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Carcass Composting – A Guide to Mortality Management on Michigan Cattle Farms

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Objectives of this bulletin:

1) Help cattle producers in Michigan become aware of and understand how to properly utilize composting for animal carcass management.
2) Help cattle producers develop or make improvements in mortality management procedures while achieving environmental compliance with state regulations (the Michigan Bodies of Dead Animals Act [BODA], Act 239 of 1982).

Cattle producers need to make decisions about mortality management on their farms and meet environmental compliance and societal expectations. For many, this can be problematic for a variety of reasons. Traditionally, on-farm burial or transfer of a carcass to a renderer have been the most common options. But the Michigan Bodies of Dead Animals Act allows several other mortality management options, and cattle owners need to be aware that composting — more specifically, open pile composting without a constructed facility — is an acceptable and viable way to dispose of livestock mortalities.

Composting is a managed biological decomposition process that converts organic matter into stable, humus-like material. In the case of mortality composting, the organic matter being converted includes the animal carcass. In the past three decades, research has proven that animal tissue can be effectively and safely composted. Before this, it was generally unacceptable to compost animal remains. Composting is a process in which microorganisms flourish with the proper mixture of bulking agents (sometimes referred to as "feedstock" or "amendments"; see Table 1), animal tissue, water and air. When done properly, the process consumes tissue, minimizes odors and produces quality finished compost.

Table 1. Bulking agents approved in Bodies of Dead Animal Act rules as amended June 2, 2011.

Sawdust	Fresh manure
Chopped straw	Manure, with or without plant fiber-based bedding
Spelt hulls	Wasted feed (ground corn, silage, haylage)
Bean pods	Legumes (peas, beans, soybeans)
Grass clippings	Hay
Leaves	Shrub and tree trimmings
Shredded cardboard or newspaper	Cornhusks, cobs
Chopped cornstalks	Wood chips
Finished compost	

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Bacteria in a compost pile carry out the majority of the active decomposition of the carcass and amendments. These organisms produce heat as they consume sugars, starches, proteins, fat and some cellulose.

Composting Site Selection

When selecting a composting site, especially if you are using the open pile composting method (Photo 1), it is critical to consider the environmental impacts. The location of the composting site should minimize the impact of odor and other air quality issues on any neighboring residences and prevent the movement of nutrient-containing water into surface water and groundwater. Other considerations include the direction of prevailing winds, the distance to property lines, proximity to recreational or public sites, aesthetics and the slope of the site.

Photo 1. Open compost piles.

Michigan has specific criteria that all composting sites must meet (BODA, 2008):

- A well-drained area with a minimum setback of 200 feet from waters of the state (this includes lakes, streams, wetlands, sinkholes, seasonal seeps or other landscape features that indicate the area is hydrologically sensitive).
- A minimum of 2 feet above the seasonal high water table.
- A minimum of 200 feet from any well.
- A minimum of 200 feet from the nearest neighboring residence.

Concrete or asphalt paving makes an excellent foundation for a composting site that is easy to clean and maintain. A small area in a field or pasture is also acceptable, however, if the environmental considerations listed previously have been taken into account. Drainage around the pile is particularly important. Water should not pond around the pile, and access to the pile with a loader should not be limited by field conditions. A base such as gravel, lime, sand, wood chips or other materials is not recommended because it may make mixing and turning the material more difficult.

Site Security

Constructing a temporary physical barrier (perimeter fence) around the compost pile will help prevent scavenging wild animals or pets from rummaging in the pile. This can be accomplished using materials such as chain-link or equally restrictive fencing with a gate or gates. If an animal in the pile has been chemically euthanized, the decomposing carcass could poison other animals that feed on it. The composting process diminishes this risk by denaturing the chemical compound while decomposing all soft (edible) tissue. Properly covering the carcass with a sufficient volume of bulking agent and a biofilter covering (described below) are also very important preventive measures.

Getting the Compost Recipe Correct

A compost recipe is designed to stimulate microbial population growth, minimize odors, and produce quality finished compost by optimizing the mix of bulking agents, animal tissue, water and air. The five criteria of a good recipe are:

1) A carbon-to-nitrogen (C:N) ratio between 15:1 and 40:1.

2) A moisture content range of 40 to 60 percent.

3) A temperature range of 100 to 150 degrees Fahrenheit.

4) An oxygen concentration greater than 5 percent.

5) A pH range of 5.5 to 9.0.

Carbon-to-nitrogen ratio (C:N). The C:N ratio describes the relationship between the carbon and nitrogen elements in the composting mixture. If there is too little carbon available, the excess nitrogen in the mixture is converted to ammonia, resulting in a strong ammonia smell. If the C:N ratio has too much carbon, the low nitrogen supply limits microbial activity and slows tissue decomposition. Low temperature readings would result in both cases. Table 2 lists C:N ratios for bulking agents that may be available on a cattle farm.

For composting whole carcasses, the C:N ratio of the mixture of bulking agents, apart from the carcass, should be within the optimum C:N ratio range of 15:1 to 40:1 at the start of the composting process. Initially, the C:N ratio of the mix of the bulking agent(s) that will surround the whole carcass is critical. The nitrogen and carbon within the carcass are isolated in the carcass and not readily available for microbial consumption. The nutrient contribution of the more nitrogen-dense animal tissue to the C:N ratio will not be available to the composting process until the whole carcass partially decomposes and opens, exposing its soft tissues. When the batch of compost is aerated or mixed for the first time, the remaining carcass breaks apart further, and the smaller pieces of carcass will then be mixed with the bulking agents. The nutrients in the carcass will then contribute to the C:N ratio of the compost. When composting carcasses have been exposed to a mechanical treatment — cut into pieces, ground and/or placed into an in-vessel composting unit with a rotating drum — the nutrient contribution of the animal tissue to the C:N ratio is available earlier in the composting process. Therefore, the C:N ratio of the entire compost mix — bulking agents and animal tissue — should be estimated initially.

Table 2. Carbon-to-nitrogen ratios of selected compost bulking agents.

Bulking agent	C:N ratio
Sawdust	442:1
Cow manure	20:1
Softwood shavings	641:1
Hardwood shavings	561:1
Hay — general	15-32:1
Wheat straw	127:1
Finished compost	30-50:1
Grass clippings	17:1
Leaves	54:1

Source: On-Farm Composting Handbook (NRAES-54), Natural Resource, Agriculture and Engineering Service. 1992.

Moisture content. As a general rule, compost should be moist to the touch. At the start of the composting process, the moisture content of the bulking agent mixture surrounding the carcass should be within the range of 40 to 60 percent. The bulking agent used as the base of the pile should be slightly drier — around 15 to 30 percent moisture — so it will readily absorb the liquids that will exit the body cavity when it is opened by microbial degradation. Active composting will fail to occur if the bulking materials surrounding the carcass are too wet or too dry. If the bulking materials form a stable ball or drip when squeezed by hand, the pile is too wet. To restart the active composting process, the pile must be mixed to allow air to infiltrate the pile and excess water to exit. If the pile becomes too dry, water should be added, preferably by a uniform, consistent spray.

The pile should be generally cone-shaped to promote the shedding of as much water as possible. This helps prevent the accumulation of moisture when large amounts of precipitation occur over a short period of time and reduces the risk of nutrients moving from the compost into the soil.

Oxygen concentration. Both anaerobic (without air) and aerobic (with air) activities occur when a whole carcass is composted. At the beginning of a composting process containing an animal mortality, an anaerobic microzone exists within the carcass. Here anaerobic microorganisms work to decompose the tissues, releasing nutrients, fluids and gases, which are dispersed into the surrounding bulking agent. This interface, where products of anaerobic animal tissue decomposition and bulking agent meet, is a critical aerobic microzone. Aeration of the compost by turning, moving or mixing the contents of the compost pile/batch (Photo 5) promotes the growth of the hardier, more robust aerobic bacteria by infusing air into the materials and providing a desirable oxygen concentration of 5 to 20 percent.

Bulking agent particle size is important because it affects the air spaces within the pile. If particle size is too fine, the spaces between particles are small and oxygen cannot move through the pile. Limited microbial activity and odor will result. Fine particles, however, are absorbent and help capture fluids released from the carcass during composting. If particle size is too large, there is too little interface between animal tissue and the carbon source, which limits microbial metabolism. Excessive coarseness results in too much air in the pile, causing the pile to cool. A non-uniform particle size range of 0.1 inch to 2 inches is recommended. A mixture of particles in this size range provides porosity, allows oxygen to enter the pile, and maximizes particle surface area and absorption capacity for odors and liquids. The compost pile should be a maximum of 6 to 8 feet tall to prevent compaction and the loss of air space within the pile.

Temperature. Composting activity and microbial respiration result in a rise in temperature. Temperatures within the desired range of 100 to 150 degrees F enhance microbial reproduction. Low temperatures can be caused by too much or too little moisture, lack of oxygen and/or an inappropriate C:N ratio. Temperatures above 150 degrees F kill composting organisms and therefore are not desirable. Temperatures within each batch must reach 130 degrees F at least once before the pile is aerated. Desirable temperatures can be achieved in winter if bulking agents and animal tissues are not frozen when the batch is initiated.

pH. Active composting will occur only within a pH range of 5.5 to 9.0. A low pH (below 5.5) slows down the composting process; a high pH (above 8.5) promotes the conversion of nitrogenous compounds to ammonia. In most cases, the pH does not need to be adjusted because of the natural buffering capacity of commonly available amendments and the normal pH of animal tissue. Do not use very acidic bulking agents such as corn silage, oak leaves and pine needles, or basic (alkaline) bulking agents such as bedding containing significant amounts of lime as the only composting amendment. The extremes in pH will limit microbial reproduction and, ultimately, microbial activity. Waste corn silage is a good bulking agent or feedstock when mixed at least 50:50 with other, more neutral materials. As a practical matter, pH usually is not monitored on the farm. But, if pile activity is not proceeding normally, sending a sample to a commercial laboratory may be appropriate, and pH would be one of the factors tested in addition to dry matter and the C:N ratio.

Carcass Placement

The carcass should be placed in the center of the pile (Photo 2) to ensure that all parts of the carcass are enclosed by the bulking agent(s). A guideline on pile size is to have 24 inches of bulking agent surrounding the entire carcass or animal mass (Photo 3). When estimating the amount of bulking agent needed under and over a carcass, plan for 1 cubic yard of bulking agent for every 100 pounds of carcass weight. For composting young stock mortalities, multiple animals can be positioned in a single batch (pile), but the batch or pile of carcasses should still be surrounded with 12 to 24 inches of bulking agent.

Photo 2. Cow carcass placed in the center of the compost pile foundation.

Photo 3. Illustrations showing the most desirable depth of bulking agent that should surround the carcass.

Photo 4. Covering the carcass and shaping the new pile.

Biofilter Cap

A biofilter cap is a layer of fresh bulking agent placed over a pile to reduce odors and discourage pests (see Figure 1). Carbon-rich materials such as chopped straw, dried grass, chopped dried hay, and sawdust or shavings are preferred as biofilter materials. A fleece blanket (synthetic fabric that sheds precipitation but allows normal composting respiration) could also be used to cover composting materials for partial odor and pest control. Nitrogen-rich materials such as animal manure solids, partially decomposed materials, green grass clippings, freshly cut forages, green leaves and litter cake are less effective in controlling odors, insects and vermin and are not recommended.

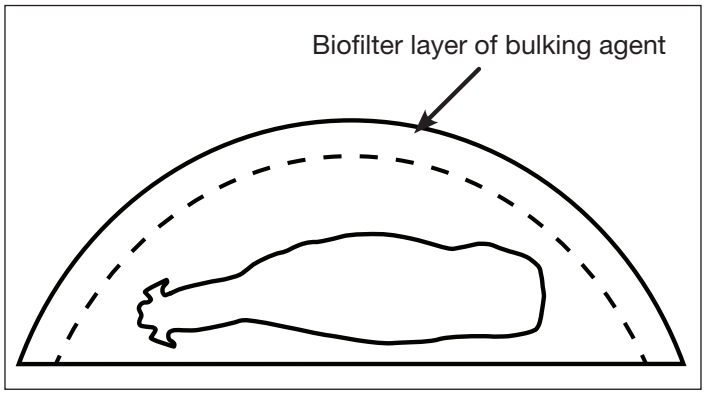


Figure 1. Biofilter layer on an open static compost pile.

Aeration

Aeration of the compost by turning, moving or mixing the contents of the compost pile (Photo 5) promotes the growth of aerobic bacteria by infusing air into the materials and encourages a desirable oxygen concentration of 5 to 20 percent. Photos 5 and 6 show the contents of a static compost pile following one month of composting. A majority of the soft tissue has decomposed, leaving very clean bones. After turning, mixing and reforming the pile, the farmer should place another biofilter cap on the pile.

Photo 5. Turning the compost pile after one month of active composting exposes clean rib bones from the cow carcass.

Photo 6. Michigan law requires that each batch of mortality compost be turned at least two times after pile formation to add air back into the material and to achieve additional periods of temperatures greater than 130 degrees F (three such high temperature cycles are required).

Compost Pile Management

The number of months of well-managed active composting in static batches for the decomposition of all soft tissues from carcasses of various sizes is shown in Table 3. Photo 5 shows the effective decomposition of soft tissues for a 1400-pound cow in a well-managed pile 30 days into the composting process.

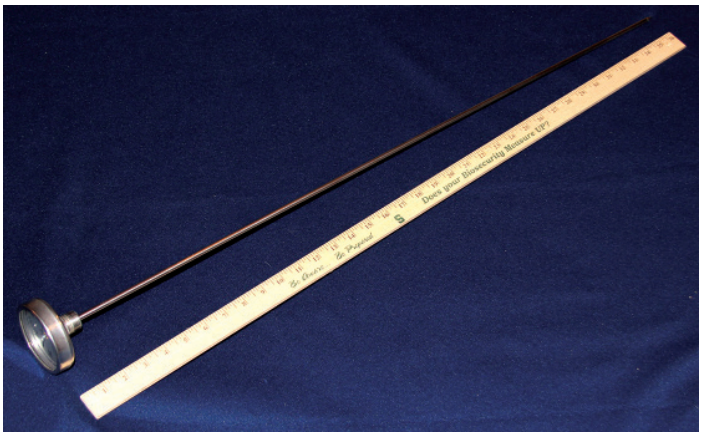
An actively composting static pile will increase in temperature over the first several days and then generally level off or continue to rise slightly. The internal temperature of the compost pile must be monitored and recorded once weekly. This can be accomplished by inserting a long-stem thermometer at least 12 inches into the compost pile (Photos 7a and 7b). The temperature within the pile should reach a minimum of 130 degrees F. During active composting, the temperature may remain in a range of 100 to 150 degrees F for several weeks before decreasing. The pile should be turned when compost temperatures have been at 100 degrees F or more for one to two weeks. It is important for the compost pile to reach these high temperatures to ensure the destruction or deactivation of pathogenic organisms. If your static pile does not reach these temperature levels within a few days, the pile may need adjustments to aeration, C:N ratio or the water content of the pile contents.

Active composting will take place in cold weather if active compost from another functioning static pile is used as a bulking agent and completely surrounds the carcass. Animal tissue enclosed in warm compost during cold weather will begin decomposition without delay. The carcass to be composted should not be allowed to freeze. (The Bodies of Dead Animals Act calls for mortalities to be incorporated in the compost pile within 24 hours after death.) Frozen animal tissue may thaw and then begin the decomposition process if placed in a large amount of active compost already at 130 degrees F or greater. If the frozen carcass is placed in a mixture

Table 3. Months of active composting suggested for the decomposition of soft animal tissues.

Carcass size, pounds	Suggested number of months for well-managed** active composting in static batches for the decomposition of all soft tissues
1 to 25	1
25 to 125	1
125 to 250	1.5
250 to 500	2
500 to 1000	2
1000 or more	3

** *Aerated by mixing two to three times, keeping a moisture level of 40 to 60 percent, and making sure all tissue resides in the interior of the pile.*



Photos 7a and 7b. Long-stem thermometer (available commercially as "compost" or "windrow" or "hay" thermometer) is used to monitor internal temperature.

of cold bulking agents, the composting process may not start until ambient temperatures increase in the spring. Temperature management can be a challenge for animal owners who do not experience consistent mortalities year round. Other carcass management options such as burial, incineration, rendering or landfill may be considered if no functioning static compost piles are available during winter months.

The Michigan Bodies of Dead Animals Act calls for animal tissue compost to undergo a minimum of three heat cycles to 130 degrees F or greater before final utilization as finished compost. As a practical matter, the batch or pile must be turned and mixed in place at least two times after the formation of the pile. Finished compost must have no visible pieces of soft tissue. The time required for full decomposition of soft tissue varies with the quality of the recipe and the retention of tissue in the center of the composting pile. Composting of soft tissue may take as little as one month or as long as six months, depending on how well the composting activity is maintained. Bones, however, may require more time to decompose – how long depends on the size of the bone and the maturity of the animal. Bones become increasingly brittle with active composting but may remain intact even though the soft tissue is gone. Spread bones on cropland only if they will be shattered during spreading. If they are not brittle enough to shatter, they should be added to another active compost pile for further composting, buried or sent to a landfill which accepts animal tissue. It may take one to two years of active composting to fully decompose the large bones of a mature animal.

Record Keeping

Additional guidelines from the Michigan BODA:

The owner or operator of the composting system shall keep records for five years containing all of the following information:

- The start date of each compost batch.
- The approximate weight of the carcass and the date composting was started.
- The date(s) the compost material was mixed or aerated.
- The final disposition of the finished compost, including the method, location, date and volume for the batch.

Conclusion

Composting mortalities of dairy and beef cattle is a viable disposal option for many farms. The composting process works best when managed attentively from start to finish. Effective composting requires meeting desirable ranges for five conditions: C:N ratio, moisture content, temperature, oxygen level and pH. Farmers need to start with a good bulking agent(s) recipe, aerate the pile multiple times and add water as needed. Under

optimum conditions, rapid and complete decomposition of soft tissue will occur. Further management of bone decomposition is essential. Knowing how to compost bovine carcasses will ensure proper consideration of the environment, neighbors and state regulations.

Acknowledgements

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For supporting information on Michigan animal carcass composting regulations, refer to:

The Bodies of Dead Animals Act (BODA; Act 239 of 1982, as amended), 2008, available at **www.michigan.gov/mdrd/0,4610,7-125-48096_48404---,00.html**.

Rozeboom, D.W., S. Reamer and J. Sanders. 2007. Michigan Animal Tissue Compost Operational Standard. Available at **www.msu.edu/~rozeboom/catrn.html**.

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