawdust will lead to the production of runoff and may freeze in the winter.

Can large animals be decomposed?

Although the process requires more time, it is possible to decompose large animals. It is not necessary to cleave or cut animals placed in the pile. To increase decomposition rates, however, it helps to puncture or splay carcasses as they are placed in the pile. Carcasses should not be splayed prior to placement in the pile because the internal organs are difficult to contain and transport.

If sawdust is not available, can other C sources be used?

Although sawdust is the best material for managing mortalities, any organic material with a high C content may be used. Long, fibrous materials, such as hay, should be chopped or ground to reduce the particle size. The material used should settle around the carcass.

Summary

By following a few general composting recommendations, above ground burial mortality management can be a successful, environmentally safe and economically feasible method for disposal of on-farm livestock mortalities.

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