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Small Animal Mortality Composting with Low Death Loss

ABSTRACT

Mortalities are a fact of life for livestock producers. Today, animal agriculture is challenged to discover innovative ways to dispose of livestock and poultry mortalities. Composting of these mortalities is one option that is now available. Rabbit mortalities from a small operation were composted from October 2001 through July 2002 using a bin system. Both the primary and secondary phase of the composting cycle were monitored for temperature, odour, and visual observations.

The primary phase did not reach temperatures capable of destroying pathogens, weed seeds, and fly larvae. However, the secondary phase was successful in reaching and sustaining these temperatures for more than three weeks.

When the completed primary bins were moved to the secondary bins the product was non-homogeneous and the effects of layering were still present. Hair and small bone fragments were present in the product. The odour was very mild yet suggested the process was anaerobic. After the completion of the secondary phase the product had little odour, was homogeneous, and contained little to no mortality evidence. Small bone fragments were present yet extremely brittle.

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INTRODUCTION

Mortalities are a fact of life for commercial livestock producers. Livestock and poultry die from disease, accidents, and competition. Under Alberta's *Destruction and Disposal of Dead Animals Regulation* of the *Livestock Diseases Act* (Appendix A), the owner of a dead animal shall dispose of the animal within 48 hours of its death. Today, animal agriculture is challenged to discover innovative ways to dispose of livestock and poultry mortality. This need has been created by the limited accessibility of rendering plants, concerns over burial and groundwater pollution, the economic cost and other issues related to incineration, and by the large volume of deads from larger livestock operations. Composting of livestock mortalities is one option that is now available. There are two general approaches to livestock mortality composting: enclosed or bin systems, and open pile systems. Alberta regulations allow either option for livestock composting.

BACKGROUND

Basics of Composting

Composting is a natural biological process of decomposition of organic materials in a predominantly aerobic (presence of air) environment. During this process bacteria, fungi, and other micro-organisms break down organic materials into a stable mixture called compost, while consuming oxygen and releasing heat, water, and carbon dioxide (CO_2). The finished compost resembles humus and can be used as a soil amendment. Composting reduces the volume of the parent materials, and pathogens are destroyed if the process is controlled properly.

Micro-organisms involved in composting can be classified according to temperatures most favourable to their metabolism and growth. The mesophilic 10 - 43°C (50 - 110°F) and thermophilic micro-organisms 43 - 71°C (110 - 160°F) are the principal groups.

Under controlled conditions, composting is accomplished in two main stages: an active composting stage and a curing stage. The active composting stage involves three sub-stages:

- An initial stage (lasting one to three days) when mesophilic micro-organisms degrade constituents such as sugars, starch, proteins and compost temperatures rise rapidly.
- A high rate thermophilic stage (lasting 10 to 100 days) in which temperatures rise above 43°C (110°F) and fats, hemicellulose, cellulose and some lignins are degraded and pathogens are destroyed.
- A stabilization stage (lasting 10 to 100 days) during which time the temperature declines and further degradation of cellulose, hemicellulose, and lignins occurs.

The high rate stage is accomplished through a high rate of oxygen uptake and carbon dioxide (CO_2) output. Large amounts of ammonia (NH_3) and other gases may be released if the process is not controlled well. During curing or maturation, mesophilic organisms recolonize the compost. The length of curing time depends on market opportunities but typically represents a minimum of one month and generally lasts three to six months.

Factors Affecting Composting

While composting is a natural process, it requires proper conditions to occur rapidly, minimize odour generation, and prevent nuisance problems. Over twenty controllable factors affect composting. Table 1 lists eight of these factors and acceptable ranges to target when composting. Four major factors to be controlled in the composting process are the material mix (nutrient balance), water content, porosity, and temperature.

Table 1: Guidelines for composting: major factors

Major Factors	Reasonable Range	Preferred Range
Nutrient Balance (C:N ratio)	20:1 – 40:1	30:1 – 35:1
Water Content	45 – 65% w.b.	50 – 60% w.b.
Particle Size	0.3 – 1.2 cm ($^1/_8$ – ½")	Depends on Material
Porosity	30 – 50%	35 – 45%
Bulk Density	< 640 kg/m^3 (1100 lb/yd^3)	n\a
pH	5.8 – 9.0	6.5 – 8.0
Oxygen Concentration	> 5%	> 10%
Temperature	45 – 68°C (113 – 155°F)	54 – 66°C (130 – 150°F)

Material Mix (C:N)

The proper compost mix requires both carbon and nitrogen at the proper C:N ratio. This will result in a composting process that generates little odour yet offers an environment where micro-organisms can flourish. Generally, an initial C:N ratio ranging from 20:1 to 40:1 is satisfactory. Most compostable materials have a C:N ratio that is too low to compost properly on its own. In order to compost these materials, amendments that contain a high C:N ratio must be added. Plant materials such as wood chips, sawdust, chopped corn stover, shredded paper, or straw have a high C:N ratio for on-farm composting.

Water Content and Porosity

Like all living things, micro-organisms need water. To encourage their growth and rapid composting, water content of the mixture should be 50 - 60% (wet basis). It is important to avoid excess water due to the potential for odour and leachate conditions. If the mixture feels moist, yet no water drips from it when a handful is squeezed, the mixture probably has adequate water content.

Micro-organisms that are encouraged to grow in a compost pile are aerobic, or require oxygen. Open spaces (porosity) must be maintained to allow air to penetrate and move through the pile providing oxygen. Ideally, 35 - 45% of the pile volume should be small, open spaces. Optimum porosity is achieved by balancing the material's particle sizes, water content of the mix and pile size.

Temperature

The composting process will generate and regulate its own temperature. However, to maintain high temperatures the pile must be large or have some insulation. A layer of inactive material, sawdust, or finished compost placed over the entire pile will insulate the pile. As the pile heats up, warm air within the mixture will rise and move out of the pile, while fresh air will be drawn in to replace it. This process exhausts the CO_2 created in the pile and maintains an aerobic environment for the micro-organisms.

The highest rates of decomposition occur at temperatures in the range of 43 - 66°C (110 - 150°F). Also, high temperatures above 55°C (131°F) over three days will kill parasites, and fecal and plant pathogens within the pile. At temperatures above 66°C (150°F), microbial activity declines rapidly with activity approaching low values as compost termperatures exceeds 71°C (160°F). Mechanical windrow turners can be used to turn the material to help release excess heat when the temperatures reach dangerously high levels.

Livestock Mortality Composting

Composting livestock mortality almost always moves toward satisfying the principles previously mentioned. Unfortunately, strict application of these standards should only be done when dealing with a consistent, thoroughly mixed pile. The reality is that a pile in which livestock mortality is composted is an inconsistent mixture. Therefore, composting livestock mortality must be approached slightly differently.

A mortality compost pile (either open or in a bin) is an inconsistent mixture. It is composed of a large mass of material (the animal) with a low C:N ratio, a high moisture content, and nearly zero porosity surrounded by material (the carbon amendment) with a high C:N ratio, moderate moisture levels, and good porosity. The animal and amendments are layered into the pile, and no mixing is done until after the high-rate stage of composting has occurred and the animal has fully decomposed. Composting livestock mortalities (primary stage) can best be described as an "above ground burial in a bio-mass filter with pathogen kill by high temperatures."

The decomposition process is anaerobic (lacking oxygen) in and around the animal mortality, but as gases are produced and diffused away from the mortality, they enter an aerobic zone. Here the gases are trapped in the surrounding material, ingested by the micro-organisms, and degraded to CO_2 and H_2O. The surrounding material supports bacteria to form a biological filter, or a biofilter.

With this scenario, avoid turning the pile until the mortality has been decomposed. For moderately sized animals (poultry, pigs, sheep, etc.) this is generally less than three months after the last mortality has been placed into the pile. After this time, the pile is moved to a secondary area where it is allowed to compost for an additional 10 days to several months. This procedure introduces air back into the pile and mixes the contents, leading to more uniformity in the finished compost. The secondary pile is then turned and placed in a pile for storage for 30 days or more. When composting large mature animals, bones sometimes remain intact after completion of the secondary/storage process. They are generally quite brittle and pose no health risks or danger to equipment when land applied. In some instances however, it may be desirable to recycle the larger bones back into the compost to allow for more decomposition.

PLANNING CONSIDERATIONS

Construction

Actual construction of a composter can be in many different forms, all producing good results. Some essential features to consider are location, type of structure, construction materials, and ingredient storage. All good composters will include some or all of the following characteristics.

Location / Access

Location of a composter should follow the criteria in Section 2, subsection (4)(d)(ii) of the *Destruction and Disposal of Dead Animals* (A.R. 229/2000) of the *Livestock Diseases Act.* It states that the compost pile be:

- at least 100 metres from wells or other domestic water intakes, streams, creeks, ponds, springs, and high water marks of lakes and at least 25 metres from the edge of a coulee, major cut or embankment,
- at least 100 metres from any residences,
- at least 100 metres from any livestock facilities, including pastures, situated on land owned or leased by another person.

The location should also take into account any impact it may have on the farm residence and any nearby neighbouring residences. While offensive odours are not usually generated in the composting process, the handling of dead animals, manure, and litter on a daily basis may not be aesthetically pleasing. When locating a composter, consideration should be given to traffic patterns required for moving dead animals, the required ingredients, and removing the finished compost from the composter. The composter site should be well-drained and provide all-weather access roads and work areas.

Foundation / Floor

An impervious, weight-bearing foundation and floor should be provided for all primary and secondary composting areas. This feature ensures all-weather operation, helps secure the composter against rodent access, and generally minimizes the potential for contamination of the surrounding area. In addition to providing concrete under the compost bins, consideration should also be given to providing a similar concrete floor in traffic areas and work alleys. Experience has shown that, with the frequent loading and unloading activities associated with composting, dirt or even gravel areas tend to become rutted and potholed. This condition worsens if the work alleys are not roofed.

Construction Materials

Any portion of the composter structure such as poles and sidewalls that will be in contact with dirt or composting material should be constructed with pressure treated lumber or other rot-resistant materials.

Roof

A roof covering the primary and secondary composting bins is required to control rainwater and the moisture content of the composting mass. Roofing the working area also facilitates all-weather activities. Additionally, any ingredient storage areas or bins should be roofed to preserve the ingredients at the desired moisture content. Roof heights must be adequate to ensure clearance for front-end loaders. However, a high roof may allow too much direct rain or water draining off the roof to be blown into the composter. This problem can be minimized by adding partial sidewalls and roof gutters.

Ingredient Storage

Having sufficient amounts of ingredients such as sawdust and litter present at the composter site greatly facilitates the day-to-day management of the process. However, litter may only be readily available during periods of partial or total building cleanout. Inclement weather can also hamper the handling and transfer of ingredients in a timely fashion. In determining the amount of storage needed, consideration should be given to the frequency with which ingredient transfer and restocking can be managed. Storage requirements may vary considerably among different operations. It has been suggested that providing a minimum of two bins (of primary bin size) for ingredient storage will sufficiently facilitate the operation of a four primary bin composter. If more than four primary bins are required, ingredient storage may need to be increased according to the above ratio. Bins used for storage can double as primary composting bins (i.e. during periods of high death loss) or they may facilitate the expansion of the composter if the farm is increased. Ingredient storage does not have to be in bins but the ingredient storage area should be roofed.

If the composter can be constructed in conjunction with a litter storage facility, ingredient handling may be greatly simplified. Litter will be readily available from the litter storage area and other ingredients can be stored appropriately in the same location.

Finished Compost Storage

Secondary compost bins provide a place for compost to undergo a second heating cycle and further composting. However, as secondary bins become full the compost must either be spread on the land or moved to a finished compost area. Any compost storage area should be covered to prevent rainfall from saturating the pile which could cause leaching. A litter storage facility can also be used to store finished compost until land spreading can be conveniently carried out.

Utilities

A water line with a freeze-proof hydrant at the compost facility will aid in adjusting the moisture content of the recipe (if needed) and further facilitate cleanup and washdown of personnel, equipment, and the compost area. A minimum 20 amp electrical circuit will allow for the use of power tools, lights, or other appliances that may be required at the compost facility.

Sizing the Composter

In sizing a composter, it is necessary to know, or estimate, the number and weight of animals in the enterprise, and the expected percentage of daily mortalities. Maximum daily mortality (on a weight basis) usually occurs when the animals are at or near market weight. Once the maximum daily mortality weight is known the number and size of composters can be calculated.

PROJECT SCOPE AND OBJECTIVES

The scope of this project was to assess the biological efficiency of composting small animal mortalities from operations where the death loss is low.

The specific objective of this project was to assess the biological efficiency of composting rabbit mortalities in situations such as: building an entire primary bin of frozen rabbits, worse case scenerio, and building the bin with frozen rabbits one layer at a time over 15 days. Three primary bins and three secondary bins were monitored from October 2001 through July 2002.

METHODOLOGY

Mortality Composter Design

Three primary and three secondary bins were evaluated. The rabbit composter was built with four bins: two primary bins, one secondary bin, and an extra bin for storage of amendments or to be used during unusually high mortality rates. The size of the bins was determined by the mortality rate and guidelines in the Poultry Mortality Composting Manual by Alberta Agriculture Food and Rural Development. The producer raised a small operation of rabbits, 2.3 - 4.5 kg (5 - 10 lbs.) of daily losses, and used a wheelbarrow for most of his chores; therefore, the bin size chosen was 1.2 m^2 (4 ft^2) by 1.5 m (5 ft) high. The composter built is shown below in Figure 1.

Figure 1: Rabbit Mortality Composter.

The walls were built with 19 mm (¾ in) treated plywood, the front from treated 5 x 15 cm (2 x 6 in) boards that slide into metal rails from the top, and the roof from 13 mm (½ in) plywood. The soil is clay and met the regulations for permeability and it was graded so all runoff would go to the manure collection area.

Compost Production Management

Amendments containing a high carbon to nitrogen ratio must be added to the bin to ensure proper composting. A carbon to nitrogen ration between 20:1 and 40:1 is satisfactory. The amendment used to compost the rabbit mortalities was a 50/50 mixture of dry litter and sawdust.

The mortalities and amendments were layered in the primary composting bins following the guidelines by AAFRD. A 30 cm (12 in) layer of amendment was placed in the bottom of the bin. Carcasses were placed at least 23 cm (9 in) away from bin walls. The layer of carcasses was then covered with 15 cm (6 in) of amendment. The layering was continued to a depth of 1.2 m (4 ft) and then it was capped with 30 cm (12 in) of amendment. Figure 2 depicts how poultry are layered into a composter, the same guidelines were used for the rabbit mortalities in this project.

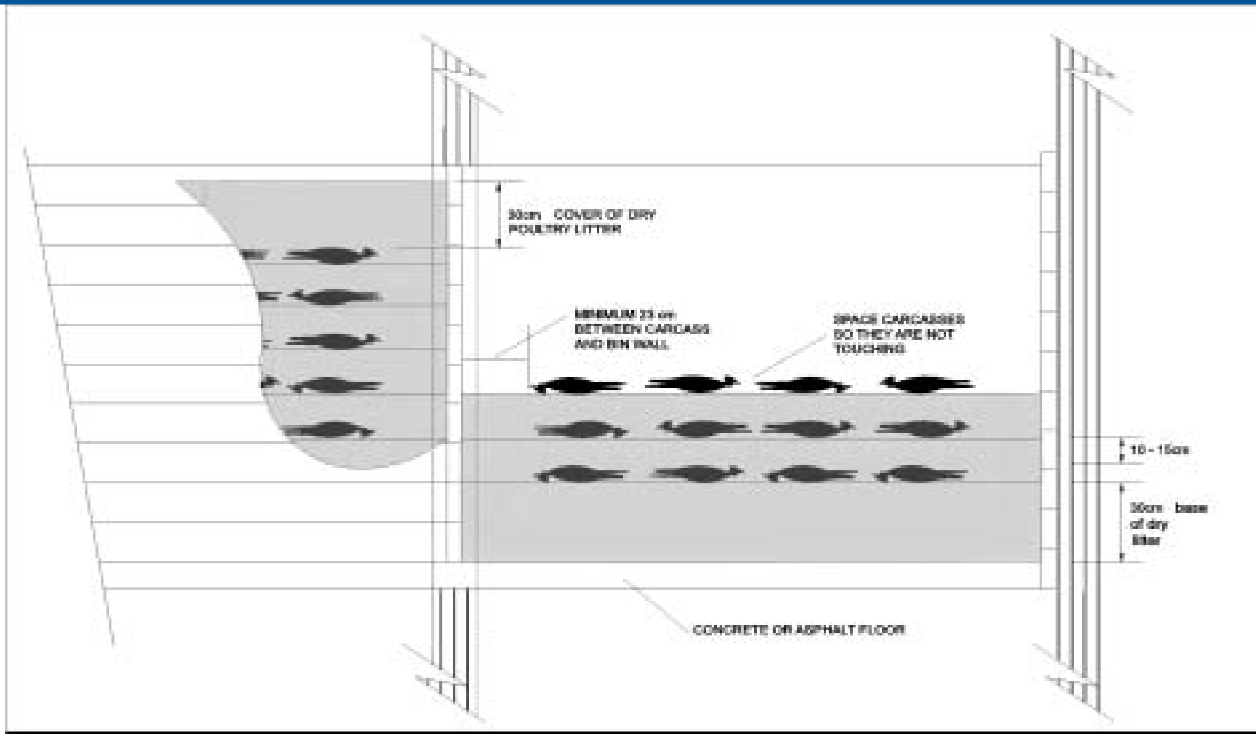

Figure 2: Composting bins are loaded in layers.

The completed primary bins were moved to the secondary bin area after five weeks of composting. The secondary bins were allowed to compost for an additional five weeks before being moved to the completed compost storage area.

Composting Temperatures

A digital temperature sensing network was used to monitor and log temperatures hourly for the second and third primary phases. The sensors were located in probes which allowed the sensors to be inserted into the bin at 30, 60, and 90 cm (1, 2, and 3 ft) depths. The temperatures were recorded for all three depths at nine locations (Figure 3). The first primary phase temperatures and the secondary phase temperatures were measured three times per week with a digital temperature probe.

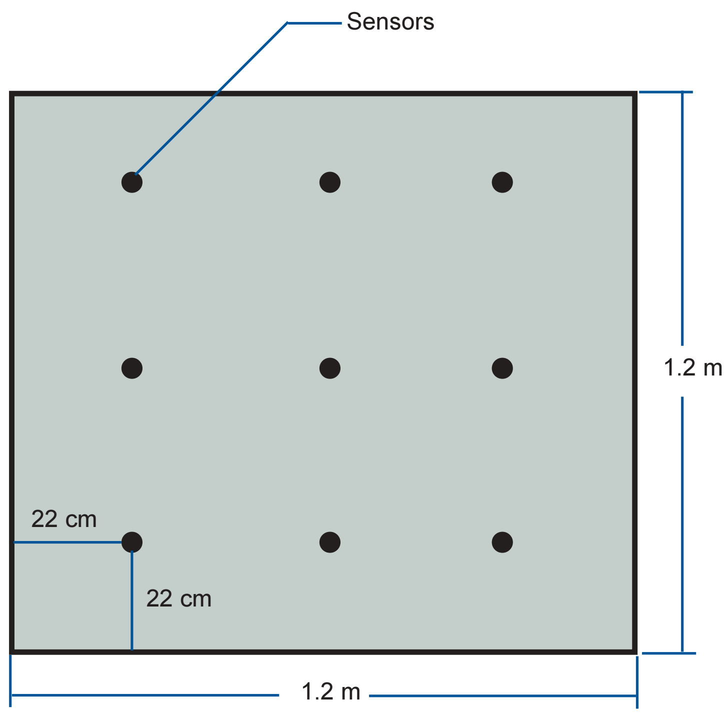

Figure 3: Top view of primary bin temperature locations

RESULTS AND DISCUSSION

Composting Temperatures

The primary phase, in all cases, produced temperatures in the mesophilic range, 10 - 43°C (50 - 110°F), not capable of destroying pathogens, weed seeds, and fly larvae. The temperature at the 30 cm (1 ft) depth briefly reached the thermophilic range. The temperatures at the 90 cm (3 ft) depth were lower than the 30 and 60 cm (1 and 2 ft) depths (Figure 4).

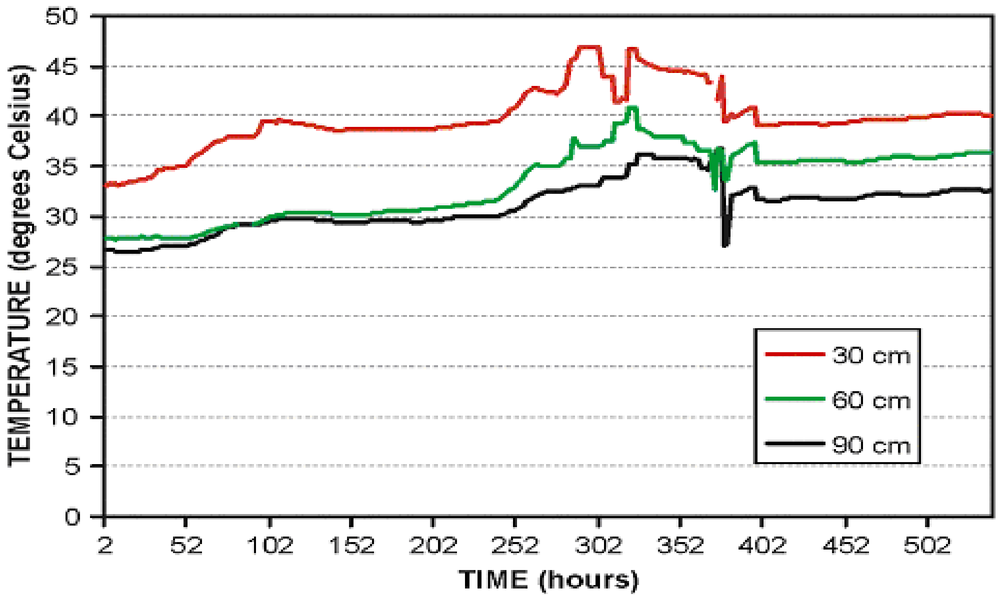

Figure 4: Primary compost temperatures

The secondary phase was successful in producing thermophilic temperatures, 43 - 71°C (110 - 160°F), that were maintained for more than three weeks. The average temperature during the secondary phase was 47°C (117°F).

Odour and Visual Observations

The completed primary bins were moved to the secondary bin area after five weeks of composting. The product was non-homogeneous and the effects of layering were still present (Figure 5). Hair and small bone fragments were present in the product. The odour was very mild yet suggested the process was anaerobic.

After the completion of the secondary phase the product had little odour, was homogeneous, and contained little to no mortality evidence. Small bone fragments were present yet extremely brittle.

Figure 5: Layering effect after completion of primary phase

CONCLUSIONS

- Small animal production with low mortality rates can be successfully composted in a bin composter.
- Building an entire bin at one time results in some compaction in the bottom layers resulting in lower primary temperatures and a less aerobic condition than the upper layers.
- The secondary phase is necessary to ensure complete degradation of mortalities, homogeneous product, and a stable product free of pathogens, weed seeds, and fly larvae.
- Composting material and mortalities for four to six weeks in each of the primary and secondary phases through the winter of 2001 and spring of 2002 was sufficient.

Appendix A

Livestock Diseases Act: Destruction and Disposal of Dead Animals Regulation

Method of Disposal

2 (4)

(d) composting

(i) in a Class 1 compost facility as defined in the Waste Control Regulation (AR 192/96) that is designed, constructed and operated in accordance with sections 6 and 7 of the Code of Practice for Compost Facilities, published by the Department of Environment, or

(ii) subject to subsection (5), in a farm open compost pile that is

(A) located at least 100 metres from wells or other domestic water intakes, streams, creeks, ponds, springs and high water marks of lakes and at least 25 metres from the edge of a coulee, major cut or embankment,

(B) located at least 100 metres from any residences,

(C) designed in a manner that will exclude scavengers, and

(D) at least 100 metres from any livestock facilities, including pastures, situated on land owned or leased by another person,

References

B.C. Agricultural Composting Handbook
Second Edition, 2nd printing, September, 1998.
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AAFRD Handbooks

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