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On-Farm Emergency Swine Mortality Disposal Methods – Incineration

500 lbs. incinerator
Source: https://www.poultryincinerator.com/hd-500_incinerator.html

Using incineration to dispose of routine mortalities is an effective method for swine farms. It's important to note up front, that incineration is different from burning because it is intended to quickly and completely consume the entire carcass by fire and heat, thereby reducing it to ash. That is not the case with open-air burning, which should not be considered for mass-casualty events due to the potential environmental impact, negative public perception and nuisance issues[1]. Therefore, open-air burning will not be addressed here.

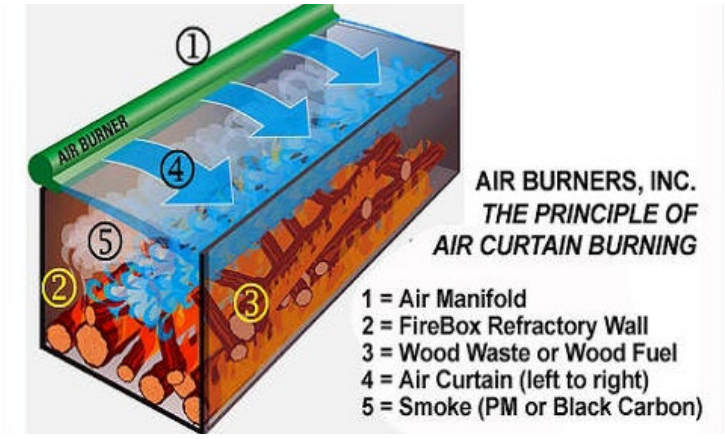
There are two types of incineration systems – fixed-facility incineration and air-curtain incineration – both use extremely high temperatures to reduce hog carcasses to ashes. Either process will produce some pollutants such as smoke, odor, hydrocarbons and heavy metals associated with fly ash, so that needs to be part of the equation and may restrict its use. It's critical to understand that provisional permits specific to the region or state will likely be required for high-volume incineration.

A trench burner

Incineration methods

An on-site, fixed-facility incinerator is a reasonable option for routine carcass disposal, but less so for a high-volume mortality event such as a foreign animal disease (FAD) outbreak. Here are some considerations:

- Most fixed-facility incinerators would not be able to handle high-volume disposal needs. Incinerator capacities typically range from 100 lbs. to 500 lbs.



- A possible option would be to use incineration for the smaller carcasses and apply other disposal methods for larger carcasses.
- Some states require fixed-facility incinerators to have a secondary burn chamber, or afterburner to decrease fly ash and other emissions. This adds to the equipment and permitting requirements, as well as increases the initial investment and operating costs.
- This system requires a fuel supply – diesel, gas or propane – which impacts costs. Actual fuel use varies with the incinerator's design and loading rate.

Air-curtain incineration is actually a process – it features a high-velocity (curtain) of air that is fan-driven through a manifold system over the burn chamber, which can be an above-ground firebox that resembles an industrial trash dumpster or a constructed earthen burn trench. Here are some considerations:

- While air-curtain incineration is not feasible for routine mortality disposal, it can accommodate large volumes.

Air-curtain incinerator options: https://airburners.com/resource-center/photos/

A firebox type air-burner

- The air-curtain helps contain smoke and particulate matter in the burn zone and boosts airflow to produce hotter temperatures and more complete combustion of carcasses.
- Air-curtain incineration is a fuel-intensive process, primarily using wood (pallets and other dry debris) and diesel fuel. Securing adequate fuel supplies could be a challenge.
- In high-volume situations, smoke and odor complaints from nearby property owners may occur.

Other considerations

Incineration is an expensive disposal option as both methods require environmental permits, often with an annual renewal, as well as significant labor and fuel supplies. Some states also require annual inspection.

The fixed-facility system requires the purchase and installation of an incinerator, which will come with maintenance costs. Routine observation and maintenance and ash cleanout are the basic steps to keep the incinerator operating properly. The unit must be loaded and operated according to the manufacturer's specifications, in which case it requires only moderate levels training and labor to operate.

It is important to consider environmental land conditions when selecting a site for air-curtain incineration, and it should be located away from public view. If using a burn trench, the state may designate specific dimensions for the trench. This method requires equipment for land preparation, as well as to construct and operate the system. A certain level of expertise is required to construct and operate it safely. Personnel working around and with an air-curtain incinerator require specific and thorough training. Loading carcasses onto the incineration site will increase labor demands.

In terms of biosecurity, on-site carcass cremation is a sound option. It eliminates the transport of dead animals and the potential of disease spread. The high heat levels significantly reduce or eliminate disease-related pathogens.

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[1]Swine Carcass Disposal Options for Routine and Catastrophic Mortality, CAST Issue Paper, No. 39, July 2008.

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On-Farm Emergency Swine Mortality Disposal Methods – Composting

(Outdoor/Windrow & Pile)

Windrow or pile composting is a least-cost option for hog-carcass disposal and is an effective way to handle large volumes and carcasses from large animals such as mature pigs. The process can be implemented rapidly as it uses common farm machinery to prepare the site, when done properly the process has a low risk of air and water pollution. As an open-air method it does require monitoring and management to ensure complete carcass decomposition and to prevent odors. An added benefit is that the final composted product may be applied as a soil amendment.

There are four main variables that are crucial to effective composting[1]:

1. Moisture content – 40% to 60%
2. Temperature – 113° F to 140° F
3. Oxygen content - 10%
4. Carbon-to-Nitrogen ratio (C:N) – 20:1 to 30:1

Policies governing mortality compost sites and management vary considerably by state, so that's always the place to start.

Bulk carbon materials

Key to success is having enough high-carbon material available for the entire process, and availability within the region will influence the overall cost. Characteristics of effective carbon material include sufficient water-holding capacity, maintaining gas permeability and porosity, biodegradability, wet-mechanical strength and adequate available carbon[1]. These properties ensure that the materials absorb excess liquids, maintain temperature and heat, permit oxygen flow and encourage microbial activity.

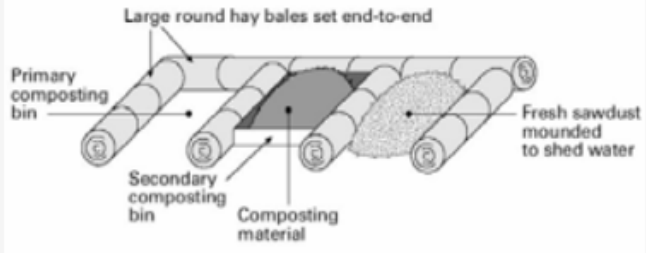
Source: SWETA and the U of Illinois - https://sweeta.illinois.edu/pdf/Composting.pdf

Suitable carbon sources include wood chips, wood shavings, leaves/yard waste, brush trimming, chopped hay or straw, chopped corn stover, oat or sunflower hulls, recycled cardboard, ground pallets and used livestock bedding. As a guide, 3 to 5 cubic yards of co-compost material is required[2,3].

For disease-related mortality, use highly-biodegradable materials that produce large amounts of pathogen-killing heat, and delay the need to turn the pile until after pathogen deactivation. This requires, maintaining a temperature above 131° F for at least three days. Special considerations may be required for a specific foreign animal disease (FAD).

Site selection and management

Site selection for windrow or pile composting is critical to prevent surface water runoff, as well as leaching raw or finished compost nutrients into groundwater. It needs to be well drained, located away from animal production facilities and public view, and have access to water.



Open bin composter made from round hay bales. Adapted with permission from Stettler D. Livestock and poultry environmental stewardship curriculum: mortality management. Lesson 51. Ames, IA: Midwest Plan Service, 2001

Source: Pork Information Gateway

The base must be an impervious pad made up of compacted soil (such as clay), a concrete floor, gravel or a geo-textile liner to control water infiltration. The pad should be designed to shed water away from the compost in all directions; a vegetative filter can address runoff if necessary.

Recommended windrow dimensions are 12 feet wide at the base and no more than 7 feet tall[4]. Windrows and piles provide easy access for loading, unloading and mixing from all sides.

To load the site:

- Apply an 18- to 24-inch base layer of carbon material on the prepared site.
- For a windrow, small and medium-sized carcasses can be layered; place large carcasses in a single layer.
- If layering carcasses, add 8 to 10 inches of carbon material in between.
- Add a final 18 to 24 inches of carbon material as a top cover to control odor and discourage scavengers.

The cover material may settle or be disturbed by wind or scavengers, so check it regularly. If excessive odors develop, add more cover material.

Other management practices include:

- The compost is left undisturbed during the active composting period or phase 1 to allow for soft tissue decomposition. For small- and medium-sized carcasses (young pigs), it may take 3 months before the pile is turned, for large carcasses (mature hogs) it may be 6 months.
- Phase 2 requires additional time to complete decomposition and will depend on conditions. Small- and medium-sized carcasses will take days to weeks; large carcasses may require months.
- Turn the compost in phase 2 to reintroduce oxygen and boost the C:N ratio. This is a good time to assess and modify the moisture content. These steps prevent odor issues and gas emissions such as methane and nitrous oxide. However, during a disease outbreak the risk of releasing infectious airborne particles may limit turning.
- A front-end or bucket loader can be used to turn small-scale piles. For large-scale turning, use a tractor-assisted windrow turner.

Starting a fresh compost pile in the winter will add significant time to composting, but it is still an option

Here is a step-by-step look at how to construct a composting pile: (a) place a liner, (b) break up a round straw bale, (c) lay the straw base and measure the perimeter after laying carcass, (d) finish the pile with adequate straw surrounding the carcass.




Source: North Dakota State University. Photos by Ying Chen, University of Manitoba, Canada

Other considerations

Most composting methods will destroy disease-causing pathogens and are considered to be sound biosecurity options. Proper maintenance of compost piles or windrows produces temperature between 90° F and 140° F and moisture ranges between 50% and 60% on a wet basis. The C:N ratio is typically between 20:1 and 25:1[5].

Temperatures should be taken twice a week and logged to monitor progress and identify when to turn the pile. One or more weeks of temperatures below 110° F indicate the compost should be turned. Use a compost thermometer with a stem length of 36 or 48 inches. Another option is to use a wireless/wired temperature probe inserted at a 45-degree angle, 18 and 36 inches deep into the compost to check temperatures above and below the carcass layer. Note that in the case of highly pathogenic diseases, such as an FAD, remote temperature monitoring is preferred.

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[1]Swine Carcass Disposal Options for Routine and Catastrophic Mortality, CAST Issue Paper, No. 39, July 2008, p. 8.
[2]Composting Large Animal Carcasses, Auvermann, B, et al., Texas A&M University, 2006.
[3]Animal Carcass Disposal Options – NDSU: Animal Carcass Disposal Options Rendering • Incineration • Burial • Composting (NM1422, Revised Sept. 2017) p. 5.
[4]Swine Mortality Composting (Alberta Agriculture and Rural Development, Canada, Government) Agdex 440/29-1; 2011.
[5]NM1422 (Revised) September 2017 Animal Carcass Disposal Options – NDSU. p. 4.

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On-Farm Emergency Swine Mortality Disposal Methods – Burial (Above-ground)

Above-ground burial (AGB) is a new concept in emergency livestock mortality management, which is a hybrid between deep burial and composting. The process involves digging a shallow trench, adding 1-foot of carbonaceous material, followed by a single layer of carcasses. The carcasses are then covered with excavated soil and the final step is to seed the mound.

The concept was developed by USDA Animal and Plant Health Inspection Service (APHIS) in conjunction with Envirotech Consulting, Oklahoma Department of Agriculture Food & Forestry, Oklahoma State University, Virginia Cooperative Extension, and the Virginia Department of Environmental Quality.

AGB was field tested at various locations to study a range of soil and climatic conditions. The tests evaluated carcass degradation, nutrient migration and pathogen inactivation, with one study monitoring scavenger and insect activity. Overall, the findings show AGB offers effective carcass decomposition and inactivated pathogens associated with swine.

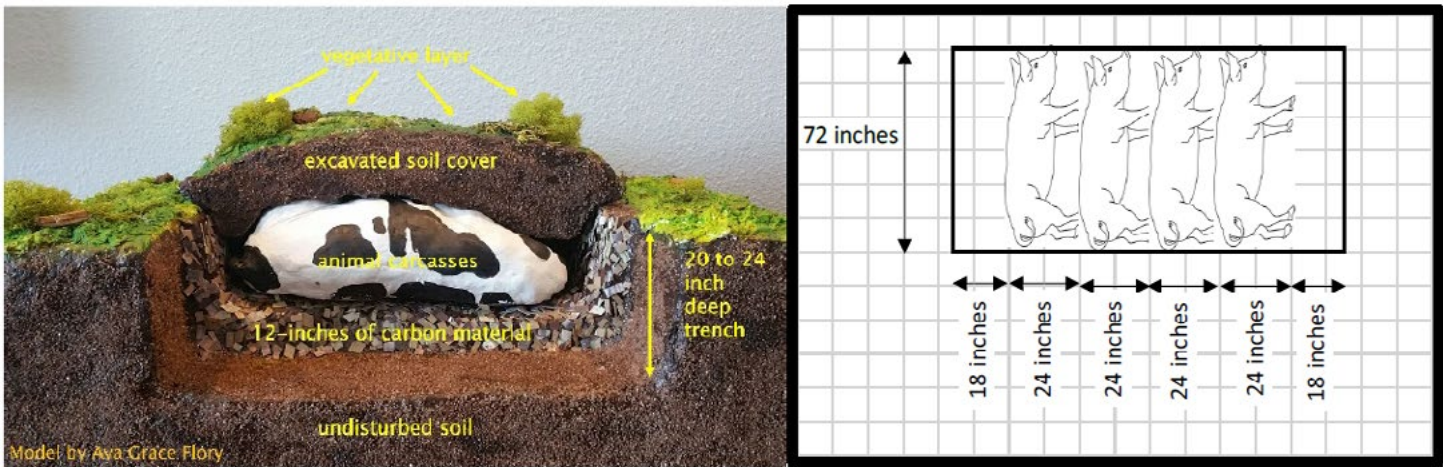
Research investigators determined the protocol is suitable for catastrophic animal mortality emergencies and could be implemented in coordination with local and State environmental and agricultural officials.

Site selection

When selecting a possible AGB site, it's important to emphasize that local and state requirements take precedence. The basic site requirements identified by the field studies, include:

- Soils considered suitable for AGB are based on the National Resource Conservation Service Web Soil Survey.
  - Use caution installing AGB units in low-permeability soils where heavy rainfall may occur over a one-year period. Such conditions can flood the units and prevent proper carcass decomposition.
- Eliminate low-lying areas and any prone to flooding.
- Allow at least 2 to 4 feet of separation from the trench bottom and the groundwater table (or as directed by qualified soil scientist). The same separation requirements apply from the trench bottom to the bedrock or restrictive layer.
- The site must be at least 200 feet from wells or springs, and at least 100 feet from surface water bodies (or as directed by qualified soil scientist).
- Allow a minimum distance of 100 feet from property lines, sinkholes or rock outcrops, structures and drain tiles.

Example of AGB Designs



Source: USDA, "Emergency Response: Guidelines for the emergency use of above-ground burial to manage catastrophic livestock mortality," January 2021.

Note that the site must accommodate sufficient space to stage construction equipment for AGB units as well as carbon resource materials. (A calculator is available at https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/emergency-management/carcass-management/carcass)

Of course, the site must be approved by state environmental agency before any construction begins.

Construction and loading

For the construction process, start by locating and marking any utilities, as well as the area dimensions to be excavated. Here's a snapshot of the AGB construction and loading process:

- Dig a trench 20 to 24 inches deep of sufficient width and length to accommodate the size and number of carcasses to be loaded. Note a trench less than 20 inches deep may not provide enough soil to cover the carcasses; deeper than 24 inches will slow decomposition.
- Place 12 inches of carbonaceous material in the trench bottom. The material should have a high carbon-to-nitrogen ratio, such as wood chips, bark mulch, sawdust, chopped corn stalks or straw, silage or animal bedding with minimal manure.
- Place the carcasses on the carbon base, positioned on their sides in a single layer as close together as possible, preferably facing the same direction. (See accompanying figure.) Ensure that the legs and heads can be adequately covered with soil.
- For carcasses larger than 300 lbs., it is advised to use a sharp knife to open the abdominal cavity from sternum to pelvis along the ventral midline to eliminate gaseous bloating and displacement.
- Cover the trench with excavated soil, forming a minimum 1-foot-thick mound to promote drainage. Ensure that the entire trench is filled in and graded to avoid pooling.
- Seed the mound with a grass-seed mix, and cover with a layer of straw mulch or biodegradable erosion-control netting extended beyond the mound's edge and be secured with soil.

Maintenance

An added bonus of AGB is that carcasses decompose more quickly and the land can be returned to its original use. A few maintenance steps will ensure a smooth process.

For the first month, inspect the AGB system weekly; then check it monthly and after extreme weather events. Look for cracks in the soil cover or evidence of animal burrowing and add more soil as needed. Reseed areas where vegetative cover emergence was poor. If excessive water ponding is evident, regrade to improve drainage.

After a year, check carcass decomposition by uncovering a small area to determine whether any soft tissue remains on the bones. If there is, recover the exposed area and monitor monthly until all tissue is degraded. Note that small pieces of hide on long bones are acceptable.

Once decomposition is confirmed complete, site restoration can begin. Regrade the AGB mound to original topography. Any bones exposed after grading either need to be covered or collected and disposed of in accordance with state and local regulations. At this point, the site can be returned to its original use.

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On-Farm Emergency Swine Mortality Disposal Methods: Burial (Below-ground)

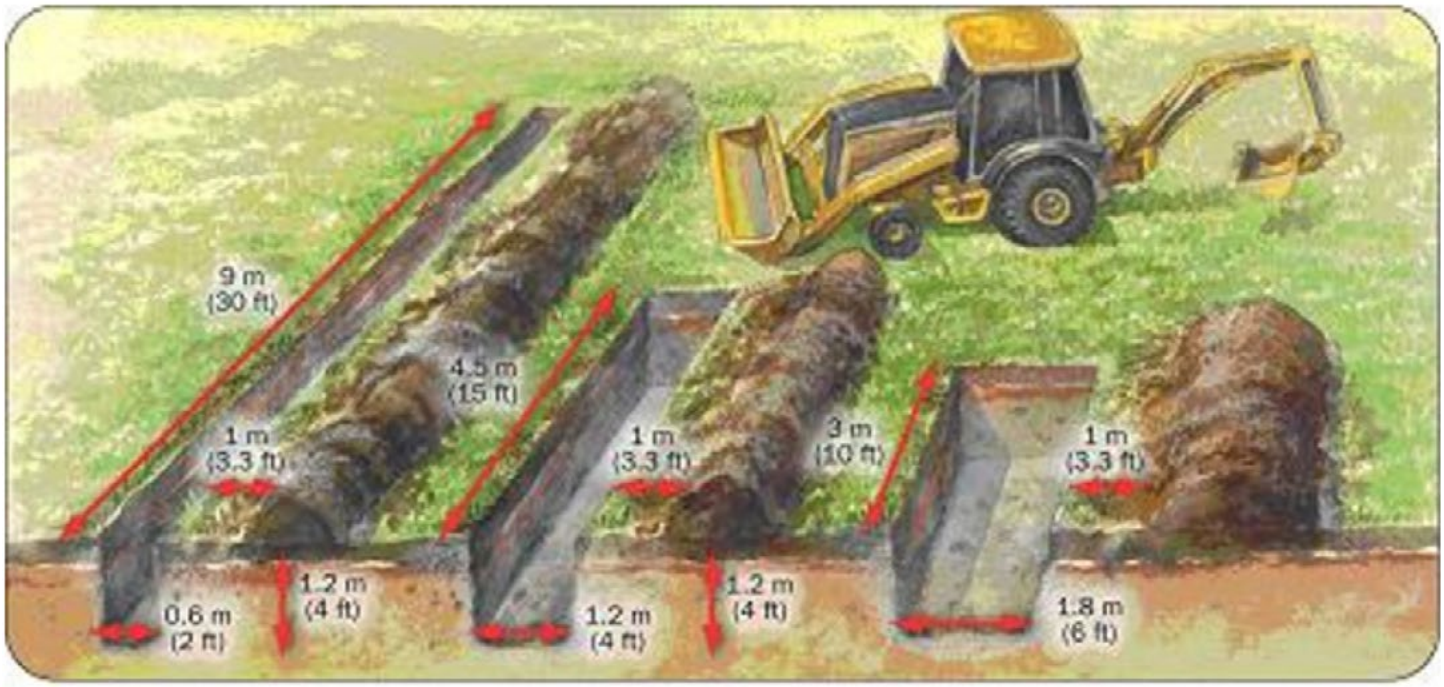
Burial of swine carcasses in the ground for mortality disposal typically involves digging a pit or trench, depending on the number of mortalities. The trench method is more applicable for mass depopulation during an emergency such as a foreign animal disease outbreak, it requires excavating a narrow, shallow trench in which to place the carcasses. The cost of on-site burial is low.

This biggest consideration for any burial method is selecting the proper site to prevent negative environmental impacts. Of specific concern is groundwater contamination of nitrogen (N) and phosphorous (P). Animal carcasses are approximately 2% N by weight, which means high-density burial can lead to high N loading rates. A buildup of high N and P concentrations near mass burial sites also may be a long-term concern.

In all cases, the combination of topographic, geologic, soil and water resource data should be used to identify and map burials sites. Important considerations for possible sites include:

- Soils that do not flood, including a 100-year flood.
- Eliminate any site with a shallow water table or sandy/gravelly soils where leachate transport to groundwater could occur.
- Wetlands or fault zones cannot be considered.
- The site should be level and located well away from any residence, as well as any public or private water supplies.

Long term, it's important to consider the possible land-use limitations for the current and future owners.



Use different trench or pit measures to bury and accommodate different sized animals. Source: Ontario Ministry of Agriculture Foods and Rural Affairs

Trench and pit specs

To prepare a mass burial site, industrial equipment such as a backhoe may be needed. Before digging a trench or pit, locate any buried utilities on the proposed site and ensure that there is no field drainage tile located in the area (states often have specific tile separation requirements of approximately 200 feet). Check to ensure that surface water drains properly around the site; and if necessary, diversion berms can be used to direct water away from burial locations.

Specific requirements for a trench or pit may vary by state, but here is some basic guidance:

- The bottom of the trench must be 2 to 4 feet above any permanent water table.
- It should be at least 200 feet from the nearest surface water.
- The trench bottom should be compacted.
- Carcasses are typically added in a single layer, but for smaller carcasses, such as from nursery or young grower pigs, mortalities can be placed in 3- to 4-feet layers with 6 to 12 inches of soil placed in between.
- The trench length is flexible and is dictated by the overall site and disposal needs.
- A site may accommodate more than one trench if there is adequate space between trenches.

Once filled, the trench should be covered with at least 2 feet of soil, with a mound to shed rainwater. The site should be inspected periodically for settling or caving as carcasses decompose, adding more soil as needed to ensure a level final site. Decomposition of the carcasses varies based on size, which has been shown to take 1.8 years for relatively small swine to a few years more for large animals, such as finisher pigs, sows and boars. Plan to seed the area with ground cover or other vegetation.

Understand short- and long-term implications

Public perception and impact are always important considerations. While burial pits or trenches address visual concerns, ensuring that the trench or pit is thoroughly and promptly covered with soil will prevent nuisance problems such as odors, flies and scavengers. Also, if not buried deep enough, predators can uncover and access the carcasses. Note that burial is not an option when the ground is frozen.

Depending on the pathogen of concern, on-farm burial is recognized as a viable option from a biosecurity standpoint. It prevents outside vehicles from entering the farm, which reduces the number of risky events. This would be especially beneficial during interventions in FAD scenarios to avoid diseases spread. It's important to note that burial could run into environmental limitations in hog-dense regions.

From a human safety standpoint, anyone burying hog carcasses must take personnel and equipment safety precautions during trench digging, carcass handling, placing carcasses into the trench or pit and backfilling with soil.

Always consult with area and state officials, as other state regulations may apply to burial site selection and management. Many states have complied maps to help identify appropriate in-ground carcass burial sites. Farm owners should work to identify locations for on-farm burial as part of emergency preparedness plans and review those plans with a state animal health official.

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On-Farm Emergency Swine Mortality Disposal Methods – Composting (Covered/Bin)

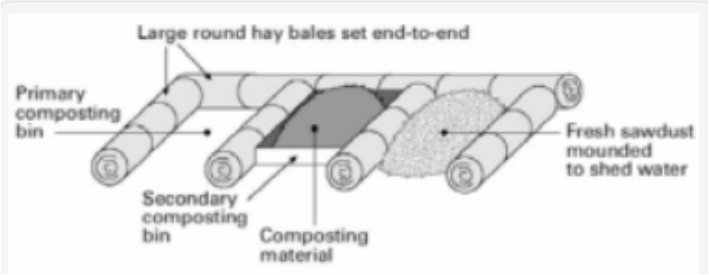
Composting is the natural biological process of organic material decomposition in the presence of oxygen. During the process, bacteria, fungi and other micro-organisms break down organic materials while consuming oxygen and releasing heat, water, carbon dioxide and other gases.

Composting has become a common mortality management method for hog farms. An added benefit is that the end product may be applied as a soil amendment.

Notably, four main variables are crucial to composting success[1]:

1. Moisture content – 40% to 60%
2. Temperature – 113° F to 140° F
3. Oxygen content - 10%
4. C:N ratio – 20:1 to 30:1

Composting is a viable option for disease-related mortality but requires that the compost temperature remain above 131° F for at least three days[2]. Special considerations may be required for a specific foreign animal disease (FAD).



Open bin composter made from round hay bales.
Source: Pork Information Gateway composting document: Composting Swine Mortality

It's important to note that policies governing site selection and management of mortality composting vary considerably by state, so that's always the place to start.

A bin system

Bin composting is a common method found on hog farms to handle routine mortalities. However, during a high-volume mortality event such as an FAD, the bin system may lack sufficient capacity. One option would be to use it for smaller carcasses or a specific production segment and apply additional mortality management methods.

Source: Minnesota Pollution Control Agency

Here are the basic elements of a bin-composting system:

- A bin is a three-sided enclosure – two side walls, a back wall – oftentimes with a roof. If there is a roof, water application will be needed to maintain proper moisture.
- The open front allows access for carcass placement, compost turning and removal using a tractor or skid loader.
- Temporary, low-cost bins have been constructed using large straw bales. This is known as open-bin composting; it does not have a roof.
- All bin composters must have floors with a low-permeability base, such as compacted clay or concrete, to prevent leachate contamination of the underlying soil.
- A typical arrangement consists of multiple bins of equal-size:
  - There should be at least two primary-stage composting or phase 1 (soft-tissue decomposition) bins.
  - Ideally, the number of secondary-stage or phase 2 (final decomposition) bins match the phase 1 bins, but there needs to be at least one bin.
  - The composting material would be moved from phase 1 to phase 2 bins.
- It's also wise to have a bin to store finished compost, and another one for fresh carbon materials.
- Bin sizes are flexible, but a basic recommendation for a minimum bin width is two-times the width of the loader bucket used to load and turn the pile. Suggested bin depth is to be one to two times the bin width.

As a general rule, having more smaller bins versus a few large ones will provide more management flexibility.

Carbon materials

Composting requires a high-carbon material, and a variety of plant-based options can be used, such as straw, waste feed/hay, sawdust, wood shavings or chips, oat or peanut hulls, poultry litter or finished compost. The availability of carbon material within the region will influence the selection and cost. A bulking material, such as cornstalks and tree trimmings, should be included to provide porosity and structure to the compost pile. As a general guide, 3 to 5 cubic yards of co-composting material is required for every 1,000 lbs. of carcass.

The process to load a bin is as follows:

- Place 12 to 18 inches of carbon material on the floor as a base.
- Carcasses are layered in the bin with carbon material between each layer, the depth depends on the carcass size.
- Ensure that no part of a carcass is exposed to prevent odors, flies and scavengers.
- Apply at least a 12- to 16-inch layer of carbon material around all sides of the carcass, including on top of the pile.
- Because bins confine the compost, it allows a stacking depth of about 5 feet.

The time needed to degrade a hog carcass depends on the size of the deceased animal. For baby pigs that can take 30 days; adult pigs (sows and boars) may need 3 months or more. Success relies on choosing the right placement of carcasses and the right amount of carbon material.

Other considerations

The carcass decomposition process produces a liquid that must be prevented from draining away. A dry, absorbent base material such as hay or straw, finished compost or sawdust helps capture such liquid.

For disease-related mortalities it's important to maximize heat production and retention to promote pathogen inactivation. This may involve using highly biodegradable cover materials, plastic biosecurity sheeting or thicker layers of carbon materials. Use a compost thermometer with a stem length of 36 or 48 inches to take temperatures twice a week and log them to monitor progress. Another option is to use a wireless/wired temperature probe inserted at a 45-degree angle, 18 and 36 inches deep into the compost to check temperatures at various layers. Note that in the case of highly pathogenic diseases, such as an FAD, remote temperature monitoring is preferred. The pile should be turned when the compost temperature exceeds 140° F or drops below 90° F.

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[1]Swine Carcass Disposal Options for Routine and Catastrophic Mortality, CAST Issue Paper, No. 39, July 2008, p. 8.
[2]Disposal of Swine Mortalities - Pork Information Gateway (porkgateway.org)

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