Composting Animal Mortalities

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Introduction

The management of animal mortalities is an important aspect of livestock farming since even the best livestock farmers lose some of their animals each year. Rendering, burial, and incineration have been the typical carcass disposal methods. However, these options are becoming less practical for many farmers because of decreasing availability and higher costs of rendering, biosecurity concerns, and potential adverse effects on groundwater and air quality. For these reasons, composting is becoming more widely used as a method of mortality disposal. A properly managed mortality composting system is low cost, environmentally sound, biosecure, and virtually odor free.

While there is much in favor of composting, you must decide whether or not it fits into your operation. Minnesota Board of Animal Health regulations allow composting of poultry, swine, sheep, and goats without a permit, and cattle can legally be composted if a permit is obtained. Like any other farm operation, successful composting requires a commitment to managing it well.

This publication describes mortality composting, answers commonly asked questions, outlines what is needed to compost on your farm, explains how to compost step-by-step, and outlines applicable regulations. It also contains resources for more information.

The Mortality Composting Process

Composting is an aerobic, natural process in which microorganisms convert organic material into a stable product called compost.

Composting is a naturally occurring process in which bacteria, fungi, and other microorganisms convert organic material into a stabilized product termed compost. This means that microorganisms do the composting work for you. Your role in managing the composting process is to make sure that the microorganisms have the environment they need in order to do their work quickly and effectively.

In mortality composting, the animal carcass is placed in a composting bin. A bulking agent such as sawdust or straw that is high in carbon is placed around the carcass to completely surround it.

Within the carcass, anaerobic microorganisms work to degrade it, releasing fluids and odorous gases such as hydrogen sulfide and ammonia. These diffuse into the surrounding bulking agent. In this bulking agent, aerobic microorganisms degrade these materials to odor-free carbon dioxide (CO_2) and water (H_2O). The aerobic process produces considerable heat, causing the temperature of the compost pile to rise. The active bacteria in both the aerobic and anaerobic zones are heat tolerant. However, the heat kills common viruses and bacteria that may be present in the carcass. Odor is controlled by having an adequate quantity of bulking agent around the carcass.

Composting produces
- ***Carbon dioxide***
- ***Water***
- ***Heat***
- ***Fertilizer***

The compost pile is usually left undisturbed until the temperature has subsided, meaning that the aerobic microorganisms are working less efficiently because they have exhausted much of the food and air in their environment. At this point the flesh and small bones will have decomposed. After this first heat cycle, the pile is turned, introducing air into the pile. This increases aerobic activity and the temperature rises again. After the temperature subsides a second time, the compost should be finished, with no flesh, hide, or small bones present, although some large bones may remain.

How the Mortality Composting Process Works on the Farm

On the farm, at least three composting bins are used:
1. A primary bin in the process of being filled
2. Another primary bin in the first heat cycle of composting, and
3. A secondary bin in the second heat cycle

When you first start composting, new carcasses and bulking agent are added to the first bin until the bin is full. This pile is then left to compost and new carcasses are layered with bulking agent into a second bin. When the first pile has completed the first heat cycle, the pile is turned by moving it to a third empty bin, and it is left to compost for the second heat cycle. By this time, the second bin is usually full and is left to compost. A new pile is started in the first bin, which is now empty. When the first pile has gone through the second heat cycle, it is removed from the bin and either stored or spread on crop fields. This on-going process ensures that carcasses can be disposed of continuously.

It takes from 7 to 24 weeks for carcasses to degrade and for the compost to reach the finished stage. The amount of time required depends on the bulking agent used, temperature, moisture, management, and the size of the animal (large animals can take longer to decompose than small animals).

The Animal Mortality Composting Process

First Heat Cycle

- Carcasses and bulking agent layered in pile
- High rate of anaerobic and aerobic activity
- Temperature increases
- Breakdown of flesh and small bones
- Temperature subsides

Second Heat Cycle

- Turning the pile initiates increased aerobic activity
- Temperature increases
- Breakdown of long bones, skull and pelvis
- Stabilization of compost material

Changes in Materials During Composting

Finished compost is
- ***Consistent and soil-like***
- ***Dark brown to black***
- ***Reduced in volume and weight***

By the time composting is complete, the material becomes more uniform and less active biologically. The material (humus) becomes dark brown to black in color. The particles reduce in size and become consistent and soil-like in texture. The volume and weight of materials are reduced due to loss of carbon dioxide and water to the atmosphere and to bulky raw materials changing into crumbly, fine-textured compost.

Why Composting is a Good Choice

Composting is
- ***Biosecure***
- ***Environmentally sound***
- ***Cost effective***
- ***Easy***

Biosecure
Composting allows immediate year-round disposal of carcasses so that disease is not spread. There is no entry of off-farm vehicles that can bring disease onto the farm from other operations, and the high temperatures in the compost pile kill pathogens.

Environmentally sound
A properly functioning compost pile gives off little odor and does not harm or affect groundwater. Composting turns a waste into a beneficial fertilizer and soil amendment, resulting in on-farm nutrient recycling.

Cost effective
Composting has low to moderate start up costs and minimal operating costs.

Easy to accomplish
Composting requires only good management and minimal training. It utilizes readily available organic materials.

Commonly Asked Questions About Composting

Will I have problems with odor?

No. A properly managed compost pile with enough bulking agent will not produce offensive odors. Farmer cooperators in three Minnesota demonstration projects found that the layer of sawdust or bedding on top of the pile greatly reduced odor and, once the compost heated up, offensive odors were essentially absent.

Will the composting piles attract flies and rodents?

No. Flies are not a problem because internal temperatures above 130° F will kill existing fly larvae. Also, when piles are covered by at least 12 inches of bulking agent, flies and rodents are not attracted to the area. If manure is used in the pile and not covered adequately by a bulking agent, some flies may be present on the surface but they will not be able to reproduce.

Will the compost spread diseases?

No. The high temperatures of proper composting will destroy most harmful bacteria and viruses associated with livestock. Viruses that cause avian influenza, Newcastle disease and pseudorabies are completely inactivated by the end of the second heat cycle. Bacteria such as *Salmonella enteritidis, Pasteurella multocida, Erysipelas rhusiopathiae* and *Salmonella cholerasuis* will be successfully destroyed by the composting process.

Will composting work with all animals?

Yes. Poultry, swine, sheep, and goats can all be composted without a permit. The Minnesota Board of Animal Health regulations require a permit for cattle. With larger animals such as sows and larger cattle, some of their large bones may take longer to decompose than with smaller animals. These bones can be removed from the finished compost and returned to an active pile for further composting. Note that while any species can be composted, Minnesota Board of Animal Health regulations do not allow composting of any animals that died from anthrax or toxic materials.

Will I recognize animal parts in the compost when I turn it?

No. Farmer cooperators in three Minnesota demonstration projects found that when the piles were ready for the first turning, the only recognizable parts were larger bones, teeth, and pieces of hides. These bones were rubbery and decalcified, and could be broken easily. There were even fewer after the second turning.

Is composting costly?

No. The main cost is in building a composting structure. Some farmers in Minnesota have renovated existing buildings for little cost. Another cost may be a front-end or skid steer loader to handle the mortalities and compost. The only on-going cost is the bulking agent and the skid steer. Your farm may have bulking agents (such as straw, litter, bedding, or corn stalks) available at no cost. If not, you will have to purchase bulking agent. This cost should be minimal.

Will composting take a lot of labor?

No. The labor involved is minimal, consisting of placing any new mortalities in the bin every day and covering them with bulking agent, checking the temperature of the pile every day, moving the pile between the primary and secondary stages of composting, and moving the finished compost to storage. One Minnesota farmer who had a composting demonstration site on his farm estimated that it took about ten minutes each day to manage.

Are there uses for the compost when it's done?

Yes. The finished compost can be used in your next compost pile to replace part of the bulking agent and provide a large microbial population right away. It can also be spread on crop fields to provide beneficial organic matter and nutrients to the soil and the crops.

Can composting be done in the winter in Minnesota?

Yes. Active piles will continue to heat during the winter. New piles should not be started during the winter unless active, hot compost is available as the bulking agent.

Can any size operation use composting?

Yes. However, if small operations use a seasonal livestock production cycle, they may have trouble composting in winter if the input of carcasses is small and inconsistent. Small compost piles do not heat as fast or as hot and are not self-insulated, and therefore may not reach ideal temperatures in winter.

Can varmits be a problem around the compost pile?

Yes. Visiting dogs, coyotes, raccoon, skunk and fox can become problems. A very hot and active compost pile where the carcasses are adequately covered is the best solution.

The Mechanics of Composting

Your job in managing the compost pile is to provide the right food and environment for the microorganisms so that they can get their composting work done quickly and effectively. There are four aspects of the compost pile that are important to microorganisms and that are important in your management of the process.

Compost microorganisms need
- ***Carbon***
- ***Air***
- ***Water***
- ***Elevated temperature***

1. Carbon: Because animal carcasses are very high in nitrogen, you must add large amounts of carbon (in the form of a bulking agent) to the pile in order to provide the right environment and food for the composting microorganisms. The carbon to nitrogen ratio (C:N ratio) describes the amount of carbon compared to the amount of nitrogen in the pile. Minnesota Board of Animal Health regulations require that the C:N ratio of the pile be between 15:1 and 35:1. However, you don't need to be too worried about measuring the exact C:N ratio, since the composting process is fairly forgiving and will occur under a range of C:N ratios, as long as you keep the overall carbon to nitrogen balance in mind. If there is too little carbon (low C:N), the high nitrogen supply is converted to ammonia and is emitted from the pile, resulting in odors. If there is too much carbon (high C:N), the low nitrogen supply can limit microbial activity resulting in slow carcass decomposition and cool temperatures.

2. Air Flow: Since aerobic microorganisms need oxygen to work, oxygen must be able to move into the pile and carbon dioxide and water vapor must be able to escape. This means that the bulking agent must have a particle size that allows air to move freely. Bulking agents, such as newsprint, can pack down, inhibiting air flow to the microorganisms, which will slow or even stop the composting process and produce odors. Large particles, such as branches, can let too much air in, cooling the pile and slowing down the work of the microorganisms.

3. Moisture Content: Microorganisms require water as a medium for chemical reactions, to transport nutrients, and to move about. Compost with too little moisture will not supply sufficient water for microorganisms to survive. Too much moisture inhibits oxygen flow through the pile, causing aerobic microorganisms to slow down, which can lead to odors.

4. Temperature: Temperature is both a necessity for and a result of microorganisms' work. The warmer the pile, the faster the microorganisms work, the more heat they produce, the warmer the pile, and so on. If the temperature is too low (less than 120°F), microorganisms are not very active, which means decomposition will occur at a slow rate and pathogens and weed seeds will not be

destroyed. The temperature should reach 130° to 150° F for several days or weeks because at this temperature, microorganisms are active, decomposition proceeds quickly, and pathogens are destroyed.

What You Need To Get Started

Bulking Agent

Bulking agent considerations
- ***Availability***
- ***Cost***
- ***Particle surface area***
- ***Carbon to nitrogen ratio***

Many organic materials can be used as bulking agents, but different materials vary in their availability, cost, and physical characteristics. Sawdust has been widely used and has excellent odor-absorbing potential. Hay and straw will also work. Greener hay or hay with more legumes will have less carbon (lower C:N ratio) while drier hay or hay with more grass will have more carbon (higher C:N ratio). Crop residues such as wheat straw or corn stalks can be used but may require shredding or some form of particle size reduction.

You can also use finished compost as part of the bulking agent in a new pile. This has the advantage of inoculating the new pile with microorganisms. Some typical bulking agents and their characteristics are shown here.

When choosing a bulking agent, you should also consider:

1. Availability: You must have access all year to enough bulking agent to make sure your piles compost well. Check out both on-farm and off-farm sources and make sure the bulking agent you decide to use will be available consistently and in high enough quantities from one or more sources throughout the year.

2. Cost: While the cost of on-farm materials is low, it is possible to find bulking agents from other sources that may also be low cost. This is especially true for materials that are considered waste products such as sawdust or wood shavings.

Common Composting Materials

Substance	***Carbon to Nitrogen Ratio (Weight to Weight)***
Sawdust[1]	200 - 750 :1
Straw[1]	48 - 150 :1
Corn stalks[1]	60 - 73 :1
Finished compost[1]	30 - 50 :1
Horse manure[1]	22 - 50 :1
Turkey litter[1]	16 :1
Animal carcass[2]	5 :1
Swine manure[2]	1 - 3 :1

[1] On-Farm Composting Handbook, NRAES-54, Natural Resource, Agriculture, and Engineering Service, Ithaca, New York.

[2] Compost Materials, 1996, EBAE172-93, North Carolina Cooperative Extension Service, Raleigh, North Carolina

3. Physical Characteristics: The physical characteristics of the bulking agent will affect how well your compost piles work. In addition to choosing a bulking agent with the appropriate C:N ratio, you want to find a bulking agent with a large enough particle size to let air flow, but not to the point that it cools the pile. It should have enough surface area for the microorganisms to grab onto.

Whatever bulking agent you decide to use, you can calculate the annual volume needed based on your annual death loss. Using sawdust as an example to estimate the bulking agent volume you will need for one year of composting, first determine the pounds of death loss you have per year (use tables on pages 12 and 13), and then multiply by .0067 yd^3 per pound of dead animal. This will give you an estimate for planning purposes only. Other bulking agents may differ. If you will use finished compost to replace part of your bulking agent, remember to factor that into your estimates.

Water

Composting happens most ideally when the pile is moist. This means that you may have to add water to your compost pile. The amount of water you will add will depend on the moisture content of your compost ingredients, especially of your bulking agent. In general, you can judge the proper moisture content by feeling the compost. It should be moist and leave your hand feeling moist, but you should not be able to squeeze any water out of it.

Other Ingredients

Manure can also be used in the compost pile but is not necessary. Manure tends to be high in nitrogen and low in carbon . The advantages of using manure are that it adds microorganisms to the pile, adds nitrogen which can help speed up the composting process, and adds moisture. The disadvantage is the danger of excessive nitrogen in the pile resulting in odor, flies and other composting problems. You may have to add more bulking agent to compensate for the increased nitrogen.

Liquid manure has very little carbon (low C:N ratio), while manures cleaned from stalls may include bedding material which will increase the carbon (higher C:N ratio). Turkey litter has been used in some composting piles in Minnesota.

Other Supplies

Thermometer: A probe-type thermometer with a minimum 36-inch stainless steel stem is needed to monitor the pile. Suppliers of thermometers are included in Further Resources.

Composting Log: A logbook is needed where you can record dates and weights of carcasses placed in the composter, temperature readings, amounts of bulking agent used, dates when compost is turned, and dates and amounts of finished compost.

Front-End or Skid Steer Loader: The loader is needed to move carcasses from the production buildings to the composter, place carcasses in the compost pile, cover the carcasses with bulking agent, mix and turn compost, and move finished compost.

Manure Spreader: A manure spreader should be available for field spreading finished compost.

Hoop structure with six bins; note concrete apron and sawdust pile in foreground.

Composting Structures

A wide range of structures is possible, including new or existing facilities, and stand-alone units or add-ons to an existing building. For new facilities, poured concrete, pole construction, and hoop houses have all been used in Minnesota. Existing facilities, such as machine sheds, corn cribs, or cattle sheds can be adapted if the ceiling is high enough to allow the front-end or skid loader to lift and turn the compost. This can be a low cost option. One Minnesota farmer adapted a Cargill open-front unit for composting with no remodeling costs.

Composting structure regulations
- ***Impervious weight bearing pad***
- ***Covered***
- ***Rot resistant building materials***

Minnesota State Board of Animal Health regulations recommend that the structure be:

• ***built on an impervious weight-bearing pad that is large enough to allow the equipment to maneuver.*** A concrete pad or other surface prevents seepage of nutrients and bacteria to groundwater. An 8-foot apron to at least support the front wheels of the loader is the minimum recommended; concrete to support the entire tractor is recommended.

• ***covered with a roof or other water-repelling materials to prevent excessive moisture on the composting material.*** A roof excludes rainwater and snow from the compost piles. The roof overhang should minimize rain blowing into the bins.

• ***built of rot resistant material that is strong enough to withstand the force exerted by the equipment.*** Possible construction materials for the bins include preservative pressure-treated lumber and concrete. To avoid corrosion, ventilation is needed and hot-dipped galvanized nails should be used.

Multiple bin composting structure; note gates on fronts of bins.

Bins should be located close to each other to facilitate moving compost from bin to bin. Consider snow and wind loads in the design. If you find you have problems with dogs or other animals that dig in the piles, you might want to add a removable gate. Opposite are some photos of typical composting structures used in Minnesota.

Hoop structure for composting with three bins.

A Cargill unit converted for composting.

New three bin composting structure.

Size of the Composting Structure

The size of your composting structure will depend on the size and amount of dead animals to be composted on a daily basis. The adjacent table lists average death losses for different animals. The primary bin volume averages three to 20 cubic feet for every pound of death loss. The table on the next page gives the ratio by size of animal. Secondary bins (those used to turn piles into for the second heat cycle) should be the same number and volume as the primary bins. The three steps described on the next page in the text box will help you calculate the size and number of your composting bins.

Composting structures that are too small may force movement of material through the bins before the composting process is complete. This can increase management problems.

Bin Size

Your goal in determining the bin size is to maximize the efficiency of the composting process and make it easy to manage the mortalities and the composting materials. All bins should be equally sized. Bin size depends on the size of equipment you will be using to turn the compost and the type of animal you will be composting. Bin width should be at least twice the width of the bucket on the equipment you will be using. The size of the structure you might be renovating must also be considered when determining bin size. Experts recommend that the bin area (width x length) should be 100 to 400 square feet to ensure proper heating and for ease of filling and emptying over a short period of time.

Number of Bins

The number of bins will depend on the bin size and your total composting volume of carcasses and bulking agent. The minimum number of bins is three, two for composting and one being filled. Larger operations may require more than three. Your goal in determining the number of bins is to be able to successfully compost all of your animal mortalities. Minnesota State Board of Animal Health regulations require that the composting structure be large enough to handle each day's normal mortality through a minimum of two heat cycles to the endpoint of the composting. You will also need to consider where you will store the bulking agent and finished compost. Having extra bins available for this can be helpful.

Mortality Estimates

Species	*Average Weight (lbs)*	*Loss (%)*
Swine[1]		
wean to nursery	10	10-12
nursery	30	2-4
grow finish	150	2-4
sows	300	2-5
Poultry[2]		
broiler	3	5
layer	3	10
turkey hens	10	7
turkey toms	17	13
Beef[3]		
pre-wean	90	8-10
young stock	600	2-3
yearlings	850	1
cows	1250	1
Dairy[4]		
pre-wean	90	8-10
heifers	600	2-3
cows	1400	1
Goats and Sheep		
pre-wean	8	8-10
lambs	50	10-12
mature	170	6-8

[1] *Pork Industry Handbook PIH 100*
[2] *Composting Poultry Carcasses in Missouri WQ205*
[3] *A. Deconstanzo, Dept. of Animal Science, U of MN*
[4] *H. Chester-Jones, Dept. of Animal Science, U of MN*

Designing the Compost Structure

Step One: Estimate the Weight of Average Daily Death Loss. You can use your own farm records or estimate the loss using industry average loss rate. See the table on preceding page for industry averages. Take the total pounds of dead animals for the year and divide by 365 days per year. This is the pounds of dead animals that need to be composted each day.

Step Two: Estimate the Volume for the Composting Bins. Multiply the pounds of dead animals per day from Step One by the cubic feet per pound listed in the adjacent table for the average size of the animals to be composted. This is the required volume for the primary composting area. Add an equal volume for the secondary composting bins.

Multiplier Factor to Estimate Bin Volume by Animal Size

Carcass Size (lb)	***Multiply Death Loss by***
0-10	3 ft^3/lb
10-25	5 ft^3/lb
25-300	10 ft^3/lb
300-750	14 ft^3/lb
750-1400	20 ft^3/lb

Example: You average 100 lb/day of death loss. Average size of dead animal to be composted is about 400 lb. The adjacent table lists the bin volume of 14 ft^3/lb of death loss for animals of that size. (100 lb/ day death loss) x (14 ft^3/lb) = 1400 cubic feet of primary bin space and an equal amount of secondary bin space.

Step Three: Design the Bins. Start with the bucket width on the loader you will be using. Multiply that width by 2 and round the number up a couple of feet to allow some maneuvering room. For example, if the bucket is 4 ft. wide, you might start your bin design with a width of 10 ft. Depth of the pile should be between five to eight feet. Bins should be at least eight feet long to obtain good pile heating. Try various bin dimensions and number of bins so that the volume available equals the volume calculated above. Bin area (width x length) should fall between 100 and 400 square feet. Include the same number of secondary bins of the same volume and consider adding additional bins for bulking agent storage.

Example: (10 ft. wide to accommodate loader bucket) x (14 ft. long) x (5 ft. deep) = 700 ft^3 per bin. As calculated above, 1400 cubic feet of primary bin space is required to compost daily death loss. 1400 ft^3 divided by 700 ft^3 per bin = 2 primary bins needed. Add two secondary bins of the same size and one bin for bulking agent storage gives a total of 5 bins measuring 10’ x 14’ x 5’.

Factors in Site Selection of the Composting Structure

Besides the following factors, Minnesota State Board of Animal Health regulations require that Minnesota Pollution Control Agency and local rules also be followed in siting your structure.

Site selection considerations
- ***Water quality***
- ***Biosecurity***
- ***Public view***
- ***Traffic flow***
- ***Water source***

Water quality
Avoid wet areas or flood plains. The facility must be high and dry. Locate at least three feet above high water table and at least 300 feet from streams, ponds, or lakes in the same drainage area. Divert clean water and provide for runoff collection and treatment or storage areas.

Biosecurity
Avoid locating the compost structure directly next to production units and use appropriate cleaning procedures on transportation vehicles.

Public perception
Minnesota State Board of Animal Health regulations require that consideration be given to prevailing winds and public view in choosing a site. Provide limited or appealing view for neighbors or passing motorists and consider aesthetics and landscaping.

Traffic flow
Consider access and traffic patterns required for moving mortalities and bulking agent to the composter and removing finished compost, as well as other farm traffic. Minnesota Board of Animal Health regulations require that carcasses be transported over public roads only in vehicles or containers that are leakproof and covered. Ensure all weather access. Locate safe distances from buried and overhead utilities.

Availability of water
Consider the distance between a water source and the bulking agent storage or the composting bins. If you need to add moisture to your composting materials, either to the bulking agent or to the piles, consider locating the structure within one hose length of a water source.

How to Compost Step by Step

Building the Compost Pile

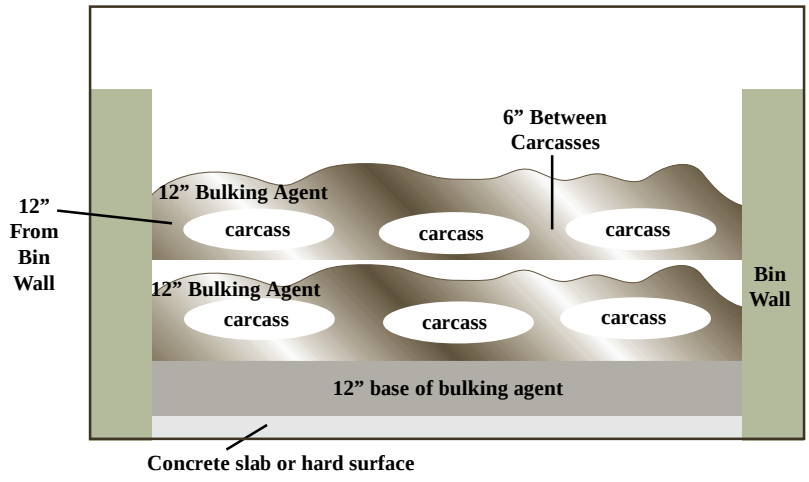
Building the compost pile
- ***Bulking agent base***
- ***Layer carcasses***
- ***Cover with bulking agent***
- ***Record information in log book***

Before you start composting, review the Board of Animal Health Regulations found at the end of this publication.

• Place at least 12 inches of bulking agent on the floor of the composting bin. This layer will insulate the composting material from the outside environment, provide carbon to fuel the composting process, and absorb liquids.

• Place the carcasses in a single layer on top of the bulking agent one foot from the wall of the bin and at least six inches apart. This allows air to circulate around the carcasses and insulates them from the environment. Depending on the size of the bin and of your loader, you may not want to build a whole single layer first, because your loader may not be able to reach the back of the bin when you want to add more carcasses later. You can avoid this by building the pile from the back, building it up and forward simultaneously.

• Cover the carcasses with about 12 inches of bulking agent. Add water as needed to maintain the proper moisture level. Because it is difficult to add water evenly, you might want to consider adding it to the bulking agent before it goes on the pile. Caution: If the pile dries out (25% to 45% moisture) and if piles are too large, spontaneous combustion can occur, just as with hay or silage. Attention to moisture, temperature, and pile size is the best protection. An accessible water supply is a good safety precaution. If you are going to use manure, add it either beneath the bulking agent or incorporated with the bulking agent. The pile is now ready for the next layer.



• Record the species, class, and weight of the carcasses, and the amount and type of bulking agent and into the compost log.

• Place additional carcasses as they become available on the pile in layers following these same steps, allowing 6 to 12 inches of bulking agent between layers. Minnesota Board of Animal Health regulations require that animal mortality be processed daily. You can compost more than one species in the same bin. It may be necessary to use the loader bucket to dig a depression to hold the fresh carcass in place before covering it with bulking agent, especially if it is a large animal. Continue adding carcasses until the pile is close to the top of the bin. Cover the top of the pile with 12 inches of bulking agent to reduce odor and protect against pests. Minnesota Board of Animal Health regulations require that flies, rodents, and vermin be controlled so as not to be a health hazard to human or animal populations.

• After the bin is full, start a second bin following these same steps. Leave the first bin to compost. This first bin has carcasses at various stages of decomposition from largely decomposed (first one in) to just beginning (last one in).

Transporting dead sow to composting structure.

One thousand pounds of pigs added in two layers.

Dead sow placed in depression formed in bulking agent.

Covering with bulking agent; note that skid loader fits into bin.

Monitoring the First Heat Cycle

Monitoring
- ***Record temperature daily***
- ***Check odor and moisture***
- ***Troubleshoot and adjust***

• Monitor the pile daily to make sure that all carcass parts stay completely covered by bulking agent. The pile will settle, so you may need to add additional bulking agent over the top.

• Check the temperature daily and record it in the compost log. The temperature should be taken at multiple locations in the pile, especially near the last animal that was added. Temperatures should be increasing and should soon be between 130° and 150° F.

Primary Composting Times

Carcass Size (lb)	*Estimated Primary Composting Days*
0-10	15
10-25	22
25-300	45
300-750	60
750-1400	90

• If it seems that the pile is not composting correctly because of the temperature or because there are odors, you will need to do some troubleshooting and make adjustments. See the section on troubleshooting for more information.

• Once the pile reaches at least 130°F, it should stay above that temperature for at least one week. Do not start counting the days until the area that you added to the pile last reaches this temperature. When the temperature drops, the pile is ready to be turned.

• The typical primary composting time is approximately 45 days for carcasses weighing from 25 to 300 lbs. See the table of estimates for primary composting times by carcass weight.

Turning the Pile

• Layer the bottom of an empty bin with 12 inches of bulking agent.

• Use a front-end or skid loader to move the material from the primary bin to the secondary bin, one bucket at a time. This aerates the pile. Minimal flesh or soft bones should be present, but long bones, skulls, teeth, and pelvis, and some hide, feathers, and fleece may remain. There may be some odor while turning due to disturbance of the anaerobic zones. Look to see whether you need to add water. If you do, add it to the existing pile as needed before or while you turn it, so that it gets evenly incorporated.

Compost Bin Management

Example for a 3-bin, 2-turn system with 15 days in primary heat cycle.

Days	*Primary Bin 1*	*Primary Bin 2*	*Secondary Bin*
1-15	filling	empty	empty
16-30	1st heat	filling	empty
31-45	filling	1st heat	2nd heat (#1)
46-60	1st heat	filling	2nd heat (#2)
61-85	filling	1st heat	2nd heat (#1)

Caution: High temperatures created by the composting material could lead to burns of the skin if caution is not exercised during compost handling.

• Cover the fresh pile with another 12 inches of bulking agent to prevent odor and visits by scavenging animals.

• Record the date turned and bulking agent type and volume used in the compost log.

Appearance of carcasses after first heat cycle.

Monitoring the Second Heat Cycle

• Monitor and record the temperature of the turned pile daily. Since the composting materials are more consistent now, you don't need to be as careful about taking the temperature in multiple locations.

• Once the pile maintains a temperature in excess of 130° F for seven days and then drops, the compost may be finished.

• Secondary composting times will be similar to the number of days in the primary cycle.

Finishing the Composting

Inspect the pile. If you can no longer see any flesh, the compost can be termed "finished." It should be dark, humus-like material with very little odor. At this stage, any bones should be so brittle that they can be easily crushed. Minnesota Board of Animal Health regulations require that the finished product contain no visible pieces of soft tissue. If there is still some flesh visible, you need to turn the pile again and let it go through another heat cycle. With larger animals such as cattle and sheep, more time is needed to completely compost their larger and denser bones. If the compost is finished other than the bones, remove them and place in a new pile for further decomposition.

Notes on Winter Composting

In order to compost in the winter, the compost pile must never be allowed to go cold. New carcasses should not be allowed to freeze and should not be added to a pile that has dropped below 60° F, which is too cool for microbial activity to start. The compost pile must be large enough to provide self-insulation. A thick layer of bulking agent between the carcasses and the floor and walls of the bins will insulate the microbial activity from cold air. Turning on extremely cold days should be avoided. You can also do your composting in or next to a heated area in the winter.

Notes on Emergency Composting

If you suffer a catastrophic death loss, you may have too many carcasses to compost in your bins. If this occurs, call the Minnesota Board of Animal Health for advice and to obtain a permit for emergency composting.

Finished compost.

Monitoring and Troubleshooting

Troubleshooting Guide for Carcass Composting

Adapted from the National Pork Producers Council Swine Mortality Composting Module

Problem/Symptom	Probable Cause	Suggestions
Improper Temperature	• Too dry • Too wet • Improper C:N ratio or bulking agent used is too porus. • Adverse environment	• Add water. • Add bulking agent and turn pile. • Evaluate bulking agent and adjust amount as necessary. • Ensure adequate cover with bulking agent to provide insulation.
Failure to Decompose	• Improper C:N ratio • Carcasses layered too thickly • Carcasses placed on the outside edge of the pile	• Turn pile and adjust amount of bulking agent. • Single layer the carcasses. • Maintain one foot of space between carcasses and outside edge of bins.
Odor	• Too wet • Too low C:N ratio • Air flow restricted • Inadequate cover over carcasses • Extended periods of low temperature	• Add bulking agent and turn pile. • Evaluate type of bulking agent used. Add bulking agent. • Maintain one foot of bulking agent near outside of bin. Turn pile. • Cover carcasses with one foot of bulking agent. • Follow steps in temperature section.
Flies	• Inadequate cover over carcasses • Poor sanitation conditions • Failure to achieve proper temperature • Too wet	• Cover carcasses with one foot of bulking agent. • Avoid leaching from pile. Maintain a clean, debris free area near the pile. • Follow steps in temperature section. • Open/remove pile contents and add additional bulking agent.
Scavenging Animals	• Inadequate cover over carcasses	• Maintain one foot of cover. Avoid initial entry by establishing a fence or barrier.

Use of Compost on the Farm

Once the compost is finished, it may be used for some of the bulking agent in a new composting pile. A rule of thumb is 50 percent, but you may want to use more or less depending on how degraded the bulking agent is in the finished compost. Using finished compost in new compost piles reduces the amount of bulking agent you need in the new pile and provides microbial inoculant.

Compost may also be applied to your fields. This should be considered part of your current manure management plan.

Since there are no state rules or regulations that specifically address land application of mortality compost, you should use the application requirements for manure as guidelines. Compost nutrient estimates are 15 lb of N, 5 lb of P_2O_5 and 10 lb of K_2O per ton of compost. Nutrients would be higher if manure or turkey litter were used in the compost. In order to determine the proper application rates for your compost, you will need to determine its nutrient content and availability. Most soil and manure testing labs will do this.

Regulations

Minnesota Board of Animal Health Rules

Composting structure

- built on an impervious weight-bearing pad that is large enough to allow the equipment to maneuver. An 8-foot apron to support the front wheels of the loader is the minimum recommended though concrete to support the entire loader is recommended.
- covered with a roof or other water-repelling materials to prevent excessive moisture on the composting material. The roof overhang should minimize rain blowing into the bins.
- built of rot resistant material that is strong enough to withstand the force exerted by the equipment. Possible construction materials for the bins include preservative pressure-treated lumber and concrete. To avoid corrosion, ventilation is needed and hot-dipped galvanized nails should be used.
- large enough to handle each day's normal mortality through a minimum of two heat cycles to the endpoint of composting.
- sited with consideration to prevailing winds and public view.

Compost Pile

- C:N ratio between 15:1 and 35:1.
- 12" base of bulking material.
- carcasses six inches from edges.
- reach a minimum of 130° F.
- carcasses covered and sealed with litter as they are added to pile.
- flies, rodents, and vermin controlled so as not to be a health hazard to human or animal populations.
- temperature taken and recorded daily.
- minimum of two heat cycles.

Livestock

- permit required for composting cattle.
- no composting of any animals that died from anthrax or toxic materials.

- animal mortality processed daily.
- carcasses transported over public roads only in vehicles or containers that are leak proof and covered.

Finished Compost
- minimum of two heat cycles have reached 130°F.
- finished product must not contain visible pieces of soft tissue.
- finished product must be handled and stored according to Minnesota Pollution Control Agency and Department of Agriculture regulations.

Protocol
The owner of the compost facility should have a written protocol for the operation containing at least the minimum steps outlined above in the composting process and should instruct and be responsible for all employees to follow the protocol.

Inspection
Representatives of the Board may inspect a composting facility and may review the operation protocol at any reasonable time.

Penalties
Construction or operation of a compost facility in violation of the rules results in penalties pertaining to improper disposal of dead animals as well as possible charges for violations of the rules of other state or local agencies.

Local Rules and Regulations

In addition to state regulations, most counties will require a building permit to construct or modify an existing building for composting. Before construction, contact your local zoning office to obtain the necessary permits. Local governments may have ordinances that are stricter than state regulations, or they may not have ordinances that cover animal mortality composting. In this case, local feedlot rules governing animal waste are generally used as guidelines for building the composting structure. Special or conditional use permits may be needed on a local level for composting. County feedlot ordinances may have carcass disposal requirements as part of the feedlot permit.

Further Resources

Publications and Web Sites

Animal Disposal Web Page.
Minnesota Department of Agriculture.
Web: mda.state.mn.us/DOCS/AGDEV/composting/composting

Composting Animal Mortality Resource Notebook.
Lynn Carpenter-Boggs, editor. 1999. Miscellaneous publication number 100-1999. Minnesota Agricultural Experiment Station. St. Paul, MN. Available from the West Central Research and Outreach Center, State Highway 329, Box 471, Morris, MN 56267-0471. (320)589-1711. Fax: (320)589-4870.
Web: wces.agri.umn.edu/

Composting Web Page.
Minnesota Board of Animal Health
Web: bah.state.mn.us/composting.htm

Dis-Solving Swine Mortality Problems.
2001. Iowa State University. Available from ISU, Department of Agricultural and Biosystems Engineering, Ames, IA 50011.
Web: ae.iastate.edu/pigsgone

Guidelines: Land Application of Manure for Water Quality Protection.
1996. Minnesota Pollution Control Agency (MPCA). Available from MPCA-Nonpoint Source Compliance Section, 520 Lafayette Road N, St. Paul, MN 55155-4194. (651)296-6300.

Manure Management Planning Guide for Livestock Operators.
2001. Available from the Minnesota Dept. of Agriculture, Ag Development Division, 90 W. Plato Blvd., St. Paul, MN 55107. (651)296-3820. Fax: (651)297-7678.
Web: mda.state.mn.us/AgDev/

Minnesota Board of Animal Health Rules.
Available from the Minnesota Board of Animal Health, 90 West Plato Blvd., St. Paul, MN 55107. (651)296-2942. Fax: (651)296-7417.
Web: revisor.leg.state.mn.us/arule/1719/4000.html

On-Farm Composting Handbook.
Robert Rynk, editor. 1992. NRAES-54. Available from the Natural Resource, Agriculture, and Engineering Service, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, NY 14853-5701. (607)255-7654. Fax: (607)254-8770. E-mail: NRAES@cornell.edu.
Web: nraes.org/publications/nraes54.html

Swine Composting Facility Design.
1997. Ohio State University. Factsheet AEX-713-97. Available from OSU Department of Food, Agricultural and Biological Engineering, 590 Woody Hayes Dr., Columbus, OH 43210.
Web: ohioline.ag.ohio-state.edu/aex-fact/0713.html

Swine Mortality Composting Module.
Kellie McGuire, editor. NPPC-04329 Available from the National Pork Producers Council, 1776 NW 114th Street, Clive, IA 50306.
(515)223-2600.
Fax: (515)223-2646.
Web: nppc.org/catalog/eap.html

Minnesota State Agencies and Other Key Organizations

Animal Mortality Composting Demonstration Sites.
For farmer demonstration sites, contact the Minnesota Department of Agriculture, Agricultural Development Division, 90 W. Plato Blvd., St. Paul, MN 55107. (651)296-7673.

Board of Animal Health.
119 Agriculture Building, 90 West Plato Blvd., St. Paul, MN 55107.
(651)296-2942. Fax: (651)296-7417.
Web: bah.state.mn.us/

Department of Biosystems and Agricultural Engineering.
University of Minnesota Extension Service. Room 213 Agricultural Engineering Building, 1390 Eckles Avenue., St. Paul, MN 55108.
(612)625-7733 Fax: (612)624-3005.
Web: bae.umn.edu/

Minnesota Department of Agriculture, Ag Development Division.
90 West Plato Blvd., St. Paul, MN 55107.
(651)296-7686. Fax: (651)297-7678.
Web: mda.state.mn.us/AgDev/

Minnesota Department of Agriculture, Energy and Sustainable Agriculture Program.
90 West Plato Blvd., St. Paul, MN 55107.
(651)296-7673. Fax: (651)297-7678.
Web: mda.state.mn.us/esap/

Minnesota Pollution Control Agency, Regional Offices.
To find the regional office closest to you, contact the MPCA at 520 Lafayette Road, St. Paul, MN 55155. (651)296-7327.
Web: pca.state.mn.us/about/regions/index

University of Minnesota North Central Research and Outreach Center.
A composting demonstration site using swine and cattle. 1861 Highway 169 East, Grand Rapids, MN 55744.
(218)327-4490. Fax: (218)327-4126.

University of Minnesota Southern Research and Outreach Center.
A composting demonstration site using swine, cattle, and sheep. 35838-120th Street, Waseca, MN 56093.
(507)835-3620. Fax: (507)835-3622.

University of Minnesota West Central Research and Outreach Center.
A composting demonstration site using swine and cattle. Headquarters Building, Morris, MN 56267-0471.
(320)589-1711. Fax: (320)589-4870.

Thermometer Suppliers

Suggested: a bimetal composting thermometer with a 20-36 inch, heavy duty 3/8 inch diameter stem, with a back connected, three inch dial with a temperature scale of 0 to 200° F. Cost varies from $11 to $90.

Nasco Farm & Ranch.
901 Janesville Ave., P. O. Box 901, Fort Atkinson, WI 53538.
(800)558-9595. Web: nascofa.com/prod/Home. *Product number C14312N, baled hay and compost thermometer, 20 inch stem for about $11.50.

Reotemp Instruments Corp.
10656 Roselle St., San Diego, CA 92121.
(800)648-7737.
Web: reotemp.com

Tel-Tru Manufacturing Co.
P. O. Box 144, Rochester, NY 14601. (800)232-5335.
Web: teltru.com

Trend Instruments, Inc.
1000 Wiegand Blvd., Lawrenceville, GA 30043. (888)WIKA-USA.
Web: wika.com

Weksler Instruments.
250 E. Main St., Stratford, CT 06614-5145. (800)788-5080.
Web: dresserinstruments.com/weksprodpage.html

Bibliography

Carpenter-Boggs, Lynn, editor. 1999. Composting Animal Mortality Resource Notebook. Miscellaneous Publication Number 100-1999. Minnesota Agricultural Experiment Station. St. Paul, MN.

Carter, Thomas A., et al. 1996. Composting Poultry Mortality. Publication Number PS&T-47. North Carolina Cooperative Extension Service. Raleigh, NC.

Collins, Eldridge R., Jr. 1996. Composting Dead Poultry. Publication Number 442-037. Virginia Cooperative Extension. Blacksburg, VA.

Fulhage, Charles. 1996 (Reprint). Composting Dead Swine. Publication WQ351.University of Missouri Extension Service. Columbia, MO.

Glanville, Thomas D. 2001. Dis-Solving Swine Mortality Problems. Iowa State University, Ames, IA. ae.iastate.edu/pigsgone/

Glanville, Thomas D., and Darrell W. Trampel. 1997. Composting Alternative for Animal Carcass Disposal. Journal of the American Veterinary Medical Association. Vol. 210, pages 1116-1120.

Langston, John, Karl VanDevender, and Jack C. Boles, Jr. Undated. Disposal of Poultry Carcasses in Arkansas. Cooperative Extension Service, University of Arkansas. Little Rock, AR.

McGuire, Kellie, editor. Undated. Swine Mortality Composting Module. National Pork Producers Council. Clive, IA.

Mescher, Terry, et al. 1997. Swine Composting Facility Design. Publication AEX-713-97. Ohio State University Extension. Columbus, OH.

Minnesota Board of Animal Health Rules.
Chapter 1719.0100 - 1719.4600.

Walker, Roger, and Bill Crawford. 1997. Composting Swine Mortality in Minnesota. Presented at 1997 University of Minnesota Pork Conference. University of Minnesota. St. Paul, MN.

Notes