

# Ohio's Livestock and Poultry Mortality Composting Manual

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## Preface

Composting livestock and poultry mortality in agricultural operations is a legal option for disposal in Ohio. This manual, used in conjunction with a required training session and its resultant certification, will make it possible for you, the operator, to compost livestock mortality of approved species and apply the compost to your own fields. It is hoped this will expand your options for disposal and enable you to improve the efficiency and profitability of your enterprise.

Composting of agricultural livestock mortality is distinct from other composting enterprises. As discussed in more detail in chapter 6 of this manual, composting of livestock mortality in specific on-farm situations does not require an Ohio Environmental Protection Agency (Ohio EPA) registration or permit as do other composting operations. If production of compost for commercial purposes (distribution of the product) is desired, please consult the Ohio EPA, Division of Solid and Infectious Waste Management.

The Ohio Department of Agriculture's chief of the Division of Animal Industry administers the regulations that determine allowable methods of livestock disposal, such as incineration, burial, rendering or composting. The chief of the Division of Animal Industry establishes conditions under which specific disposal methods may be used. The current listing of livestock species approved for composting mortality includes:

- Cattle (except those over 2-years-of-age showing signs of neurologic disease, unless authorized by the chief of the Division of Animal Industry)
- Horses
- Poultry
- Sheep and goats
- Swine

If a dangerously infectious disease is discovered on any farm, the chief of the division of animal industry will determine the allowable method of disposal.

Owners of other livestock species who wish to compost must submit their request to the chief of the division of animal industry; approval will be based on the availability of pathogen control data. (For more information, please refer to chapter 5.)

This manual includes information applicable to any livestock mortality composting operation, as well as information specific to each of the species approved for composting in Ohio. Material will be appended as additional information becomes available, as new procedures are developed and approved, or as other species are added to the list of those approved for mortality composting.

## Chapter 1

# Mortality composting principles and operation

Dr. Harold Keener, OARDC and OSUE  
and  
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Animal agriculture is challenged today to discover innovative ways to dispose of livestock and poultry mortality. This need has been brought on by the disappearance of rendering plants, concerns over burial and ground water pollution, and the economic cost and other issues related to incineration. Composting of livestock mortalities is one option that is now available. This chapter is an overview of the principles of composting and the management practices for composting animal mortalities.

### Principles of general composting

#### *Basics of composting*

Composting is a natural biological process of decomposition of organic materials in a predominantly aerobic environment. During the process, bacteria, fungi, and other microorganisms break down organic materials to a stable mixture called compost while consuming oxygen and releasing heat, water, and carbon dioxide (CO<sub>2</sub>). The finished compost resembles humus and can be used as a soil amendment. Composting reduces the volume of the parent materials, and pathogens are destroyed if the process is controlled properly.

Microorganisms involved in composting can be classified according to temperatures most favorable to their metabolism and growth. The mesophilic (50–110°F) and thermophilic microorganisms (110–160°F) are the principal groups. A simplified view of the composting process is presented in Figure 1-1.

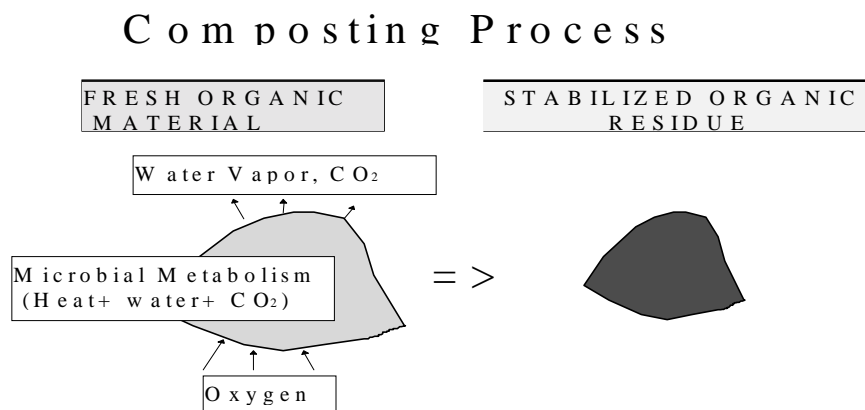
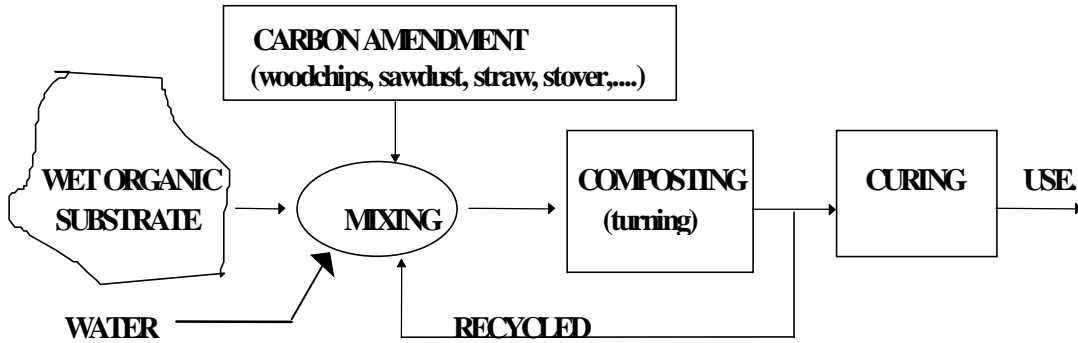


Figure 1-1. Simplified overview of the composting process showing the breakdown of organic material to water, CO<sub>2</sub>, and compost.

In conventional composting, one brings together ingredients and mixes them and then puts the material into a pile to compost. Figure 1-2 depicts the material flows (non-gaseous) in the conventional composting process. Generally the mix gets turned every three or four days, but sometimes every day, weekly, or monthly. In some systems, air is forced through the compost to control temperature and keep the pile supplied with oxygen. When little or no heat output is observed, the material is removed, re-mixed and put in a curing pile for several months.

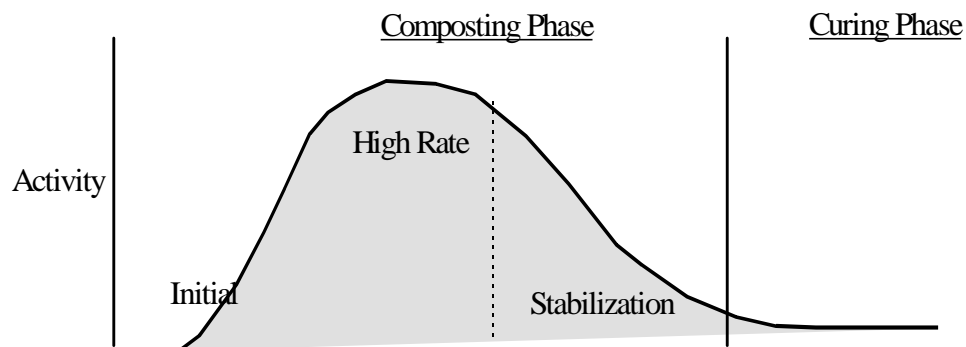


**Figure 1-2. Material flow for the conventional composting process. Airflows into the composting and curing pile, also a part of the process, are not shown.**

Under controlled conditions, composting is accomplished in two main stages: a composting stage and a curing stage. Figure 1-3 depicts these two stages. The composting stage involves three sub-stages:

1. An initial stage lasting one to three days when mesophilic microorganisms degrade constituents such as sugars, starch, proteins, etc., and compost temperature rises rapidly.
2. A high-rate thermophilic stage, lasting 10 to perhaps 100 days, in which temperatures rise above 110°F, and fats, hemicellulose, cellulose and some lignins are degraded and pathogens are destroyed.
3. A stabilization stage, lasting 10–100 days, during which the temperature declines and further degradation of cellulose, hemicellulose and lignins occurs.

The high-rate stage is accompanied by high rates of oxygen uptake and CO<sub>2</sub> output. NH<sub>3</sub> and other gases may be evolved if the process is not controlled well. During curing or maturation, mesophilic organisms re-colonize the compost. Length of curing time depends on market opportunities, but typically represents a minimum of 1 month and generally lasts 3–6 months.



**Figure 1-3. Stages of the conventional composting process.**

While composting occurs naturally, the process requires proper conditions to occur rapidly, minimize odor generation, and prevent nuisance problems. Over 20 controllable factors affect composting. Table 1-1 lists eight of those factors and acceptable ranges to aim for when composting. Of these factors, the four major factors to be controlled in the composting process are the material mix (nutrient balance), water content, porosity, and temperature.

**Table 1-1. Guidelines for composting: major factors.**

	Reasonable range	Preferred range
<b>Nutrient balance, C/N</b>	20:1–40:1	30:1–35:1
<b>Water content</b>	45–65% w.b.	50–60% w.b.
Particle size	0.8–1.2 cm (1/8-1/2 inch)	Depends on material
<b>Porosity</b>	30–50%	35–45%
Bulk density	<640 kg/m <sup>3</sup> (1100lb/yd <sup>3</sup> )	
PH	5.8–9.0	6.5–8.0
Oxygen concentration	>5%	> 10%
<b>Temperature</b>	45–68 C (110-155°F)	54–66 C (130-150 °F)

***Material mix (C/N)***

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

***Water content and porosity***

Like all living things, microorganisms need water. To encourage their growth and rapid composting, water content of the mixture should be 50–60 percent (wet basis). It is important to avoid excess water because of the

potential for odor and leachate conditions. **If the mixture feels moist, yet when a handful is squeezed no water drips from it, the mixture probably has adequate water content.** Composting in the open air is affected by rainfall and in some regions rainfall saturates compost piles. This results in leachate formation, odors and other problems. In dry regions and in covered facilities, *water must be added* to avoid process inhibition.

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

### **Temperature**

The composting process will generate, and regulate its own temperature. However, to maintain high temperatures the pile must be large or have some insulation. A layer of inactive material, sawdust, or finished compost, placed over the entire pile will insulate the pile. The insulation layer should be a foot or more thick. As the pile heats up, warm air within the mixture will rise and move out of the pile, while fresh air will be drawn in to replace it. This process exhausts CO<sub>2</sub> created in the pile and maintains an aerobic environment for the microorganisms.

The highest rates of decomposition occur for temperatures in the range of 110–150°F as shown in Figure 1-4. Also, high temperatures above 131°F for three days will kill parasites, and fecal and plant pathogens within the pile. At temperatures above 150°F, microbial activity declines rapidly with activity approaching low values as compost temperatures exceed 160°F. More information on composting can be found in the reference material cited at the end of this manual.

## **Temperature**

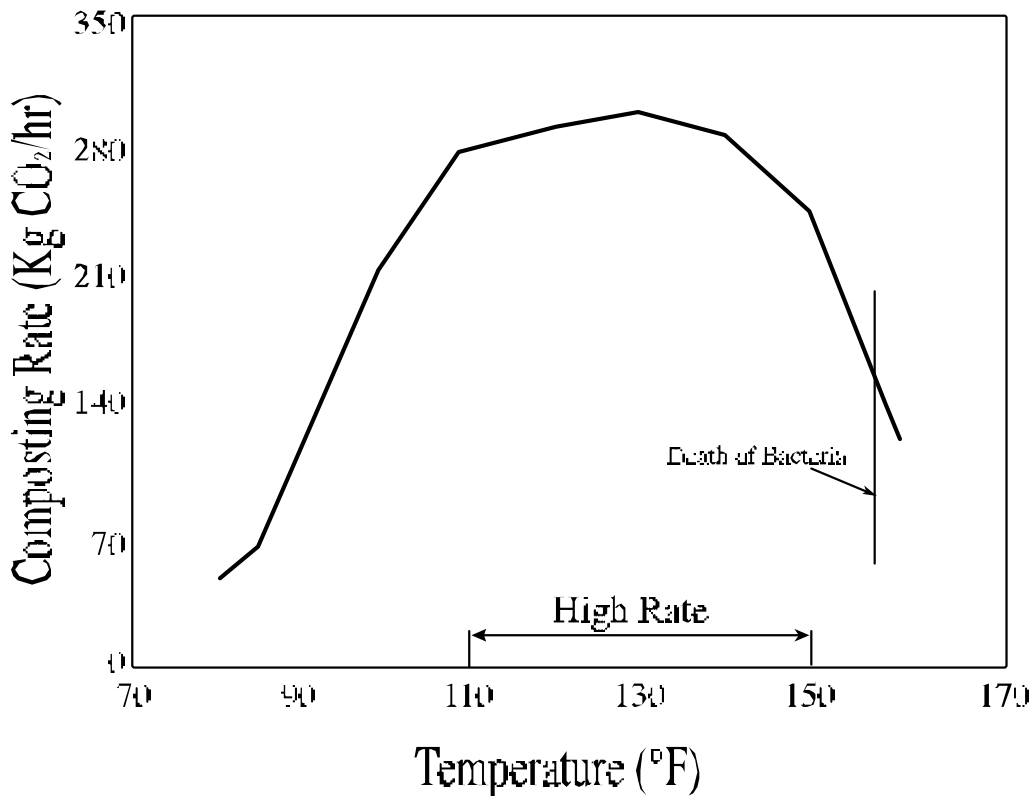


Figure 1-4. Effect of temperature on the composting rate as measured by CO<sub>2</sub> evolution

## Livestock mortality composting

Discussions and articles on composting livestock mortality almost always gravitate toward satisfying the principles mentioned above. Unfortunately, strict application of those standards should only be done when dealing with a consistent, thoroughly mixed pile. The reality is that a pile in which livestock mortality is composted is an inconsistent mixture. Therefore composting livestock mortality must be approached in a slightly different way.

Figure 1-5 is a schematic showing the process followed for composting animal mortality. This approach has been successful on over 6,000 farms throughout the United States. The compost pile (either open or in a bin) is an inconsistent mixture with a large mass of material (the animal) having a low C/N ratio, a high moisture content, and nearly zero porosity surrounded by a material (the carbon amendment) with a high C/N ratio, moderate moisture levels, and good porosity. The animal and amendments are layered into the pile, and no mixing is done in this process until after the high rate stage of composting has occurred and the animal has fully decomposed. Composting livestock mortalities (primary stage) can best be described as “above ground burial in a bio-mass filter with pathogen kill by high temperature.”

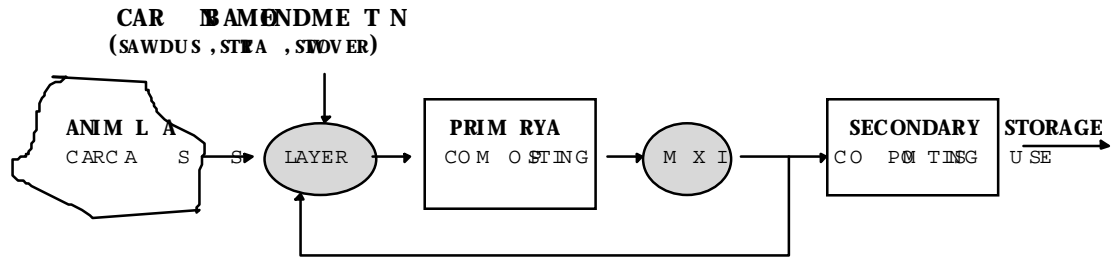


Figure 1-5. Material flow in livestock mortality composting. Forced aeration is *not* used. Materials are *not mixed* until flesh of the animal body is completely decomposed. Time can vary from 10 days (poultry) to over 100 days (>400 lb. animal).

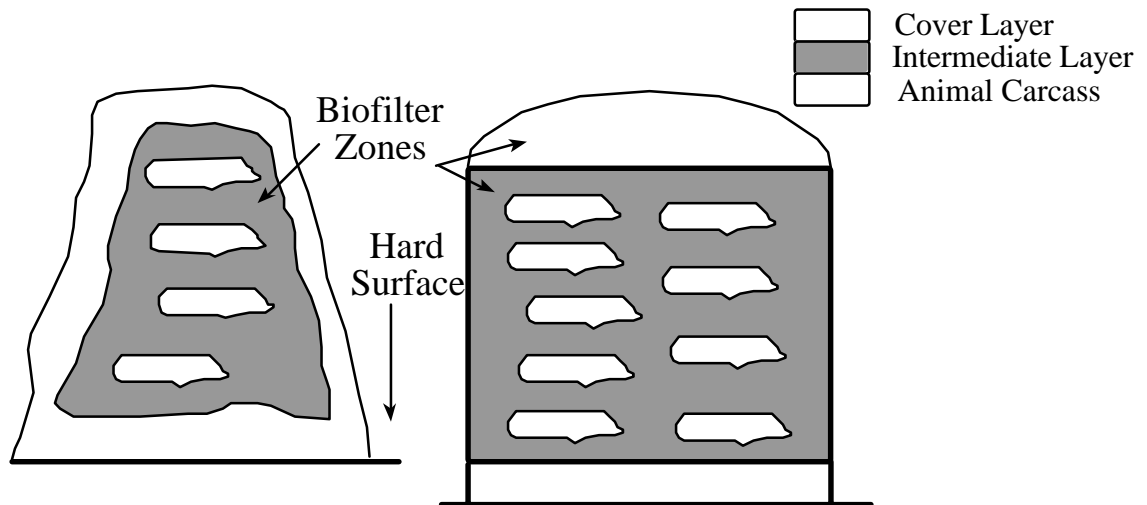


Figure 1-6. Cross-section views of composting in a windrow (pile) or bin for animal mortality—layering of animal mortalities surrounded by material which not only provides carbon (energy) for the microorganisms, but also acts as a biofilter. Pile is not turned until animals are decomposed. Pile shape will depend on



**whether done in the open or in a bin.**

Figure 1-6 is a cross-section of the compost pile for animal mortality. The decomposition process is anaerobic (lacking oxygen) in and around the animal mortality, but as gasses are produced and diffuse away from the mortality, they enter an aerobic zone. Here the gasses are trapped in the surrounding material, ingested by the microorganisms, and degraded to CO<sub>2</sub> and H<sub>2</sub>O. Thus the surrounding material supports bacteria to form a biological filter, or a biofilter.

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

#### ***Data collection***

In order to monitor the composting process, it is necessary to measure and record temperatures of the compost pile. Pathogen-kill can be monitored by measuring the internal pile temperature. Progress of the pile can also be surveyed from temperature records. Temperatures should be taken at several points near the animals placed in the pile. Temperature recording can be done easily with a three-foot probe thermometer (1/4 -inch probe diameter is recommended). Data recorded should include date, size, number of animals added, and the internal temperature of the pile.

#### ***Managing the composting of livestock/poultry mortality***

There are two general approaches to livestock mortality composting: enclosed, or bin, systems and open pile systems. Ohio regulations specify only bins for poultry composting, but they allow either option for the other approved livestock species. The following discussion of the overall management illustrates some of the basic ideas involved in either approach. More details are given later for each species.

Sawdust is widely used for composting animal mortality. It works well as a biofilter, allows high temperatures to be achieved and sustained during the primary stage, and promotes bone-breakdown when doing large (>400 lb.) animals. Because of its ability to shed rainwater, sawdust works well for outside piles where exposure to rain and snow could result in high moisture levels leading to leachate or odors. When using sawdust, it is recommended 25–50 percent of the material be recycled compost from the storage pile as this reduces cost, improves the composting process, and leads to a higher quality finished compost. Recycle rates should not exceed 50 percent as this may limit carbon availability, thus interfering with the composting process.

Recent studies in Ohio have shown that: (1) mixtures of sawdust and straw (or cornstover) can be used both under cover or in outside piles, and (2) straight straw or cornstover can be used in roofed piles, but require periodic water addition during composting to prevent inhibiting the process. If straw or cornstover is used in the mix, the amount of recycled material will need to be reduced. For poultry mortality, poultry litter and straw work very well.

The following table lists potential materials for use in composting animal mortality. Discussions of materials suitable for each species is detailed in the later chapters of this manual.

**Table 1-2. Carbon sources/carbon amendments identified for possible incorporation into animal mortality composting operations.**

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Cornstover	Chopped soybean stubble
Peanut hulls	Wood shavings/chips
Sawdust	Recycled paper/cardboard
Yardwaste	Leaves
Hay	Chicken litter
Rice hulls	Manure and bedding (horse, sheep, swine)
Straw	

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Source: *National Pork Producers Handbook*

Practices of composting mortality are very simple. The methods recommended by the Ohio Composting Development Team are:

1. Construct a base from sawdust or acceptable amendment at least 1 foot thick. (This may not be enough for very large animals.) This base will collect liquids that are released during mortality decomposition. It also permits air movement and microbial action underneath the mortality. If liquids begin to leach out of the pile, spread sawdust around the pile to absorb the liquids, and increase the depth of the base when constructing new piles.
2. Place a layer of animals on the sawdust base. A single layer of animals should be centered on, and evenly spaced across, the base. Do not stack animals on top of one another (with the exception of very small animals where mortalities can be layered up to 4 inches thick.) Four to six inches of amendment is necessary between layers of mortality for the compost system to work effectively.
3. Cover the animals with 2 feet of damp amendment. This cover acts as the biofilter for odor control around the pile and insulates the pile to retain heat. Odors may be released when an inadequate cover is used or when it is too dry. The released odors may also attract scavenging animals and pets to the pile. Maintaining a 2-foot cover prevents this.

When additional animals are placed in the pile the following steps should be followed.

4. Hollow out a hole in the amendment (in the 2 feet of cover material). Maintain 4–6 inches of amendment over animals already in the pile.
5. Place a new layer of animals in the pile.
6. Cover new layer of animals with 2 feet of damp amendment.

Pile (bin) management is a simple cycle, based on a primary stage (primary-stage compost time =T1), secondary stage (T2), and storage stage (T3). A minimum of two primary piles (bins) is required. The secondary pile is the same size as the primary pile. The storage pile size is dictated by how long the compost will be stored before land application.

Each pile is constructed for T1 days, composted for T1 days, and then turned and composted for T2 days. Finally the material is placed in the storage area where it is kept for T3 days. Each primary bin gets filled at (2 \* T1) intervals. A more complete description of the design and operation is presented in chapter 3.

## Chapter 2

### Mortality composting site selection and design options

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Dr. David Elwell, OARDC, and  
Michael J. Monnin, PE, USDA-Natural Resources Conservation Service (NRCS)

Ohio's Livestock Composting Development Team has identified four basic objectives that must be met when composting animal mortalities in Ohio. These objectives are:

1. Protect ground and surface waters from pollution.
2. Reduce the risk of the spread of disease.
3. Prevent nuisances such as flies, vermin, and scavenging animals.
4. Maintain air quality

Selecting the proper location and design for a composting facility are the first steps in meeting the objectives listed above.

#### Siting guidelines

Several factors must be considered when siting facilities for composting livestock mortalities. Water quality, public perception, nuisance concerns, Biosecurity issues, and traffic around the compost area are some of the primary factors.

##### *Water quality*

A number of organic compounds are produced during the composting process. Some of these compounds, such as nutrients and bacteria, pose water-quality problems if allowed to leach out of the compost and find their way into ground or surface waters. These problems are avoided by controlling leachate from the pile, managing runoff of wastewater and solids from the site, and establishing a composting base with low permeability.

##### *Leachate control*

Leachate problems occur due to excess liquids escaping the compost pile. Leachate is best controlled by using adequate amounts of an absorbent carbon amendment at the bottom of the compost pile. If leachate does occur, it must be collected and treated before entering a water resource. Treatment can take place through properly designed vegetative filter strips, infiltration areas, or other accepted treatment methods.

##### *Runoff Control*

Composting facilities should be located on high ground to avoid flooding problems and located away from streams, lakes, and wells to minimize the risk of polluted runoff entering water supplies.

Off-site surface water should be diverted away from the composting facility to minimize the amount of runoff water generated from the compost site. If facilities will be located in areas subject to flooding, they must be protected from a 25-year, 24-hour rainfall event. Runoff from a non-roofed facility should be controlled and directed to a properly designed vegetative filter strip, infiltration area, or other accepted treatment method. Regardless of the method used, there must not be any discharge of polluted runoff to waters of the state. Consult your local Soil and Water Conservation District, the Natural Resources Conservation Service office, or Ohio EPA District Office for more assistance.

##### *Ground water protection*

To protect ground water, the base of the composting facility should have a low permeability and be a minimum

of 3 feet above the high-water table. Concrete or crushed rock base overlying a geo-textile cloth (low permeability) is recommended when the site has high-permeability soil. These requirements help prevent water from leaching through the base of the composting facility into the ground water.

### ***Biosecurity***

Control of pathogens and disease are critical to any livestock operation. Traffic from the composting facilities to production housing should be minimized and if possible eliminated. The composting process successfully destroys most diseases, but bacteria and viruses from fresh mortality can be passed through the transport vehicle to production housing. Collection of leachate should direct runoff away from production facilities. Scavenging animals and vermin must also be kept out of the compost. Maintaining the recommended cover (2 feet in outside piles, 1 foot in enclosed bins) over the compost pile should eliminate these problems. However, experience has shown that once scavengers know there are mortalities in the pile, they will dig in the pile to find them. Fencing may have to be installed if scavenging animals are a problem. Greater detail on biosecurity is given in chapter 5.

### ***Public perception***

Composting will generate little, if any, odor, flies, or other nuisances when managed properly. However, when siting the composting facility, consideration must be given to the location of neighboring residences, production facilities, and public roads and highways. Composting facilities should be located downwind of nearby residences. Aesthetics should also be considered; handling of dead livestock may not be a welcome sight to nearby residents or passersby. Consider their view or area of sight when siting the facility.

### ***Traffic***

Depending on the size and management of the livestock facilities, animals may be added to the pile several times a week or every day. Ponding of water and mud will interfere with access to the composting area. To avoid these problems, construct a roadway that provides all-weather access to the compost area. Loading and unloading of the compost facility must be possible in all weather conditions. Areas around the composting facilities that are used to unload finished compost must be firm and well drained. A solid base, such as gravel or concrete, is required in this area, and will help prevent ponding water and accessibility problems from occurring around the compost facility.

Traffic flow to and from the compost area must be taken into account. Appropriate distances from overhead and underground utilities must be maintained to insure safety. The composting facility should be located and constructed so as not to interfere with other farm operations.

## **Summary**

A checklist of requirements for the composting area produced by the Natural Resources Conservation Service is given in Table 2-1. Refer to this checklist when comparing possible composting sites on your farm. Figure 2-1 shows a general layout for a composting site. Although all sites will be unique, this figure illustrates the general requirements for a composting site.

Siting the composting facility is an important step in meeting the objectives set forth for proper disposal of livestock mortalities. Selecting a proper composting site will help protect water quality, prevent complaints and nuisance problems, maintain biosecurity, and minimize the challenges in operating and managing the composting process.

**Table 2-1. Site selection checklist for livestock mortality composting facilities**

**Is the site:**

- Away from ponding areas or drainage patterns (High and Dry)?
- Able to divert clean water?
- At least 3 ft. above the high water table?
- At least 300 ft. from streams, lakes, waterways, etc.?

**Does the site have:**

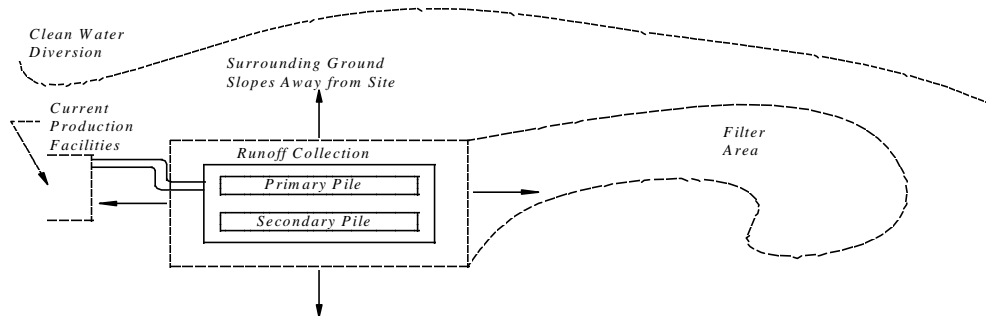
- Runoff collection and available treatment areas?
- All-weather access to the compost area?
- All-weather compost pad?

**Does the location provide:**

- Suitable access to sawdust storage?
- Clearance from underground and overhead utilities?
- Minimal interference with other farm traffic?

**Has the producer considered:**

- View from neighboring residences?
- Prevailing winds for the site?
- Biosecurity precautions?
- Aesthetics and landscaping?



**Figure 2-1. General site layout recommendations for composting facilities.**

## Facility design alternatives

Mortality composting is commonly conducted in one of four primary facility types: a bin, static-pile, windrow, or mini-composter. Each facility option has unique advantages and disadvantages and producer-choice is driven by a number of concerns, including:

1. Ability to meet the four objectives required of a compost system.
2. Type of production unit serviced.
3. Economic costs associated with startup and operation of the bin or pile.
4. State regulations and/or restrictions on facility type and design specifications.
5. Access to economical sources of carbon amendment.
6. Access to appropriate loading, unloading and handling equipment.
7. Appropriate land area for application of compost material.

Given these driving factors, producers must make informed decisions based upon the specific advantages of each facility option.

### Bin composting

Composting in a bin usually involves construction of a facility with a concrete floor, wood or concrete sidewalls on at least three sides, and a roof over the facility to eliminate water infiltration.

Advantages of bin composting	Disadvantages of bin composting
+ Reduced risk of weather affecting the compost process.	- Initial investment in facilities.
+ More aesthetically pleasing appearance.	
+ Reduced risk of scavenging animals.	
+ Compost moisture content is consistent and controllable.	
+ Many carbon amendments can be used in the process.	
+ Leachate risk is reduced and easily contained.	
+ Existing facilities, barns, etc. may be easily modified to meet the needs.	

### Windrow and static-pile composting

The windrow composting system is established on a concrete, geo-textile fabric-lined gravel base or low permeable soil to control water infiltration. In this system, walls and roofs are not used, so access to the pile from all sides is necessary in order to load, unload and mix the compost material. Producers using this design will load the livestock mortalities for a specific time period while continually extending the length of the compost pile and will mound the compost material to shed rainfall, control moisture loss and maintain adequate biofilter cover. Turning of any portion of the pile is delayed until that portion has met acceptable times for stage 1 (1<sup>st</sup> turn) or stage 2 (2<sup>nd</sup> turn) or storage (removal). Specific size and number of windrows and management will be based on site parameters of layout and loading rates. These topics are discussed in chapters 3 and 4.

Static-pile composting is similar to windrows except the pile is not extended in length. Turning of any pile is delayed until that it has met acceptable times for stage 1 (1<sup>st</sup> turn) or stage 2 (2<sup>nd</sup> turn) or storage (removal). With pile composting there will be three active piles in operation at any given time. (2 primary and 1 secondary).

<b>Advantages of windrow and static-pile designs</b>	<b>Disadvantages of windrow and static-pile designs</b>
+ Low initial investment in facilities.	- Exposure of the compost to the elements (wind and rain) increases risk of leachate and runoff.
	- Acceptable carbon amendment more limited than bin system.
	- Scavenging animals, if present, may be difficult to eliminate.

### **Mini-composters**

Mini-composters are a smaller version of a bin composter. Generally these facilities are about 40 inches square and 36 inches high and handle disposal of very small animals and/or birth materials. Animal size is limited to less than 40 pounds, and primary-bin requirements would be less than 70 cubic feet. For Ohio's climate, some additional insulation may be needed to enable the composter to reach the desired temperatures (> 131°F) for pathogen destruction and effective degradation.

For mini-composters that are not covered or under-roof, use the carbon amendments recommended for pile or windrow systems (ex. sawdust). For mini-composters that are setup inside a building or under their own protective roof, use carbon amendments recommended for bin composting (ex. straw, litter/manure, sawdust). See Table 1-2 for more options.

<b>Advantages of mini-composters</b>	<b>Disadvantages of mini-composters</b>
+ Low investment cost.	- May lose effectiveness under low ambient temperatures.
+ Compact size	
+ Fast degradation of small animals and birth materials.	

This chapter was adapted from *OSUE Extension Factsheet AEX 712-97, Swine Composting Site Selection* by Mescher, Wolfe, Stowell and Keener, 1997; *OSUE Extension Factsheet AEX 713-97, Swine Composting Facility Design* by Mescher, Wolfe, Foster and Stowell, 1997; and the *NPPC Composting Module*, McGuire (ed), 1997.

## Chapter 3

# Mortality compost facility sizing

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Chapter 2 listed the four basic objectives for composting animal mortalities: protect ground and surface waters from pollution; reduce the risk of the spread of disease; prevent nuisances such as flies, vermin, and scavenging animals; and maintain air quality. Meeting these objectives requires proper sizing of the compost facility. This chapter presents the basic formulas along with worksheets and graphs for sizing and specifying the design of composting facilities for livestock enterprises.

### Sizing guidelines

Sizing of a composting facility is critical for its successful operation. Composting facilities that are undersized will lead to problems with odor and flies. Proper sizing will make the management and operation of the composting process easier. Sizing is based on:

- Three stages for composting mortality: primary, secondary, and storage;
- Weight of the largest animal in the primary composting stage;
- Daily mortality rate and composting time determining total loading for each primary bin;
- All systems having a minimum of two primary bins or equivalent; and
- All primary bins using a Biofilter cover of 1–2 feet and a minimum of 1 foot of base material.

Analysis of the mixing ratios and specific volumes of materials and livestock mortalities, based on the guidelines for C/N ratio and biofilter cover as outlined in chapters 1 and 2, were analyzed by Keener et al. (1999) for poultry, swine and cattle. From that analysis equations were developed for primary stage time and volume, secondary stage time and volume, and storage time and volume.

### Equations for primary, secondary and storage stage time and volume

Primary stage time,  $T_1$ , is calculated using  $W_1$  is the design (usually largest) body weight of mortality (lb).

$$T_1 = 5 \times \sqrt{W_1} \geq 10, \text{ days}$$

ADL is average daily loss (lbs.) and is calculated using mortality rates, animal numbers and batches per year.

Primary compost volume,  $V_1$ , is calculated using:

$$V_1 = 0.2 \times \text{ADL} \times T_1, \text{ feet}^3 \quad (2)$$

With large animals and infrequent deaths, equation 2 will sometimes underestimate the primary volume needed. Equation 2a is a modification of equation 2 that correctly calculates primary volume and is applicable for any animal size.

The modified version of equation 2 is:

$$V_1 = 0.2 \times W_1 \times \text{integer} (\text{ADL} \times T_1 / W_1), \text{ ft}^3 \quad (2a)$$

Studies (Brodie and Carr, undated; Elwell et al., 1998) on composting mortality indicated secondary composting time does not need to be equivalent to the primary-stage time. Instead, it should be based on heating and cooling of the pile. Usually, this stage lasts from 10–30 days. For design and operational purposes, an estimate of secondary stage time,  $T_2$ , and volume,  $V_2$ , is calculated using:

$$T_2 = 1.3 \times T_1 \geq 10, \text{ days}; \quad (3)$$

$$V_2 = 0.2 \times \text{ADL} \times T_2, \text{ ft}^3. \quad (4)$$



The use of a minimum of 10 days or one-third the primary time is based on approximating minimum times found in poultry mortality composting and the times of sustained re-heating in the secondary bin for larger animals. A modified version of equation 4 for use with large animals or infrequent mortality cases is:

$$V_2 = 0.2 \times W_1 \times \text{Integer}(\text{ADL} \times T_2 / W_1), \text{ ft}^3. \quad (4a)$$

Volume for the secondary bin must be greater or equal to the primary bin size since it must hold all material emptied from a primary bin. This results in one secondary bin handling up to three primary bins. In windrow



Because land application may not be feasible at all times, storage time for compost needs to be considered. A minimum of 30 days is recommended. Volume of storage,  $V_3$ , can be calculated using:



$$T_3 \bullet 30, \text{ days}; \quad (5)$$

$$V_3 \bullet 0.2 \times \text{ADL} \times T_3, \text{ ft}^3. \quad (6)$$

A modified version of equation 6 for use with large or infrequent mortality cases is:

$$V_3 = 0.2 \times W_1 \times \text{Integer} (\text{ADL} \times T_3 / W_1), \text{ ft}^3. \quad (6a)$$

Volume for the storage bin must be greater or equal to the secondary bin size since it must hold all material emptied from a secondary bin. In windrow composting, this restriction generally doesn't apply. Equation 6a will avoid underestimating windrow size.

## Livestock mortality composting facility design guides

Table 3-1 summarizes the steps in sizing of a composting facility. As noted earlier, for large animals and low average daily loss (ADL), the volumes needed for primary, secondary and storage are better calculated using equations 2a, 4a and 6a.

Worksheets, developed by NRCS are presented here to help design and size composting facilities for individual farms. These worksheets are a step-by-step guide to determine the size and number of bins required for a given operation, or the size of the composting area for a windrow system. Examples of design are included under Examples of Design.

Design of the composting facility is easy, but requires knowledge of death losses. Table 3-2 summarizes the average death losses for poultry, swine, cattle/horse and sheep/goats and can be used in the design process for new facilities. **However, actual death loss data from the operation should be used in sizing the composting facilities whenever possible for existing facilities.** An example worksheet for calculating the poundage of annual and ADL is given in Table 3-3 (from NRCS OH-ENG-233a). Table 3-4 can be used to calculate ADL for swine.

Dimensions of windrows or bins are determined using Tables 3-5 and 3-6. These tables are a step-by-step guide to determine the size and number of bins required for a given operation or the composting area for a windrow system. Table 3-5 (from NRCS - OH-ENG- 234a) is used to calculate windrow dimensions and Table 3-6 (from NRCS OH-ENG- 235a) bin dimensions. If body size, and mortality rate (lbs./day) are known, Tables 3-7, 3-8, and 3-9 can be used directly to find required stage times and windrow or bin volumes.

## Examples of design

Examples for poultry, swine and cattle are presented here to illustrate the use of the equations 1-6 and Tables 3-5 and 3-6.

### Example 1—Poultry (mini-bin).

Given:  $W1 = 3$  lbs. and average daily loss (ADL) is 30 lbs./day. Design a composting bin system.

Solution: From equations 1–6 find:

$$T1 = 10 \text{ days, } T2 = 10 \text{ days and } T3 = 30 \text{ days; and}$$
$$V1 = 60 \text{ ft}^3, V2 = 60 \text{ ft}^3 \text{ and } V3 = 180 \text{ ft}^3.$$

From Table 3.6 for bin depth = 5 feet, select a bin volume of 80 feet<sup>3</sup>  
(A mini-bin of 4 feet x 4 feet x 5 feet).

Solving for bin numbers following procedure in step 2 gave: two primary bins, one secondary bin of 4 feet x 4 feet x 5 feet and one storage bin (or multiply bins) > 180 feet<sup>2</sup>.

### Example 2—Swine (bin).

Given:  $W1 = 450$  lbs. and ADL is 75 lbs./day. Design a composting bin system.

Solution: From equations 1-6 find:

$$T1 = 106 \text{ days, } T2 = 35 \text{ days, and } T3 = 30 \text{ days; and}$$
$$V1 = 1590 \text{ feet}^3, V2 = 525 \text{ feet}^3, \text{ and } V3 = 450 \text{ feet}^3$$

Equations 2a, 4a and 6a gives

$$V1 = 1,620 \text{ feet}^3, V2 = 540 \text{ feet}^3, \text{ and } V3 = 450 \text{ feet}^3$$

Because this is a bin system, *individual* bin sizes for secondary composting must be equal or greater than individual bin sizes for primary composting and individual bin size for storage must be equal or greater than secondary bin size. From Table 3.6 for bin depth = 5 feet select a bin volume of 800 feet<sup>3</sup> (16 feet x 10 feet x 5 feet). Solving for bin numbers following procedure in step 2 gave: three primary bins and one secondary bin 16 feet x 10 feet x 5 feet and one storage bin of 16 feet x 10 feet x 5 feet.

### Example 3—Swine (windrow).

Given:  $W1 = 450$  lbs. and ADL is 75 lbs./day. Design a composting windrow system.

Solution: From Equations 1–6 find:

$$T1 = 106 \text{ days, } T2 = 35 \text{ days and } T3 = 30 \text{ days; and}$$
$$V1 = 1,590 \text{ feet}^3, V2 = 525 \text{ feet}^3 \text{ and } V3 = 450 \text{ feet}^3$$

From Table 3.5 for windrow height = 7 feet , find windrow section area = 56 feet<sup>2</sup> and base width is 15 feet.

This implies the primary windrow length = 28 feet; secondary windrow length = 10 feet (assuming 56 feet<sup>2</sup> cross-section) and storage windrow length = 8 feet. The design windrow length would be 28 feet. Therefore, pad length is 38 feet.. Pad width is = 60 feet (10 feet + 15 feet + 10 feet + 15 feet + 10 feet). Compost pad area is (38 feet x 60 feet) 2,280 feet<sup>2</sup> or 0.052 acres.

**Example 4—Cattle (windrow).**

Given:  $W1 = 1,400$  lbs. and ADL is 20 lbs./day. Design a composting windrow system.

Solution: From equations 1–6 find:

$$T1 = 187 \text{ days, } T2 = 62 \text{ days and } T3 = 30 \text{ days; and}$$

$$V1 = 748 \text{ feet}^3, V2 = 248 \text{ feet}^3 \text{ and } V3 = 120 \text{ feet}^3$$

Equations 2a, 4a and 6a give:

$$V1 = 840 \text{ feet}^3, V2 = 280 \text{ feet}^3 \text{ and } V3 = 280 \text{ feet}^3.$$

Use alternate volumes from equations 2a, 4a and 6a. From Table 3.5 for a windrow height = 7 feet, find windrow section area =  $56 \text{ feet}^2$  and base width = 15 feet. This implies: primary windrow length = 15 feet; secondary windrow length = 5 feet (assuming  $56 \text{ feet}^2$  cross-section); and storage windrow length = 5 feet. The design windrow length is 15 feet. Therefore, pad length is 25 feet. (15 feet + 10 feet). Pad width is 60 feet (10 feet + 15 feet + 10 feet + 15 feet + 10 feet). Compost pad area is  $1,500 \text{ ft}^2$  (25 feet x 60 feet).

Comments: Composting large animals requires additional evaluations to ensure adequate sizes. In this problem, over a 187-day time period, 3 (2.7 calculated) animals would need to be composted. Using the alternate calculation for primary bin volume gave  $840 \text{ feet}^3$  which translated to a total pad size of 25 feet x 60 feet.

**Table 3-1. Design procedures for animal mortality composting system.**

Step	Description
A	<p>Determine the average daily weight of animal mortalities to be composted:</p> <ol style="list-style-type: none"> <li>1. Multiple livestock species can be composted together, unless a dangerously contagious or reportable disease is suspected (see listing in chapter 5). Biosecurity measures must be considered in the siting and operation to prevent disease transmission.</li> <li>2. Use farm records for building capacity, animal sizes and livestock production values and loss records when possible; or calculate the livestock mortality rates (from NRCS OH-ENG-233a, 233swine or 233poultry) developed for the various livestock species.</li> <li>3. For swine facilities the following assumptions should be used if operator records are not available: <ul style="list-style-type: none"> <li>• Each sow yields 2.5 litters of pigs per year</li> <li>• Each litter = 10 pigs</li> <li>• For finish operations, the number of hogs = 2.7 x farm building capacity</li> </ul> </li> <li>4. The average daily death loss should be determined for each growth stage on the farm.</li> <li>5. Pounds of mortality produced from operations in one year using <b>“average weight”</b>.</li> </ol> <p>Average daily loss in pounds per day to be composted. For some livestock operations the mortality rate is not constant throughout the year. See form NRCS OH-ENG -233a.</p>
B	<p>Determine the composting stage times for the <b>“design weight”</b> to be composted in each windrow or bin. Note that the time for primary composting as well as the needed composting volume increases as the animal weight increases. For an operation with different growth stages, segregated bins or windrows should be evaluated for feasibility. Consider separate facilities for animals within these weight ranges: less than 50 pounds, 50–250 pounds, and greater than 250 pounds. For animals exceeding 500–600 pounds, the windrow composting method is preferred because individual primary bins would be large and the placement of animals would be difficult. For mature cattle or horses, a pile on a composting pad for each individual mortality is preferred. The following equations are solved in Tables 1 through 3.</p> <ol style="list-style-type: none"> <li>1. Primary Stage Time (in days) = 5 x (Design Animal Weight)<sup>1/2</sup>, Minimum time: 10 days</li> <li>2. Secondary Stage Time (in days) = 1/3 Primary Stage Time, Minimum time: 10 days</li> </ol> <p>Storage Time: 30 days (needs to be considered when land application is not feasible immediately following completion of secondary stage)</p>
C	<p>Determine the needed composter volumes using NRCS OH-ENG-234a or 235a. The following equations are solved in Tables 1 through 3.</p> <ol style="list-style-type: none"> <li>1. Primary-composter volume (in ft<sup>3</sup>) = 0.2 x Average daily loss (ADL, in lbs./day) x Primary-stage time (days)</li> <li>2. Secondary-composter volume = 0.2 x ADL (in lbs./day) x Secondary-stage time (days)</li> <li>3. Storage volume = 0.2 x ADL x 30 days</li> </ol> <p><i>Note: For large animals use alternate equations in NRCS OH-ENG-234a or 235a</i></p>
D	<p>Determine the dimensions of the compost facility, bin dimensions, and windrow size or number of bins using NRCS OH-ENG-234a or 235a. Note, in a bin system, the minimum front dimension (width) should be 2 feet greater than the loading bucket width. Also as an alternative to building individual secondary bins, a large area to accommodate more than one primary bin can be used. This bin is generally directly behind the primary bins. Standard NRCS Drawing OH-N-506-CAD is an example of this configuration.</p>
E	<p>Determine the annual sawdust requirement for the composting system using NRCS OH-ENG-234a or 235a. This calculation assumes all sawdust needs are met with fresh sawdust. In practice, it is recommended that up to 50 percent of the fresh sawdust needs be met with compost that has completed the secondary cycle.</p>



**Table 3-2. Livestock mortality rates and design weights.**

	Poultry <sup>1</sup>			Design weight <sup>4</sup> (pounds)
	Average weight <sup>3</sup> (pounds)	Loss rate (%)	Flock life	
Broiler (mature)	4-8	4.5-5	42-49 days	Up to 8
Layer	4.5	14	440 days	4.5
Broiler, breeding hen	4-8	10-12	440 days	8
Turkey, female (meat)	15-25	6-8	95-120 days	25
Turkey, male (meat)	25-42	12	112-140 days	35
Turkey, breeder replace.	15 (birth-30)	5-6	210 days	20
Turkey, breeding hen	28-30	5-6	180 days	30
Turkey, breeding tom	70-80	30	180 days	75

Growth stage	Average weight <sup>3</sup> (pounds)	Swine <sup>2</sup>			Design weight <sup>4</sup> (pounds)
		Loss rate (%)			
		Excellent	Good	Poor	
Birth to weaning	6	<10	10-12	>12	10
Nursery	24	<2	2-4	>4	35
Growing-finishing	140	<2	2-4	>4	210
Breeding herd <sup>5</sup>	350	<2	2-5	>5	350

Growth stage	Average weight <sup>3</sup> (pounds)	Cattle/horses <sup>6</sup>			Design weight <sup>4</sup> (pounds)
		Loss rate (%)			
		Excellent	Good	Poor	
Birth	70 - 130	<8	8 - 10	>10	130
Weanling	600	<2	2 -3	>3	600
Yearling	900	<1	1	>1	900
Mature <sup>5</sup>	1400	<0.5	0.5 - 1	>1	1400

Growth stage	Average weight <sup>3</sup> (pounds)	Sheep/goats <sup>6</sup>			Design weight <sup>4</sup> (pounds)
		Loss rate (%)			
		Excellent	Good	Poor	
Birth	8	<8	8 - 10	>10	10
Lambs	50-80	<4	4 - 6	>6	80
Mature <sup>5</sup>	170	<2	3 - 5	>8	170

<sup>1</sup>Adapted from Ohio Poultry Association Information; <sup>2</sup>Adapted from *Pork Industry Handbook* – 100; <sup>3</sup>Average weight used to calculate pounds of annual mortality; <sup>4</sup>Design weight used to calculate composting stage periods; <sup>5</sup> For mature animals the percent loss is an annual rate for the average number of head on the farm; <sup>6</sup>The design weight and mortality rates for cattle, horses, sheep and goats need to be verified with the producer, the table figures are estimates from OSU livestock specialists. The mortality rate for these species will not likely be constant throughout the year.

**Table 3-3. Annual livestock death loss calculations.<sup>1</sup> (general livestock) NRCS OH-ENG-233a, 12/99**

Cattle, horses, sheep, goats, other (list) \_\_\_\_\_ Poultry (use 233p), Swine (use 233s)  
*Complete one form for each livestock species. When the composting facility will include multiple livestock species, calculate daily losses by animal growth stage for each species, then sum the species worksheets to determine daily farm loss (see bottom of this form).*

**Total pounds death loss per year** (use “average weight” to calculate death loss)

Birth stage:

$$\left( \frac{\text{Number of births}}{\text{Average weight}} \right) \times \left( \frac{\text{(\% loss/100)}}{\text{lbs. of annual mortality}} \right) = \text{_____}$$

Weanling stage:

$$\left( \frac{\text{Number of animals}}{\text{Average weight}} \right) \times \left( \frac{\text{(\% loss/100)}}{\text{lbs. of annual mortality}} \right) = \text{_____}$$

Yearling stage:

$$\left( \frac{\text{Number of animals}}{\text{Average weight}} \right) \times \left( \frac{\text{(\% loss/100)}}{\text{lbs. of annual mortality}} \right) = \text{_____}$$

Mature stage:

$$\left( \frac{\text{Number of animals}}{\text{Average weight}} \right) \times \left( \frac{\text{(\% loss/100)}}{\text{lbs. of annual mortality}} \right) = \text{_____}$$

$$\text{Total special annual mortality per year (AM)} = \text{_____ lbs.}$$

$$\text{Average daily loss (ADL)} = \text{AM} / 365 = \text{_____} / 365 = \text{_____ lbs./ day ADL}$$

(1- see next page)

*Note:* For animals weighing less than 500–600 pounds, a bin composting system should initially be evaluated. For larger animals a windrow or compost pile for an individual mature animal will likely be the most practical.

1- For poultry and swine, normal daily death loss can be assumed as a constant throughout the year. However in some livestock operations, high seasonal death rates are the norm (during calving and lambing), where the majority of annual death loss occurs during a short period of time. The other circumstance is where specific growth stages are moved off the farm at less than a year old (lambs sold at 120 days). In these instances, the average daily death loss calculation is modified as follows:

$$\text{Daily death loss (ADL)} = (\text{AM} \times P) / t = \text{_____ lbs./day}$$

AM = total annual mortality, for species or growth stage (lbs.)

t = duration of seasonal high loss period, or duration, less than a year, species are on the farm (days)

P= percentage of total annual loss that occurs during seasonal peaks (decimal)

Optional ADL calculation method

(select largest ADL from either method)

Birth stage:

$$(ADL) = \left( \frac{\text{AM} \times \text{P}}{t} \right) = \text{lb/day}$$

Weanling stage:

$$(ADL) = \left( \frac{\text{AM} \times \text{P}}{t} \right) = \text{lb/day}$$

Yearling stage:

$$(ADL) = \left( \frac{\text{AM} \times \text{P}}{t} \right) = \text{lb/day}$$

Mature stage:

$$(ADL) = \left( \frac{\text{AM} \times \text{P}}{t} \right) = \text{lb/day}$$

$$\text{Total ADL/species} = \text{lb/day}$$

---

Total farm ADL (complete for last form used)

Species	Daily mortality (ADL) from forms 233a, 233p or 233s
Cattle/dairy	lbs./day
Goats	lbs./day
Poultry	lbs./day
Sheep	lbs./day
Swine	lbs./day
Horses	lbs./day
Other (list)	lbs./day
Sum (total farm)	lbs./day

Go to forms 234a (windrow) or 235a (bin) to size the composting facility

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Table 3-4. Swine production and death loss calculations

(NRCS OH-ENG-233s, 12/99)

<u>Production (%)</u> Stage of growth	Average weight (lbs.)	Design weight (lbs.)	<u>Typical mortality losses for swine</u>		
			Excellent	Good	Poor
Birth to weaning	6	10	Under 10	10-12	Over 12
Nursery	24	35	Under 2	2-4	Over 4
Growing/finishin g	140	210	Under 2	2-4	Over 4
Breeding herd	350	350	Under 2 / yrs.	2-5 / yrs.	Over 5 / yrs.

Source: Pork Industry Handbook - 100

Production

Number of pigs born per year (pre-weaning):

$$\frac{\text{_____}}{\text{(#sows)}} \times \frac{\text{_____}}{\text{(litters/yr.)}} \times \frac{\text{_____}}{\text{(pigs/litter)}} = \frac{\text{_____}}{\text{\#pigs born/year}}$$

Number of nursery pigs per year:

$$\frac{\text{_____}}{\text{(#pigs born/yr.)}} - \left( \frac{\text{_____}}{\text{(#pigs born/yr.)}} \times \frac{\text{_____}}{\text{(% loss/100)}} \right) = \frac{\text{_____}}{\text{\#nursery pigs/yr.}}$$

Number of finishing hogs per year:

$$\frac{\text{_____}}{\text{(#nursery pigs/yr.)}} - \left( \frac{\text{_____}}{\text{(#nursery pigs/yr.)}} \times \frac{\text{_____}}{\text{(% loss/100)}} \right) = \frac{\text{_____}}{\text{\#finishing hogs/yr.}}$$

Total Pounds of death loss per year (use "average weight" to calculate death loss)

$$\frac{\text{_____}}{\text{(# sows)}} \times \frac{\text{_____}}{\text{(Average weight)}} \times \frac{\text{_____}}{\text{(% loss/100)}} = \frac{\text{_____}}{\text{(lbs. loss/year)}}$$

$$\frac{\text{_____}}{\text{(# pigs born/ yr.)}} \times \frac{\text{_____}}{\text{(Average weight.)}} \times \frac{\text{_____}}{\text{(% loss/100)}} = \frac{\text{_____}}{\text{(lbs. loss/year)}}$$

$$\frac{\text{_____}}{\text{(# nursery pigs/ yr.)}} \times \frac{\text{_____}}{\text{(Average weight.)}} \times \frac{\text{_____}}{\text{(% loss/100)}} = \frac{\text{_____}}{\text{(lbs. loss/year)}}$$

$$\frac{\text{_____}}{\text{(# finish hogs/ yr.)}} \times \frac{\text{_____}}{\text{(Average weight)}} \times \frac{\text{_____}}{\text{(% loss/100)}} = \frac{\text{_____}}{\text{(lbs. loss/year)}}$$

Total pounds of death loss per year = \_\_\_\_\_

Average death loss per day = (Total lbs. of death loss per year)/365

**Table 3-4. Poultry production and death loss calculations**  
(NRCS OH-ENG-233p, 12/99)

Annual livestock death calculations (poultry)

Typical mortality losses for poultry production (%)

	<b>Poultry<sup>1</sup></b>			
	Average weight <sup>3</sup> (pounds)	Loss rate (%)	Flock life	Design weight <sup>4</sup> (pounds)
Broiler (mature)	4-8	4.5-5	42-49 days	Up to 8
Layer	4.5	14	440 days	4.5
Broiler, breeding hen	4-8	10-12	440 days	8
Turkey, female (meat)	15-25	6-8	95-120 days	25
Turkey, male (meat)	25-42	12	112-140 days	35
Turkey, breeder replace.	15 (birth-30)	5-6	210 days	20
Turkey, breeding hen	28-30	5-6	180 days	30
Turkey, breeding tom	70-80	30	180 days	75

Source: Ohio Poultry Association information

Poultry type: \_\_\_\_\_

B = Number of birds on farm = \_\_\_\_\_

M = Anticipated mortality for flock (as a decimal) = \_\_\_\_\_

T = Life of flock (days) = \_\_\_\_\_

W<sub>b</sub> = Weight of birds near maturity (lbs.)= \_\_\_\_\_

ADL = Average daily loss during flock life (lbs./day)

ADL = B x [(M/T) x W<sub>b</sub>]

ADL = \_\_\_\_\_ x ( \_\_\_\_\_ • • • • • ) x \_\_\_\_\_ ] = \_\_\_\_\_ lbs./day

Go to form OH-ENG 235a to size the bins (*poultry compost bins must have a roof*)

**Recipe of material proportions for poultry composting**

Material	Parts by weight
Poultry carcasses	1.0
Poultry litter	1.2
Straw	0.1
Water	0.75



(NRCS OH-ENG-234a, 12/99)

1. Calculate primary, secondary, and storage volumes (or use Tables 3.7 to 3.9):

$$\text{Primary volume} = 0.2 \times \frac{\text{lbs. loss/day}}{\text{Primary-stage time}} \text{ cubic feet}$$

$$\text{Secondary volume} = 0.2 \times \frac{\text{lbs. loss/day}}{\text{Secondary-stage time}} \text{ cubic feet}$$

$$\text{Storage volume} = 0.2 \times \frac{\text{lbs. loss/day}}{\text{lbs. loss/day}} \times 30 \text{ days} = \text{cubic feet}$$

Alternate: (use with large animals)

$\text{Primary volume} = 0.2 \times W1 \text{ (lbs.)} \times \text{integer (ADL * T1/ W1)} = \text{cubic feet}$
$\text{Secondary volume} = 0.2 \times W1 \text{ (lbs.)} \times \text{integer (ADL * T2/ W1)} = \text{cubic feet}$
$\text{Storage volume} = 0.2 \times W1 \text{ (lbs.)} \times \text{integer (ADL * T3/ W1)} = \text{cubic feet}$

2. Indicate the windrow height and resulting windrow area used.

Assume a windrow height of 7 feet and continue. Windrow height = \_\_\_\_\_ feet  
 Windrow section area and base width assume 1 foot top width and 1:1 side slopes

Windrow height (feet)	Windrow section area (square feet)	Windrow base width (feet)	Pad width (feet)
5	30	11	52
6	42	13	56
7	56	15	60

3. Calculate the length of the primary, secondary and storage windrows. **\*\*The design windrow length is longer of the primary windrow length or sum of the secondary and storage windrow lengths.** Then calculate the pad length.

$$\text{Primary windrow length} = \left( \frac{\text{Primary volume}}{\text{Primary-windrow area}} \right) = \text{feet (nearest feet)}$$

If the composting windrow length is less than twice the windrow height, reduce the height and go back to step 2. This indicates the composting configuration will be a compost pile versus a windrow.

$$\text{Secondary windrow length} = \left( \frac{\text{Secondary volume}}{\text{Primary-windrow area}} \right) = \text{feet (nearest feet)}$$

$$\text{Storage windrow length} = \left( \frac{\text{Storage volume}}{\text{Primary-windrow area}} \right) = \text{feet (nearest feet)}$$

$$\text{Pad length} = \text{**Design windrow length} + 10 \text{ ft.} = \text{feet (nearest feet)}$$

4. Calculate composting pad area

Pad width = 10 feet + primary windrow base + 10 feet. + secondary windrow base + 10 feet  
(See table in step 3)

$$\text{Compost pad area} = \frac{\text{Pad length}}{\text{Pad length}} \times \frac{\text{Pad width}}{\text{Pad width}} = \text{_____ square feet}$$

5. Calculate annual sawdust requirements. (This assumes no reintroduction of finished compost to the primary windrow, however it is recommended that up to 50 percent of fresh sawdust requirements be met with finished compost.)

$$\text{Cubic yards sawdust} = \frac{\text{lbs. loss/year}}{\text{lbs. loss/year}} \times 0.0069 = \text{_____ cubic yards/year}$$

**Table 3-6. Composting worksheet for bins.**  
(NRCS OH-ENG-235a, 12/99)

1. Calculate primary, secondary and storage volumes (or use tables 5 to 7):

Primary-cycle time  $T_1 = 5 \times \sqrt{\frac{\text{Design weight } (W_1)}{\text{largest animal anticipated}}} = \text{_____ days}$   
(10-day minimum)

Secondary stage time  $(T_2) = 1.3 \times \frac{\text{Primary-stage time}}{\text{Primary-stage time}} = \text{_____ days}$   
(10-day minimum)

2. Calculate primary, secondary and storage volumes (or use tables 1 through 3):

Primary volume =  $0.2 \times \frac{\text{lbs. loss/day (ADL)}}{\text{lbs. loss/day (ADL)}} \times \frac{\text{Primary-stage time } (T_1)}{\text{Primary-stage time } (T_1)} = \text{_____ cubic feet}$

Secondary volume =  $0.2 \times \frac{\text{lbs. loss / day (ADL)}}{\text{lbs. loss / day (ADL)}} \times \frac{\text{Secondary-stage time } (T_2)}{\text{Secondary-stage time } (T_2)} = \text{_____ cubic feet}$

Storage volume =  $0.2 \times \frac{\text{lbs. loss/day (ADL)}}{\text{lbs. loss/day (ADL)}} \times \frac{30 \text{ days } (T_3)}{30 \text{ days } (T_3)} = \text{_____ cubic feet}$

Alternate (use with large animals);  $W_1$  = weight of largest animal

Primary volume =  $0.2 \times W_1 \text{ (lbs.)} \times \text{integer } (ADL * T_1 / W_1) = \text{_____ cubic feet}$

Secondary volume =  $0.2 \times W_1 \text{ (lbs.)} \times \text{integer } (ADL * T_2 / W_1) = \text{_____ cubic feet}$

Storage volume =  $0.2 \times W_1 \text{ (lbs.)} \times \text{integer } (ADL * T_3 / W_1) = \text{_____ cubic feet}$

3. Calculate number of bins with a minimum of two primary, one secondary, and one storage bin required. *In doing calculations always round up to whole number, i.e. 2.1 bins = 3 bins (or) increase the bin size and refigure.*



Bin volumes versus width and length; depth of compost = 5 feet

Width / length	4	6	8	10	12	14	16
	Bin volume (feet <sup>3</sup> )						
4	80	120	160				
6	120	180	240	300	360		
8	160	240	320	400	480	560	640
10		300	400	500	600	700	800
12		360	480	600	720	840	960
14		420	560	700	840	980	1120
16		480	640	800	960	1120	1280

**Number of primary bins**—Choose bin dimensions within the capability of the loading equipment. Also account for the size of the animals to maintain 6–12 inches of clearance between the carcasses and the bin walls (minimum volume). The bin width should be at least 2 feet greater than the loader-bucket width. The equation for calculating the number of primary bins includes one additional bin to allow placing additional carcasses during the primary curing stage. *A minimum of two primary bins is required.*

$$\text{Trial bin volume} = \frac{\text{Width (feet)}}{\text{Width (feet)}} \times \frac{\text{length (feet)}}{\text{length (feet)}} \times 5 \text{ feet} = \text{cubic feet}$$

$$\text{Number of primary bins} = \frac{\text{Primary volume (step 2)}}{\text{Trial-bin volume}} + 1 \text{ bin} = \text{bins}$$

**Number of secondary bins**—Select secondary bin volume. *Each secondary bin must be greater than or equal to the volume of the primary bin since volume reduction during the compost stage is neglected.* A minimum of one secondary bin per three primary bins (The 3:1 ratio requires immediate utilization or separate storage of compost following the secondary stage.)

$$\text{Number of secondary bins} = \frac{\text{Secondary volume (step 2)}}{\text{selected secondary bin volume}}$$

$$\text{Number of secondary bins} = \frac{\text{Secondary volume. (step 2)}}{\text{Secondary-bin volume}} = \text{bins}$$

**Number of storage bins** - Select storage bin size. *Volume of each storage bin must be greater than or equal to the secondary bin volume.*

$$\text{Number of bins for compost storage} = \frac{\text{Storage volume (step 2)}}{\text{selected storage bin volume}}$$

$$\text{Number of storage bins} = \frac{\text{Storage volume (step 2)}}{\text{Storage-bin volume}} = \text{bins}$$

4. Calculate annual sawdust requirements. (This assumes no reintroduction of compost that has completed the secondary cycle to the primary bin, however it is recommended that up to 50 percent of fresh sawdust requirements be met with this compost.)

$$\text{Cubic yards of sawdust} = \frac{\text{lbs. loss / yr.}}{\text{lbs. loss / yr.}} \times 0.0069 = \text{cubic yards/year}$$

$$\text{Additional bin(s) for fresh sawdust storage} = \text{_____}$$

**Summarize bin sizes and numbers:**

	Primary	Secondary	Compost storage	Sawdust storage
Number of bins				
Size (w x l)				

**Table 3-7. Primary volume (feet<sup>3</sup>) vs. body size and mortality rate**

Body size (lbs.)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Stage time (days)	10	11	16	30	35	50	61	74	87	94	112	158	194
Mortality rate (lbs./day)	Vol. <sup>1</sup>												
1	2	2	3	7	10	20	30	44	60	70	100	200	300
5	10	11	16	30	35	50	61	74	87	94	112	200	300
10	20	21	32	59	71	100	122	148	173	187	224	316	387
25	50	53	79	148	177	250	306	371	433	468	559	791	968
50	100	106	158	296	354	500	612	742	866	935	1118	1581	1936
75	150	159	237	444	530	750	919	1112	1299	1403	1677	2372	2905
100	200	212	316	592	707	1000	1225	1483	1732	1871	2236	3162	3873
150	300	318	474	887	1061	1500	1837	2225	2598	2806	3354	4743	5809
200	400	424	632	1183	1414	2000	2449	2966	3464	3742	4472	6325	7746
300	600	636	949	1775	2121	3000	3674	4450	5196	5612	6708	9487	11619
400	800	849	1265	2366	2828	4000	4899	5933	6928	7483	8944	12649	15492
750	1500	1591	2372	4437	5303	7500	9186	11124	12990	14031	16771	23717	29047
1000	2000	2121	3162	5916	7071	10000	12247	14832	17321	18708	22361	31623	38730
1500	3000	3182	4743	8874	10607	15000	18371	22249	25981	28062	33541	47434	58095

<sup>1</sup> Shaded area is minimum volume based on the size of the animal.

**Table 3-8. Secondary volume (ft<sup>3</sup>) vs. body size and mortality rate**

Body size (lb)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Stage time (days)	10	10	10	10	12	17	20	25	29	31	37	53	65
Mortality rate (lb/day)	Vol. <sup>1</sup>												
1	2	2	2	7	10	20	30	44	60	70	100	200	300
5	10	10	10	10	10	20	30	44	60	70	100	200	300
10	20	20	20	20	24	33	41	49	60	70	100	200	300
25	50	50	50	50	59	83	102	124	144	156	186	264	323
50	100	100	100	100	118	167	204	247	289	312	373	527	645
75	150	150	150	150	177	250	306	371	433	468	559	791	968
100	200	200	200	200	236	333	408	494	577	624	745	1054	1291
150	300	300	300	300	354	500	612	742	866	935	1118	1581	1936
200	400	400	400	400	471	667	816	989	1155	1247	1491	2108	2582
300	600	600	600	600	707	1000	1225	1483	1732	1871	2236	3162	3873
400	800	800	800	800	943	1333	1633	1978	2309	2494	2981	4216	5164
750	1500	1500	1500	1500	1768	2500	3062	3708	4330	4677	5590	7906	9682
1000	2000	2000	2000	2000	2357	3333	4082	4944	5774	6236	7454	10541	12910
1500	3000	3000	3000	3000	3536	5000	6124	7416	8660	9354	11180	15811	19365

<sup>1</sup> Shaded area is minimum volume based on the size of the animal.

**Table 3-9. Storage volume (ft<sup>3</sup>) vs. body size and mortality rate**

Body size (lb)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Stage time (days)	30	30	30	30	30	30	30	30	30	30	30	30	30
Mortality rate (lb/day)	Vol. <sup>2</sup>												
1	6	6	6										
5	30	30	30	30	30	30	30						
10	60	60	60	60	60	60	60	60	60				
25	150	150	150	150	150	150	150	150	150				
50	300	300	300	300	300	300	300	300	300		USE VALUES FROM TABLE 3-8		
75	450	450	450	450	450	450	450	450	450				
100	600	600	600	600	600	600	600	600	600				
150	900	900	900	900	900	900	900	900	900				
200	1200	1200	1200	1200	1200	1200	1200	1200	1200				
300	1800	1800	1800	1800	1800	1800	1800	1800	1800				
400	2400	2400	2400	2400	2400	2400	2400	2400	2400				
750	4500	4500	4500	4500	4500	4500	4500	4500	4500				
1000	6000	6000	6000	6000	6000	6000	6000	6000	6000				
1500	9000	9000	9000	9000	9000	9000	9000	9000	9000				

<sup>2</sup> Shaded area is minimum volume based on the size of the animal.

## Chapter 4

# Management of the compost facility and compost utilization

Michael J. Monnin, PE, NRCS

Chapter 3 described the sizing of the facility for composting animal mortalities in Ohio. This chapter presents the procedures to follow in managing the operation of the mortality composting facility, either bin or windrow systems.

### The compost process

Composting is a controlled natural process in which beneficial microorganisms reduce and transform organic wastes into a useful end product (compost). It is a predominately aerobic process that does not produce offensive odors and does produce a final product that is safe and is available as a crop fertilizer or soil amendment.

#### *Mortality composting*

The mortality composting method utilizes sawdust or other acceptable materials as the carbon amendment. The livestock mortality supplies the necessary nitrogen and some moisture for the composting process to take place. This combination will satisfy the requirements of certain readily available bacteria and fungi to convert these materials to an inoffensive and useful product. The volume of the mass will be reduced 25–30 percent by the process. The composting process consists of a primary and secondary stage. The primary stage is to reduce the mortality to where only larger bones remain. The secondary stage is to allow complete decomposition of the mortality and for the compost to stabilize. The composting time is dependent upon the size of the mortality. Therefore it is best to group similar sized animals into the same windrow. The time for secondary composting should generally be about one-third the time of primary composting. The following table can be used to estimate the required time in each stage of mortality composting based on the size of the animals:

Mortality size (lbs.)	4	10	50	100	220	350	500	1000	1500
Primary stage (days)	10	16	35	50	75	95	115	160	195
Secondary stage (days)	10	10	12	15	25	30	40	55	65
Storage stage (Suggested minimum days)	30	30	30	30	30	30	30	30	30

#### *How to get started (primary stage)*

Start composting by placing a minimum 1 foot of sawdust on the floor of the primary bin or base of the area for the windrow; if the mortality weight exceeds 200 pounds, use at least 1 foot of sawdust. Animals should not be placed directly on soil, gravel, or concrete floors because they will *not* compost properly and will not meet composting requirements. Place one layer of livestock mortalities on the sawdust and cover with a minimum of 1 foot of sawdust for bins and 2 feet for windrows or piles. Place no animals closer than 1–2 feet from the sides. The cover on the sides and on top is important to eliminate scavenging animals and minimize odors. Most problems in animal mortality composting arise when insufficient sawdust is used in covering animals. Small animals less than 20 pounds may be grouped. Larger animals may need to be recovered as the sawdust settles around the mortality. For windrows or piles, it is important to shape or round the material, so that it will shed rainfall. Do not allow pockets to form in the windrow/pile, and eliminate any areas that will trap water. As large animals begin to decompose, the material will settle and form pockets; as this occurs the windrow/pile must be reshaped.

### ***Loading***

To place additional animals, hollow-out a cavity in the existing compost, place the mortalities one animal thick and cover with a minimum of 1 foot of sawdust for bins and 2 feet for windrows or piles. If finished compost is available, it should be used to cover the mortality to provide additional heat and bacteria to start the process. Sawdust should then be used to provide the final cover. Use a pointed dowel or rod to measure the thickness of the sawdust cover. Do not put animals on top of animals. Maintain  $\frac{1}{2}$ –1 foot between animals to prevent a large anaerobic mass. Make every effort to collect animals in inclement weather before they are frozen. If adding frozen animals to a new pile or bin, allow additional primary-staging time for thawing and compost bacteria to activate when ambient temperatures rise. Monitor progress with a compost thermometer to determine when primary composting begins.

### ***Monitoring***

It is recommended to monitor the temperature of the compost with a long-stem, dial-type thermometer. When composting is proceeding properly, temperatures will reach 130–160°F. Other than testing, this is the best way to prove pathogen-kill and identify problems. Primary bins, piles, or windrows started during cold weather may not begin composting immediately. As temperatures warm up, composting will begin. There is usually enough heat in active compost to continue composting through cold weather, regardless of the ambient temperature. If sawdust is used as recommended, the insulation effect is sufficient to minimize the effects of ambient temperature. However during cold weather, incorporate animals into the compost as soon as possible; frozen animals will take very long to compost.

### ***Secondary stage***

After the primary bin, pile, or windrow has composted for the primary-stage time (after adding the last animal), turn the contents into the secondary unit. This step provides mixing and aeration of the material so it will reheat and compost through the secondary stage. After the secondary stage has completed, the compost should appear as a dark, humus-type material with very little odor. Some resistant parts such as teeth and bones may still be identifiable but should be soft and easily crumbled. If not, reintroduce the large bones into the primary or secondary compost stage.

### ***Storage***

After completion of the secondary stage, the compost can be recycled or spread as per the utilization plan. Storage of compost for at least 30 days following completion of the secondary stage will give additional management flexibility. This is particularly important where the primary plus secondary stage is less than 90 days, since land application may not be possible immediately following the secondary stage.

### ***Utilization***

Use the finished compost for a starter material over the new animals being composted in the primary area. This provides heat and bacteria to kick-start the process. Experience has shown that up to 50 percent of the sawdust requirements can be filled using recycled, finished compost. However, plan to use sawdust in the amounts noted for starting up the operation until sufficient finished compost is available. It is important to recognize that as finished compost becomes available, 50 percent of the fresh sawdust requirement must be maintained for the system to function effectively.

### ***Sawdust management***

Keep sawdust relatively dry. Sawdust in the range of 40–50 percent moisture is recommended. Sawdust will shed rainfall reasonably well if the windrow is mounded with no pockets or depressions. Positive drainage must be maintained. All leachate and runoff must be collected and stored or treated in a manure storage system or filter area. However, in a properly maintained windrow leachate will generally be absorbed into the sawdust surrounding the mortality.

During dry periods of the year the surface of the windrow can become too dry and sawdust can be blown off by the wind leading to exposed animals and odor concerns. If other carbon amendments such as cornstover or chopped straw are used, moisture loss will be more prevalent than with sawdust. Therefore a supplemental water source is needed to maintain the proper moisture content necessary for composting.

### ***Windrow and pile-area management***

Keep the area around the compost unit mowed and free of tall weeds and brush. Watch for any leaching that may occur. Using sawdust for the foundation of the primary windrow will help eliminate leaching. There should be no leaching in a covered bin composting system.

### ***Nutrient utilization***

Finished compost should be applied to supply N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O requirements of agricultural crops. The nutrient requirements for any particular crop should be based on a current soil test. Compost application rates should be calculated on its nutrient content according to a recent laboratory analysis. In the absence of a laboratory analysis the nutrient content of the compost is estimated to be:

Total nitrogen—20 lbs./ton  
Ammonia nitrogen—4 lbs./ton  
Phosphorus—2 lbs./ton  
Potassium—6 lbs./ton

Finished compost shall be applied as per the compost utilization plan.

### ***Record keeping***

In order to properly manage the composting facility, daily records should be kept, particularly during the first several compost batches. This can be helpful in identifying problems that may occur. It is suggested to record daily the amount of sawdust added, the weight of the livestock mortalities, and the temperature of the compost.

### ***Maintaining base***

Maintain a *dry*, well-drained, solid base for the compost unit for two reasons: the base of the windrow will not turn anaerobic and an all-weather access can be maintained for daily loading. A wet compost area will be prone to failure.

### ***Pest management***

Animals digging into the compost can be a problem, although it is less likely in bins. Measures must be taken if this occurs to maintain biosecurity and a positive public perception. The easiest way to prevent this from occurring is to maintain the necessary minimum cover (1 foot of sawdust for bins and 2 feet for windrows or piles) over all dead animals.

*Never allow animals to be exposed.* It may become necessary to fence or build a structure to eliminate scavengers from the compost unit if they cannot be kept out. It is easier and cheaper to maintain adequate cover than to incur the additional cost of a fence or structure. Operation and management will determine the needs of the system.

### ***Maintenance***

Inspect compost unit when it is empty. Replace any broken or badly worn parts or hardware. Patch concrete floors, curbs, or gravel areas as necessary to assure proper operation and integrity. Examine roofed structures for structural integrity and leaks.

### ***Landscape Maintenance***

Keep all trees, shrubs, and flowers healthy in order to maintain a positive rural image.

***Additional considerations for poultry mortality composting***

1. The process uses a simple mixture of poultry manure, poultry carcasses, straw, and water. This will satisfy the requirements of certain readily available bacteria and fungi to convert these materials to an inoffensive and useful compost. The volume of the mass will be reduced 25–30 percent by the process.

**Recipe of material proportions for poultry composting**

Material	Parts by weight
Poultry carcasses	1.0
Poultry litter	1.2
Straw	0.1
Water	0.75

2. Once the weight of a day's poultry carcasses is determined, the other elements can be weighed out according to the recipe. The elements should be weighed in buckets on scales for the first few batches. For subsequent batches, a loader can be used once the weight of a full loader bucket has been determined for each element except water. A hose can be used to deliver the correct amount of water based on the time necessary to deliver the required weight of water through the hose. The moisture content must be maintained between 40 and 60 percent, equivalent to that of a damp sponge. This is an important part of the composting process, since a mixture that is too wet can become anaerobic and cause severe odor problems. Additional water may not be needed if sufficient moisture is available from other recipe ingredients.
3. For primary composting, the material is placed in the bins in layers in the following sequence: (*Note:* See Figure 1.)
  - a. One foot of dry poultry manure should be placed on the concrete floor to absorb the excess moisture that is added. This manure weight is not part of the recipe.
  - b. A 6-inch layer of loose straw is placed on top of the manure layer to allow aeration under the carcasses.
  - c. A layer of carcasses is placed on the straw. Be sure to maintain 6 inches from the edge of the compost pile to the edge of the dead carcasses, so the carcasses are not exposed.
  - d. If needed, water is added according to the recipe.
  - e. A layer of manure, as per the recipe, is placed over the carcasses according to the recipe. The manure must completely cover the chickens. This completes the first batch.
  - f. The second and each subsequent batch continues by repeating steps b through e above until the bin is full.

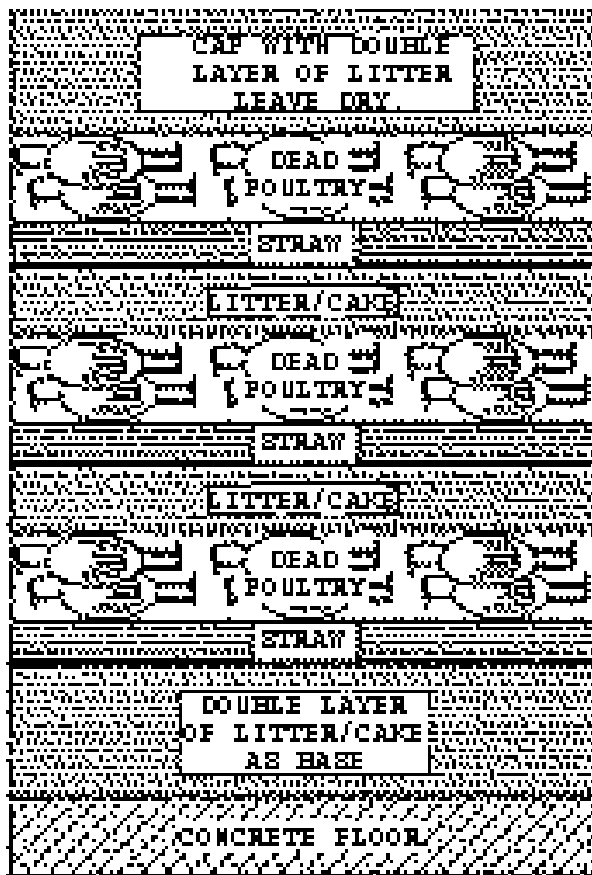


Figure 1

4. Temperature shall be monitored on a daily basis using a 36-inch, probe-type thermometer with a rigid protective covering. Temperatures should peak at 130–140 °F after 5–7 days of composting. If temperatures of 130 °F are not achieved during the composting process, the resulting compost shall be incorporated immediately after land application. If temperatures exceed 160 °F, the compost shall be removed from the composting bin, spread on the ground to a depth not to exceed 6 inches in an area away from buildings, and saturated with water to prevent spontaneous combustion.
5. The primary composter can be unloaded as peak temperatures decline below 110°F after a minimum of 10 days. Unloading the primary composter and loading the secondary composter shall be done in a manner that assures maximum mixing of the composting material.
6. Moisture and temperature requirements, discussed in paragraphs 3 and 5 above, also apply to the secondary-composting process. The compost removed from the secondary-composting process should be stored for 30 days before land application. Storage depth shall not exceed 7 feet to reduce the potential for spontaneous combustion. In addition, it should not come in contact with any manure stored in the same facility. Storage will allow the compost to dry allowing greater ease in handling.



7. Compost shall be applied to supply N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O requirements. The nutrient requirements for any particular crop should be based on a current soil test. Compost application rates should be calculated on its nutrient content according to a recent laboratory analysis. In the absence of a laboratory analysis, the nutrient content of the poultry compost is estimated to be:
  - Total nitrogen—40 lbs./ton
  - Organic nitrogen—28 lbs./ton
  - Phosphorus—20 lbs./ton
  - Potassium—25 lbs./ton
8. To utilize the nutrients in compost for crop production in an environmentally safe manner, it is important to follow the waste utilization details outlined in your waste utilization plan.
9. Inspect compost structure at least twice annually when the structure is empty. Replace any broken or badly worn parts or hardware. Patch concrete floors and curbs as necessary to assure water-tightness. Examine roof structures for structural integrity and leaks.
10. As discussed in item 3, maintaining the moisture content between 40 and 60 percent is vitally important. The primary and secondary composters and the storage or "resting" area should be protected from outside sources of water such as rain or surface runoff.
11. In order to properly manage the composting facility, daily records should be kept, particularly during the first several compost batches. This can be helpful in identifying problems that may occur. It is suggested to record daily the amount of sawdust added, the weight of the livestock mortalities, and the temperature of the compost. Daily records may be kept on the attached *Composting record worksheet*.
12. Occasionally, composters will not heat up or will produce odors or seepage. Composting is a biological process that depends on providing nutrients and an environment favorable for bacterial metabolism. Common mistakes are failure to provide all the materials needed for food and aeration or sloppy loading of primary boxes so that materials are not "sandwiched." Too little straw (or alternate carbon source) results in a dense, anaerobic mass and one in which energy (from cellulose) is limiting. Too much water is a common problem. Saturated compost piles are anaerobic and will not support the desired aerobic, thermophilic metabolism needed for rapid, odorless digestion of carcasses. If the mixture is too wet or too dry, the decomposition rate is greatly reduced. Too wet, too dry, improperly mixed, or incomplete mixes of compost materials can be amended. When primary compost is turned, dry manure or straw may be added to too wet compost, water can be added to "dusty-dry" compost, and improperly mixed materials can be remixed. A little experience and perseverance usually give good results in a short time.

## Chapter 5

# Biosecurity and disease prevention

Dr. Sheila D. Grimes, Ohio Department of Agriculture, and  
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### ***What is biosecurity?***

“Bio” means life and “security” implies some sort of protection. Thus, biosecurity implies the protection of life. In its simplest meaning, it means keeping germs (infectious disease agents) away from animals *and* keeping animals away from germs. A biosecurity program is a very important part of any animal and poultry health management program.

### ***Why is biosecurity important?***

Whenever we deal with a large number of animals or birds in a confined area, biosecurity is important. If a disease outbreak occurs, it could spread rapidly throughout the population. A disease outbreak could result in increased morbidity (sickness) or mortality (death loss) and be economically devastating for the producer. Therefore, a biosecurity program is a top priority in maintaining animal health.

### ***What types of infectious agents cause disease, and how are they transmitted?***

Many types of infectious agents can cause disease including the following:

- Bacteria and bacterial spores (the hardy resting phase of some bacteria such as the one which causes tetanus).
- Viruses .
- Fungi (including the resistant reproductive forms called “spores”).
- Parasites (lice, mites, and worms).
- Protozoa (such as coccidia).
- Unconventional agents such as prions which cause scrapie and bovine spongiform encephalopathy.

There are many ways in which infectious agents can be spread. They include :

- Aerosols (*i.e. through the air*).
- People (clothing, boots, shoes).
- Equipment (cleaning equipment, manure handling equipment, vehicles, grooming equipment, livestock trailers, etc.).
- Other animals (rodents, pets, wild birds, insects, carrier animals of the same species, etc.).

### ***What are some biosecurity measures?***

Biosecurity measures used on farms include:

- Rodent control inside and outside of buildings.
- Wildlife control such as bird-proofing buildings.
- Insect control (lice, flies, beetles, roaches etc.).
- Proper disposal of livestock mortalities.
- Disinfection of equipment and vehicles.
- Cleaning and disinfection of facilities after animals are removed.
- Restricting people entry and access.
- Isolation of new animals and quarantine of sick animals.

### ***How does composting destroy disease-causing organisms?***

All disease-causing organisms are subjected to at least three adverse conditions during composting: heat, toxicity caused by products of decomposition, and microbial antagonism. Heat generated in the composting process is the primary determinant studied as the inactivator of disease-causing organisms. An extended period of heat in the desired range achieved during composting is essential for the destruction of most pathogens. The effect of pH and the action of other bacteria and fungi on the destruction of disease-causing organisms is still largely unknown.

### **Will composting destroy all disease-causing organisms?**

*No.* Only minimal research has been done with disease-causing organisms of animals with regard to the ability of the composting process to destroy them. A recent review of chemical and microbial hazards to humans from urban waste composting facilities indicates that the assumption that all disease-causing organisms are killed by composting may be faulty.

Generally speaking, viruses are more heat-sensitive than bacteria or fungi. Most viruses are typically inactivated at 50–60° C. (122–140° F.). Viral surface proteins are inactivated at 50–60° C. rendering the viral particles noninfectious, since they are no longer capable of cellular attachment and uncoating. Most viruses, therefore, would not pose a significant problem with composting, because most compost piles obtain an internal temperature of 60° C. However, certain viruses, such as foot and mouth disease virus, can withstand a temperature of 95° C. (203° F.) for 15 seconds.

The majority of vegetative bacteria are readily inactivated at 100° C. (212° F. or boiling). Bacteria have been classified into several categories based on their heat sensitivities. Some bacteria, called thermophiles, grow well at elevated temperatures of 60° C. or greater. Such bacteria are useful in the decay of organic material in compost piles. However, other bacteria, called mesophiles and psychrophiles, are relatively heat-sensitive, and have reduced or limited growth at 60° C. Temperature limits of growth for the mesophilic and psychrophilic bacteria are less than 50° C., and therefore bacterial growth for the previously listed categories of bacteria would probably not be enhanced by composting. Bacteria which are inactivated at 60° C. include *Bacillus anthracis*, the cause of anthrax and *Mycobacterium tuberculosis*, which causes tuberculosis. Vegetative forms of the bacterium, *Bacillus anthracis*, are inactivated at 60° C., but *not* anthrax spores. Other bacteria, such as clostridia, including *C. chauveoi*, *C. novyi* and *C. tetani*, are particularly resistant to heat inactivation. Some clostridia can survive boiling for two or more hours.

To our knowledge, data regarding the susceptibility of prions and bacterial and fungal spores to inactivation by composting are not currently available. However, in general, the literature indicates that a temperature of 121° C. (250° F.) for 15 minutes is essential for the inactivation of bacterial spores. The most common spore-forming bacteria on Ohio farms belong to the genus clostridia and cause tetanus, enterotoxemia, blackleg, and malignant edema. Infectious agents referred to as prions are extremely resistant to heat inactivation as well as other forms of disinfection and sterilization. For the inactivation of prions, autoclaving (moist heat and a pressurized container) at 121° C. for five hours is recommended. Transmissible spongiform encephalopathies are prion-associated diseases. Composting temperatures typically range between 50–65° C. and therefore would be ineffective in the heat inactivation of prions and bacterial spores.

### ***Will composting increase the chances of disease or disease spread on my farm?***

In general, composting should not increase the risk of disease or disease spread if the process and pile are properly managed. Some important procedures to minimize risk include the following.

- Locate the compost pile in a site that minimizes potential contact between animals and the pile.
- Manage the site to prevent contaminated runoff or leachate from contacting animal housing or vehicles and equipment. Disease-causing organisms may survive in contaminated leachate for at least several days and possibly a long period of time.
- Prevent rodents and scavenging animals from digging in the pile and spreading contaminated material.
- Following recommendations for sawdust covering will provide a barrier to most pests.

- Fencing may be necessary if proper coverage is not maintained and animals have gained access.
- Fly infestation problems are eliminated with appropriate pile temperature and sawdust cover on livestock mortalities.

***Are there situations in which I would not be allowed to compost animal mortality?***

In order to compost animal mortality other than the species already provided for (poultry, swine, cattle, sheep, goats and horses), approval by the Ohio Department of Agriculture, the Ohio Environmental Protection Agency, and the Ohio Department of Health is required. Special regulations may apply to some approved species such as cattle and sheep. Because of the special concerns of the transmissible spongiform encephalopathies and their resistance to destruction sheep with scrapie and cattle over two-years-of-age showing signs of neurologic disease will not be permitted to be composted unless authorized by the chief of the Division of Animal Industry.

The following are designated as dangerously contagious or reportable diseases in Ohio (*Ohio Revised Code* 941.03 and Administrative Rule 901:1-21-02):

- 1) Anthrax
- 2) Ovine and caprine bluetongue
- 3) Brucellosis (*Brucella abortus*, *B. melitensis*, *B. suis*)
- 4) Newcastle Disease
- 5) Foot and mouth disease
- 6) Hog cholera
- 7) Psoroptic cattle scabies
- 8) Psoroptic sheep scabies
- 9) Vesicular exanthema
- 10) Venezuelan equine encephalomyelitis
- 11) Fowl typhoid
- 12) Highly pathogenic avian influenza
- 13) Pullorum (*Salmonella pullorum*)
- 14) Tuberculosis (*Mycobacterium bovis*)
- 15) Pseudorabies (Aujeszky's disease)
- 16) Equine infectious anemia
- 17) Contagious equine metritis
- 18) *Mycoplasma gallisepticum* in turkeys
- 19) Scrapie
- 20) Rabies
- 21) Eastern equine encephalomyelitis
- 22) Poultry chlamydiosis-ornithosis
- 23) Poultry paramyxovirus (other than Newcastle disease)
- 24) Infectious encephalomyelitis (poultry)
- 25) Infectious laryngotracheitis (other than vaccine-induced)

Under most circumstances, premises upon which these diseases are found are placed under quarantine, and the disposition of animal mortality will be under the guidance and direct supervision of the Ohio Department of Agriculture. Decisions concerning the suitability of composting for disposal of mortality rest with that Department. In addition, the federal government maintains a list of foreign animal diseases, and authority for composting animal mortality caused by these diseases rests with the federal government and cooperating state governments.

## Chapter 6

# Rules and regulations

## Tammie Brown, Ohio Department of Natural Resources

Several agencies in the state of Ohio share responsibility to regulate and provide technical and educational assistance to insure responsible livestock and poultry mortality composting. Following is a summary of each agency's role.

### Ohio Department of Agriculture

The Ohio Department of Agriculture regulates how animals may be disposed of in the *Ohio Revised Code* (ORC) Chapter 941.14 and 941.15. Accordingly, livestock mortality may be burned, buried (at least 4 feet deep), removed in a watertight tank by a licensed renderer or composted in accordance with Ohio EPA or ODNR, Division of Soil and Water Conservation Rules. If the Department of Agriculture determines that the livestock died because of a dangerously infectious disease the director may require a specific method of disposal. Individuals who haul raw rendering material, which includes livestock mortality, must obtain a license from the Ohio Department of Agriculture. Individuals composting livestock mortality according to ODNR, DSWC Rules are exempt from this licensing requirement.

### Ohio Department of Natural Resources

The Ohio Department of Natural Resources, Division of Soil and Water Conservation, regulates livestock mortality composting through animal waste pollution abatement rules *Ohio Administrative Code* (OAC) Rules 1501:15-5-01 through 1501:15-5-18 under ORC Section 1511.022. ODNR rules apply exclusively to operations described below. Other composting operations are regulated by the Ohio EPA, Division of Solid and Infectious Waste.

- 1) The composting is conducted by the person who raises the animals and the compost product is used in agricultural operations owned or operated by that person, regardless of whether the person owns the animals (*in essence, a farmer composts his livestock mortality on his own farm and reapplies it to his own fields*); or
- 2) The composting is conducted by the person who owns the animals, but does not raise them and the compost product is used in agricultural operations either by a person who raises the animals or by a person who raises grain that is used to feed them and that is supplied by the owner of the animals (*the same general principal as above applied to contract/cooperative farming operations*).

To comply with ODNR's Composting of Livestock Mortalities Rule (1501:15-5-18), the owner or operator of any existing or planned concentrated animal feeding operation, or owner of animals raised by an owner or operator of a confined animal feeding operation wishing to conduct composting of livestock mortality resulting from the operation shall:

1. Participate in an educational course concerning composting conducted by the Ohio State University Extension Service, and obtain a certificate of course completion.
2. Use the appropriate method, technique, or practice of composting as established in the *USDA-NRCS Field Office Technical Guide (Standard 317 Composting Facility Standard)* or other such standard as approved by the chief.

This rule is intended to prevent water pollution by livestock mortality composting. It does not address "nuisance issues" such as odors, dust, noise, or flies. It is enforced by ODNR working through county SWCDs on a complaint basis as are all of the agricultural pollution abatement rules.

### **Ohio Environmental Protection Agency**

The Ohio Environmental Protection Agency, Division of Solid and Infectious Waste, has regulatory authority (through Section 3734.028 of the *Ohio Revised Code*) over any composting facility that distributes the compost for sale or uses in conditions other than those covered by the ODNR, DSWC composting rules (*described in items 1 and 2 in the previous section*). Individuals who compost livestock mortality other than defined earlier must submit a registration and follow the testing procedure identified in the compost quality standards determined in OAC rules 3745-27-46.

The Ohio Environmental Protection Agency, Division of Surface Water, approves livestock waste management plans and issues permits to install for livestock operations exceeding 1,000 animal units. The scope of this regulation is to prevent water pollution by manure and wastewater management. Applicants are required to indicate their plan for livestock mortality disposal in the livestock waste management plan.

### **Ohio State University Extension (OSUE)**

The Ohio State University Extension provides and conducts the Livestock Mortality Composting Certification Training. This training is required by law to compost livestock mortalities on-farm.

### **Ohio Agricultural Research and Development Center (OARDC)**

The Ohio Agricultural Research and Development Center provides research and leadership in the development of the mortality composting standard and training program. Specifically through its Compost Research Facility, OARDC is a leading source of practical compost science.

### **USDA-Natural Resources Conservation Service**

The Natural Resources Conservation Service develops and maintains technical conservation practice standards, including livestock mortality composting. On-farm composting of livestock must follow this standard by law. The standard is covered in this manual and courses taught from it.

### **Nuisance Complaints**

Odors, flies, noise, and dust are considered nuisance complaints. Properly managed, by maintaining adequate sawdust cover (1 foot for bins, 2 feet for windrows or piles), mortality compost units across the state have operated successfully without nuisance concerns. However, given the potential for nuisance complaints, it is a good idea to be familiar with the two Ohio statutes that cover them:

- ORC 929.04, commonly known as *The Farmland Preservation Act* governs civil suits between neighbors. In a civil action for nuisances involving agricultural activities, the law can be used as a defense if the farm is operating in an “agricultural district” (registered with the county auditor), the farm was in operation first, the person complaining is not a farmer, the activities do not conflict with any other rules, and reflect generally accepted agricultural practices.
- ORC 3767.13 is a statute enforced by the county health departments or Ohio Environmental Protection Agency. Section D that states: “persons who are engaged in agriculture-related activities and who are conducting those activities outside a municipal corporation, in accordance with generally accepted agricultural practices, and in such manner so as not to have a substantial, adverse effect on the public health, safety, or welfare are exempt from . . . public or ordinances, resolutions, rules, and other enactment’s of a state agency or political subdivision that prohibit excessive noise or noxious smells from the keeping or feeding of animals.”

### **Summary**

Livestock mortality composting became legal in Ohio with the passage of Senate Bill 73, the *Dead Animal Composting Bill*. Over 2,000 poultry and swine producers to date have completed the OSUE certification training and are successfully using this very popular conservation practice. Few complaints have been registered with ODNR in that period. However, because of its very nature, livestock producers are encouraged to be vigilant in maintaining the management practices prescribed in this course and to meet the four objectives to retain the ability to legally use this management tool.

## Chapter 7

# Economics of composting

### Terry Mescher, Darke Soil & Water Conservation District

There are several factors to consider when comparing the economics of alternative disposal methods:

- Volume and weight of mortality produced per established time period.
- Frequency of mortality occurrence.
- Required facilities and equipment (new and existing) and their useful life expectancy.
- Labor requirements.
- Accessibility and timeliness.
- Impact on the environment.

Start by evaluating the factors influencing the cost of mortality composting

- a) Initial investment in equipment and facilities.
  - i) Facility construction (bin, pile, or windrow system).
  - ii) Number of bins or pile area required for the facility.
  - iii) Animal and material handling equipment.
- b) Annual operating costs.
  - i) Volume and cost of carbon amendment required.
  - ii) Labor requirement for proper management.
- c) Expected life of the facility.
  - i) Cost factors for compost facilities.
- d) Bin composting.
  - i) 4–5 feet in concrete base + 5–10-foot front apron.
  - ii) 5-foot treated sidewalk construction (min 3 sides).
  - iii) Steel roof.
  - iv) 6-inch square posts.
  - v) 2 feet x 4 feet and 2 feet x 6 feet purlin and rafter supports.
  - vi) Labor.
  - vii) Estimated cost: \$1,250–\$1,700 per bin.
- e) Static pile or windrow systems.
  - i) Concrete pad.
  - ii) 4–5 inch thickness
  - iii) Site development, gravel access.
  - iv) Geo-textile cloth with gravel base.
  - v) Site development, accessibility.
  - vi) Cost of gravel and geo-textile cloth.
  - vii) Cost estimates: <sup>1</sup>•<sub>3</sub>–<sup>2</sup>•<sub>3</sub> less than bins.

- f) Cost factors when comparing to alternative disposal methods.
  - i) Incineration.
    - (1) Incinerator cost (speed and volume dependent).
      - (a) Estimates = \$2,500–\$4,000.
      - (b) Capacity estimates = 100 lbs./hour .
    - (2) Fuel costs (type of fuel and area dependent).
      - (a) Estimates = \$0.7–\$1.50/gal.
    - (3) Life expectancy (volume and design dependent).
      - (a) Estimates = 3,000 to 5,000 hours.
    - (4) Cost estimates : \$0.80 to \$1.75 per lbs. mortality.
  - ii) Rendering (not available in all areas).
    - (1) Frequency of pick-up.
    - (2) Cost of pick-up per trip .
      - (a) Estimates in some areas \$50 per trip.
    - (3) Storage area for livestock mortalities.
    - (4) Disease considerations from truck on/near farm.
  - iii) Burial.
    - (1) Machinery cost and availability to dig hole .
      - (a) Cost estimates = \$50–\$75 per hour.
    - (2) Soil type and topography for safe burial.
    - (3) Water table depth and soil structure.
    - (4) Seasonally of burial (climatic conditions).
    - (5) Digging and burial in frozen soil.
- g) Economic advantages of mortality composting over the alternatives.
  - i) Long-life of the facility or pad
    - (1) Nothing to wear out so cost is minimal after start-up
  - ii) Generally no new equipment is needed
  - iii) Labor requirements are similar to alternatives and may be less
  - iv) Carbon sources are inexpensive and readily accessible in most areas



## Chapter 8

# Compost troubleshooting and frequently asked questions

Tom Price, Pork-Q-Pine Farms and  
Michael J. Monnin, PE, NRCS

Occasionally, composters will not heat up, or will produce odors or seepage. Composting is a biological process that depends on providing nutrients and an environment favorable for vigorous bacterial growth. Common mistakes are:

- Failure to provide all the materials needed for energy and aeration.
- Sloppy loading.
- Insufficient cover over the animals.
- Insufficient sawdust between the animals.

These mistakes typically result in a dense, anaerobic mass and one in which energy is limiting. Turning the pile and adding *dry* sawdust will remedy these problems. Daily records are the best way to diagnose problems. Exposed piles or windrows seldom need additional water.

### Frequently asked questions

*Doesn't mortality compost produce offensive odors, and attract rodents and dogs?*

If animals are properly covered (1 foot of sawdust for bins and 2 feet for windrows or piles) odors are sufficiently suppressed or absorbed so they are not a problem in most cases. When properly operated and managed, composters do not add to or increase odor levels around a production facility. Using too little sawdust is the single greatest factor associated with odor and rodent or scavenger problems. It is important to prevent these problems during start up because once scavengers learn the composter is a source of food, they can be difficult to stop.

*What happens in the wintertime when temperatures are cold?*

In general the warmer the ambient temperature, the better the composting process works. However, an active compost unit contains considerable heat which, with the insulating effect of sawdust, minimizes the effects of ambient temperatures. Interior compost unit temperatures of 130–160 °F are typical in properly operating composters when ambient temperatures are as low as 0 °F. Cold or frozen animals placed in cold, fresh sawdust will not compost during cold weather. However, animals placed under these conditions will begin to compost as ambient temperatures increase in the spring.

Animals placed in an active compost unit during cold weather should begin to compost as heat is absorbed from the composting mass. Covering the animals with warm or hot finished compost from an active secondary compost unit will further enhance the composting of fresh animals in cold ambient temperatures.

*Are a roof and concrete floor necessary?*

It has been shown that a roof is not necessary when sawdust is used as the carbon amendment. Sawdust has the unique ability to shed water and if kept on a dry and well-drained base, will not cause leachate. Until research proves otherwise, a roofed structure will be required unless:

- Sawdust is used as the carbon amendment, and
- An all-weather, dry, positively drained composting surface is used and all-weather access is maintained, and
- The runoff and any possible leachate are collected and stored or treated in a storage or filter area.

*How large a mortality can be put in a composter.*

Mature sows and boars (300–600 lbs.) and cattle (over 1000 lbs.) have been successfully composted. Longer composting times are required for the larger animals. Four months of active composting time should be sufficient for most swine mortalities. The animals are composted whole; no cleaving or cutting up is necessary. If certain parts, such as the skull or ball joints, are not fully composted, reintroduce them to the primary composting process for another stage. If this is happening a lot, look for reasons the process is being slowed. Many times it is because not enough sawdust is being added to the system.

*Do composters fail, and why?*

Occasionally, yes. Composters may not heat, producing odors and/or creating seepage. Composting is a biological process that depends on providing nutrients and an environment favorable for bacterial decomposition. Common mistakes are:

- Failure to provide enough sawdust to the system to provide for the Biofilter and to maintain an appropriate carbon source for the system to operate over time.
- Placing animals too close together may create a large anaerobic mass that will need to be turned and dry sawdust added.

In windrow composting, the pile must be well rounded to shed water and the base must be well drained and solid to allow for access and prevent anaerobic conditions.

The problems with too-wet, improperly mixed, or incomplete mixes of compost materials can be amended. When primary compost is turned, dry sawdust may be added to wet compost, and improperly mixed materials can be re-mixed. A little experience and perseverance usually give good results in a short time.

*Can finished compost be used as a partial or full substitute for fresh sawdust in the primary stage?*

Experience to date indicates that up to 50 percent of the fresh sawdust requirement may be fulfilled with finished compost. The long-term viability of the process cannot be maintained if fresh sawdust is not added, because the source of carbon would eventually be exhausted. Advantages of recycling finished compost include: less fresh sawdust required, active bacteria and heat available in the finished compost, and less finished compost to haul for land spreading.

*What about diseases, flies, and pathogens?*

Fly breeding has not been a problem with composters. However, if positive drainage is not maintained, rutting or ponding of water occurs, or the windrow is above 60 percent moisture, flies will be a problem. The answer is the proper location and construction of the composting area so there is no free standing water, positive drainage is maintained to the collection area, and the windrows are rounded.

Exposed animal parts will invite flies and scavengers, compromising biosecurity. Properly covering all animals with 2 feet of sawdust is critical.

Temperatures will rise above 135 ° F for greater than a 3-day period, which has been shown to eliminate pathogens associated with swine production. No disease outbreak has been associated with composting to date. It is recommended that composting occur on-site, eliminating the spread of disease associated with transporting dead stock. Spreading finished compost on fields or pastures helps assure that disease organisms do not find their way back to the production area.

*What should finished compost look like?*

Properly finished compost should appear as a dark, granular material resembling humus or potting soil. It should have the feel of moist soil and may have a slight musty odor. Some resistant bones will be visible, but they should be soft and easily crumbled.

*If I do not have sawdust available, can I use another carbon amendment?*

Yes, if you plan to compost in a roofed structure. If you plan to compost without a roof, until research discovers otherwise, sawdust is the only acceptable carbon source in Ohio to legally compost without a roof.

Any granular organic material with a high carbon content should be a candidate as an ingredient in composting. Successful swine composting without the use of a roofed structure has been accomplished using sawdust as the carbon amendment or carbon source. More research and experience is needed to evaluate other carbon sources such as straw, hay, corn stalks, or rice hulls. A long, fibrous material such as cornstalks or straw would likely work better for composting if it were ground to reduce the particle size, similar to that of sawdust.

This would allow the material to settle around the mortality and provide the contact needed for good bacterial activity. Composting structures for swine have been successful utilizing straw and poultry litter as the carbon and nitrogen source. It is necessary to construct a structure with a roof, concrete floor, and concrete or treated timber walls for these systems. Their success has been documented and design criteria are available.

*What should I do with finished compost?*

Finished compost in the secondary compost unit, not recycled to the primary unit, should be spread as per the compost utilization plan. Conventional "beater-type" manure spreaders are ideal for handling and spreading compost.

*Can I compost in just one step, rather than moving the material from primary to secondary windrows or bins?*

Moving compost from primary to secondary windrows or bins provides mixing, adds oxygen, and allows the compost to "finish off" with a high degree of breakdown. The success of the primary/secondary approach has been demonstrated in many other areas of composting, as well as mortality composting. Some producers have reported acceptable results with single step composting, but the total composting time can be longer than the primary/secondary composting time. Also, bin or windrow volume requirements are not reduced by single-step composting.

*What about using "green" or wet sawdust?*

Generally dry sawdust is better since dryer sawdust can absorb more water and contains more air space. Producers have reported success using green sawdust for some or all of the fresh sawdust requirements. Sawdust containing excessive moisture may freeze in the winter, making it difficult to handle and place around the animals. A compost windrow with greater than a 60 percent moisture content increases the risk of leachate, anaerobic activity, and fly production. Aged sawdust of 40–50 percent moisture content is recommended.

*Compost troubleshooting guide\**

<b>Problem</b>	<b>Probable causes</b>	<b>Suggestions</b>
Temperature does not rise to desired level.	<ol style="list-style-type: none"> <li>1. Too dry.</li> <li>2. Too wet.</li> </ol>	<ol style="list-style-type: none"> <li>1. Add water.</li> <li>2. Turn and aerate, add more carbon amendment if needed.</li> </ol>
Temperature does not stay at desired level long enough.	Compost may have dried out.	Break crust and add additional water.
Breakdown of materials does not occur. Small animals may be “mummified.”	<ol style="list-style-type: none"> <li>1. Adequate moisture may not be available.</li> <li>2. Adequate nitrogen source for small animals, or</li> <li>3. Small pile with cold ambient temperature does not have sufficient mass to maintain activity.</li> </ol>	<ol style="list-style-type: none"> <li>1. Add water.</li> <li>2. For small animals add dry manure (poultry if available) to mirror desired recipe.</li> <li>3. Leave pile intact until ambient temperatures rise or add to larger active primary pile.</li> </ol>
Odor—high sulfur.	<p>Compost is anaerobic (needs oxygen).</p> <ol style="list-style-type: none"> <li>1. Too wet.</li> <li>2. Not enough carbon amendment.</li> <li>3. Bin is air-tight.</li> </ol>	<ol style="list-style-type: none"> <li>1. Reconstruct pile with more carbon amendments and fresh sawdust for exterior cover.</li> <li>2. Do not use solid sides, construct to permit air flow.</li> </ol>
Odor—decay.	Animal layer is too thick or too close to the sides or top.	Re-layer the animals and cover sides and top well.
Odor—ammonia.	Improper C:N ratio.	Add more fresh sawdust to cover material.
Flies	<ol style="list-style-type: none"> <li>1. Improper storage of manure. Keep it dry.</li> <li>2. Failure to reach temperature, incomplete compost.</li> </ol>	<ol style="list-style-type: none"> <li>1. Cover manure.</li> <li>2. Cover pile with fresh carbon amendment. If small animal or secondary stage, remix before adding fresh cover. Check temperature to monitor compost response.</li> </ol>

## Appendix A

### Worksheets and standardized operation and management plans

NRCS practice standards and composting design worksheets:

- Conservation Practice Standard 317, Composting Facility (6/96)
- Preventing fires in litter storage structures (from NRCS Alabama Guide Sheet 313)
- Standard Drawing OH-N 506 – CAD, Composting facility

# Natural Resource Conservation Service Conservation Practice Standard

## Composting Facility (No.) Code 317

### Definition

A facility for the biological stabilization of organic material.

### Purpose

To biologically treat organic materials by composting to protect the environment, stabilize nutrients, and destroy pathogens.

### Conditions where practice applies

This practice applies where:

1. Ground and surface water resources are protected.
2. The risk of spread of disease is reduced.
3. Nuisances such as flies, vermin, and scavenging animals are prevented.
4. Air quality is maintained.
5. A compost utilization plan has been developed.

### Criteria

#### *Federal, state, and local laws*

The disposal of the compost shall adhere to all federal, state, and local laws, rules and regulations. It is the responsibility of the producer to secure any permits necessary to install structures and for properly managing the facility on a daily basis.

#### *Facility size for composting*

For dead animal and bird composting, establish the size of the composting units on the basis of known or published normal mortality rates. Dead animal or bird facilities require a two-stage composting system except for the use of mini-composters used for small animals or birds during periods of less than normal mortality rates. A minimum of two primary stages shall be required for all composters. The volume of the second stage shall be site specific but is generally greater than or equal to the first stage. Size the facility as per an NRCS Design Worksheet or OSUE Fact Sheet for the appropriate species.

To decrease the chances of fire, the bin walls shall be no more than 5 feet high, and static piles or windrows shall be no more than 7 feet at the peak.

#### *Structure design*

Material and structural design of the composting facility shall conform to the requirements of NRCS, Standard 313, Waste Storage Structure. Details of material requirements shall be determined by the designer on a case by case basis.

Dead bird composters shall have the following requirements:

1. A roof to provide year round operation and to control rain water and percolation. Design the roof for applicable wind and dead loads for agricultural buildings.
2. A concrete floor that is designed for the anticipated loads.
3. All posts and planks shall be pressure-treated and all metal shall be galvanized.

### *Soils*

All composting facilities shall be located a minimum 3 feet above the high-water table. Animal composting facilities without a roof shall be located on low permeability soils. A solid base of concrete or gravel with a filter fabric base shall be required for the composting area unless it can be kept dry or free of ruts. Heavy-use areas such as access to the compost area shall be managed to prevent rutting and ponding. It is recommended the access be gravel or concrete.

### *Odor and scavenging animals*

Locate the composting facility where movement of odors toward neighbors will be minimized. Buffer areas, vegetative screens, and natural landscape features can help minimize the effects of odor.

Static pile and windrow composting shall require 2 feet of cover over dead carcasses. Bin composting shall require 1 foot of cover over the dead carcasses.

### *Pile configuration*

Windrows and static piles should be triangular to parabolic in cross-section. Windrows and static piles shall be aligned to avoid accumulation of precipitation. Positive drainage shall be maintained on the pad parallel to the windrows. Windrows and static piles shall be rounded to shed rainfall.

### *Runoff*

Runoff from the outside drainage areas shall be diverted away from the facility. The composting facility should not be located on a floodplain unless protected from inundation or damage from a 25-year, 24-hour flood event. The facility must remain high and dry.

Leachate and runoff from a dead animal composter without a roof shall be collected, stored and/or utilized as per the operation and maintenance plan. It shall be required to control the 25-year, 24-hour rainfall event within the composting, storage and utilization area without discharge to the waters of the state or from the landowner's property.

## **Considerations**

### *Location*

Composting facilities should be located as near the source of organic material as practical with consideration given to:

- The location of neighboring dwellings and how they will be affected by prevailing winds.
- Location of ingress and egress so as not to interfere with traffic flow or utilities.
- Location of the access for easy loading and unloading of compost.

The area surrounding the composting facility will be subject to a high traffic load during loading, mixing, and unloading. This area must be a well drained stable area. It is recommended that this area be concrete or gravel with filter fabric for ease of clean up and stability.

### *Biosecurity*

It is very important for anyone working on or about poultry or animal farms to follow biosecurity techniques to prevent the spread of diseases. Biosecurity measures should be followed when working in or around poultry or animal buildings and where animals, manure, debris, and poultry manure exist. If possible, entry into poultry houses or animal facilities should be avoided. However, if entry is necessary, the farm operator's permission is required.

Scavenging animals can be a problem with static pile or windrow composting. The 2-foot cover requirement is critical. It will be necessary to use additional measures to prevent scavenging animals if a problem occurs.

In order for proper pathogen-kill to occur, it will be necessary to maintain a temperature of 135 ° F for a minimum of three days within the active composting area. Other than testing, monitoring temperatures is a good indicator of pathogen kill.

### **Plans and specifications**

Plans and specifications for dead poultry or animal composting shall be in keeping with this and other referenced standards. They shall be site-specific and describe the requirements for applying the practice or practices to achieve their intended purpose. All standard drawings shall be accepted for this practice provided that they comply with this standard and are approved by a registered professional engineer in Ohio, or the Natural Resources Conservation Service, or are issued by the Extension Service. For standard drawings that originate in other states, special attention should be paid to the structures ability to handle the snow or wind loads required in Ohio. If no agricultural building code exists, a minimum snowload of 20 pounds per square foot shall be used.

### **Operation and maintenance**

A written operation and maintenance plan for the composting component of the animal resource management system is required for this practice. As a minimum, the operation and maintenance plan shall include:

1. The mix proportions, moisture requirements, and materials to be used.
2. The design sheet used to size the facility.
3. The process to be followed in loading the bins, windrows, or static piles.
4. Temperature monitoring requirements.
5. The aeration or turning schedule.
6. Frequently encountered mistakes in composting and brief "fix it" scenarios.
7. Utilization Plan as per the Waste Utilization Standard, 633.

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- Arkansas Cooperative Extension Service, *Recommended Operating Procedures (for) Swine Composting (Recipe)*, University of Arkansas, 2201 Brookwood Drive, P.O. Box 391, Little Rock, Arkansas 72203. (501) 671-2000
- Arkansas Cooperative Extension Service, *Basic Operating Procedures*, University of Arkansas, 2201 Brookwood Drive, P.O. Box 391, Little Rock, Arkansas 72203. (501) 671-2000

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.



## **Preventing Fires in Litter Storage Structures** (from NRCS Alabama Guide Sheet 313)

### **Definition**

Litter stacks and even dead animal compost can catch fire if not properly maintained. Storing poultry litter in a covered storage structure is a good management technique. It provides flexibility in timing applications to the land; prevents the possibility of polluting surface or ground waters, as could occur with litter stored outdoors; and is a good way to maintain quality feed for cattle. However, careful management must occur to prevent fires.

### **Operation and maintenance**

#### *Background Information*

It has long been known that heat is generated when microbiological activity occurs in an insulated environment, such as a garden compost pile or even dairy manure stored outside. Overheating and spontaneous combustion in hay barns, coal piles, land fills, and barrels of oily rags are not uncommon. Both biological and chemical factors may be associated with litter storage fires, although the exact causes are not fully known.

Fires and explosions have occurred in unvented sanitary landfills due to the generation of combustible methane. In order for methane to be generated, conditions must be right for the growth of anaerobic bacteria. This includes proper moisture content (greater than 40 percent) and an oxygen-free or low-oxygen environment. Methane has a specific gravity less than air and, therefore, can escape to the atmosphere if a proper conduit is provided (i.e., adequate pore spaces in the surrounding litter). Methane is flammable in air at concentrations of 5 to 15 percent. As such, the production of methane in litter storage is a potential hazard.

Another phenomenon, called the heat of adsorption, can occur when dry matter such as litter comes into contact with moist material or even moist air. As the dry material adsorbs water vapor, heat is released. In an insulated environment this generated heat can be significant. The heat from this process begins to dissipate when the moisture occupies or is adsorbed to all the available attachment sites in the dry material.

However, another process, called pyrolysis or heat of oxidation, can take over at higher temperatures, usually between 250° to 400°F. This process is self-sustaining as long as adequate oxygen is available.

Thus, the processes which relate to the generation of heat are both biological and chemical. However, since most bacteria are killed between 130° and 165°F, chemical reactions are ultimately responsible for the processes that lead to combustion.

The Delaware NRCS, Cooperative Extension Service, and Conservation Districts conducted a survey of poultry producers to identify management practices which tended to cause fires and overheating in dry stacks. Eighty producers were interviewed. They found that seven dry stacks had experienced one or more fires. An additional twelve experienced excessive heat during the storage period. A statistical analysis did not reveal a single common cause of all fires, but it did reveal that common factors were prevalent in nearly all cases.

### **Study findings**

*Moisture:* Moisture was found to be a critical factor in all manure pile fires. All structures having fires had litter from houses with plason waterers or water troughs in some or all the houses. One pile was also exposed to wind-driven rain. These findings suggest that higher moisture levels caused more heat to be generated in the piles.

*Layering:* Piles which experienced fires were all layered either horizontally (new litter stacked on top of old) or at an angle (litter pushed against the sloping sides of old litter). (*Note:* Layering brings into contact old litter which can be very dry and new litter that may be moist. The boundary between the two layers becomes an

insulated, heat-producing area.)

*Compaction:* The majority of piles that experienced fires were compacted. Heat is not easily released from a compacted pile.

*Pile size:* The pile height and width were found to be more critical than pile length. The larger the pile size (cross sectional area) the greater the chance for excessive heat or fire. Heat is more easily released from a smaller pile because of its larger ratio of surface area to volume.

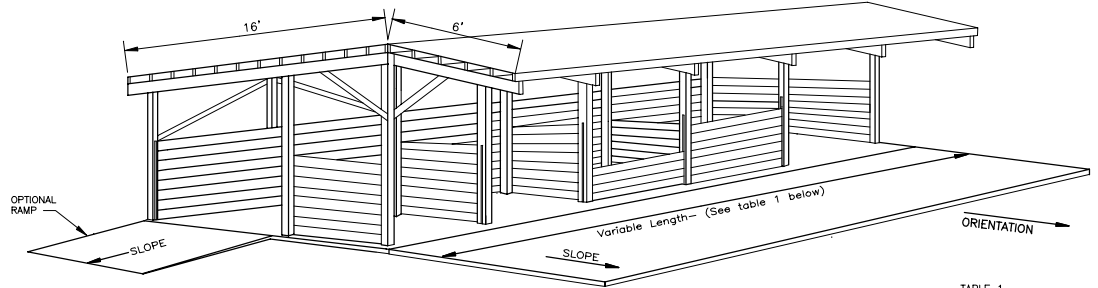
**Recommendations:**

In order to reduce the potential for fires in litter storage structures the following is recommended:

1. Pile height should not exceed 7 feet. Storing the material in separate small windrows reduces the cross sectional area and is the safest option for stacking.
2. *Keep the litter dry!* Don't wet the litter in the hope of preventing a fire; just the opposite may occur. In addition, protect the litter from blowing rain.
3. Avoid placing the wet material in contact with dry material. Don't layer new litter on top of old, and don't let dead poultry compost come into contact with stored litter.
4. Don't compact the material by driving over it or packing it with equipment.
5. If litter is stored against wooden walls, limit height to 4 feet and monitor temperatures in this area daily. If temperatures cannot be monitored regularly, do not store litter against wooden walls.
6. Monitor temperatures at different points in the pile frequently. If temperatures exceed 190°F, or if the material is smoldering, prepare to remove material from the building. This includes notifying the local fire department to be on hand. A smoldering pile could burst into flames if exposed to air. A garden hose could be inadequate to extinguish the fire.
7. Do not store expensive equipment in the litter storage structure.

# NRCS Standard Drawing OH-N 506- CAD (4 sheets)

**NOTE**  
For clarity, view is shown without enclosures (above primary bin on near end and storage bin on far end).



**PERSPECTIVE VIEW**  
NOT TO SCALE

**NOTES**

1. This plan set shows details for a four (4) primary bin unit. The plan set is to be adapted for \_\_\_\_\_ primary bins and \_\_\_\_\_ storage bins.
2. The Ohio Construction Specification for Composting Facilities is to be used as a part of this plan set.
3. The composting facility shall be located 300 feet from any well. The facility floor shall be 3 feet above bedrock or the highest ground water elevation.
4. An equivalent roof design shall provide for a uniform load to meet the county code or 20 psf, which ever is greater.

OHIO SCS DESIGN SECTION

THIS STANDARDIZED DESIGN MUST BE ADAPTED TO THE SPECIFIC SITE. IT WAS PREPARED AT THE SCS STATE OFFICE, 200 NORTH HIGH STREET, RM 522, COLUMBUS, OHIO 43232, FROM A STANDARD DETAIL DEVELOPED IN MADISON, WISCONSIN.

**Estimated Quantities \***

Item	4 Primary Bin Unit **	Each Additional Primary Bin
6" x 6" Posts	260 lin. ft.	44 lin. ft.
4" x 6" Posts	24 lin. ft.	6 lin. ft.
4" x 4" Posts	45 lin. ft.	8 lin. ft.
2" x 8" Planks	1240 lin. ft.	220 lin. ft.
2" x 6" Planks	84 lin. ft.	14 lin. ft.
2" x 4" Planks	880 lin. ft.	162 lin. ft.
Concrete	20 cu. yds.	4 cu. yds.
Sand and Gravel	25 cu. yds.	5 cu. yds.
Wire Mesh Reinforcement	1240 sq. ft.	228 sq. ft.

\* Does not include any optional items listed on sheet 2 or cutting losses for wood members.  
\*\* Includes one 8' wide storage bin.

**TABLE 1**

No. of Primary Bins	Total * Length Feet-lin.
2	26'-4"
3	34'-11"
4	43'-6"
5	52'-1"
6	60'-8"
7	69'-3"
8	77'-10"

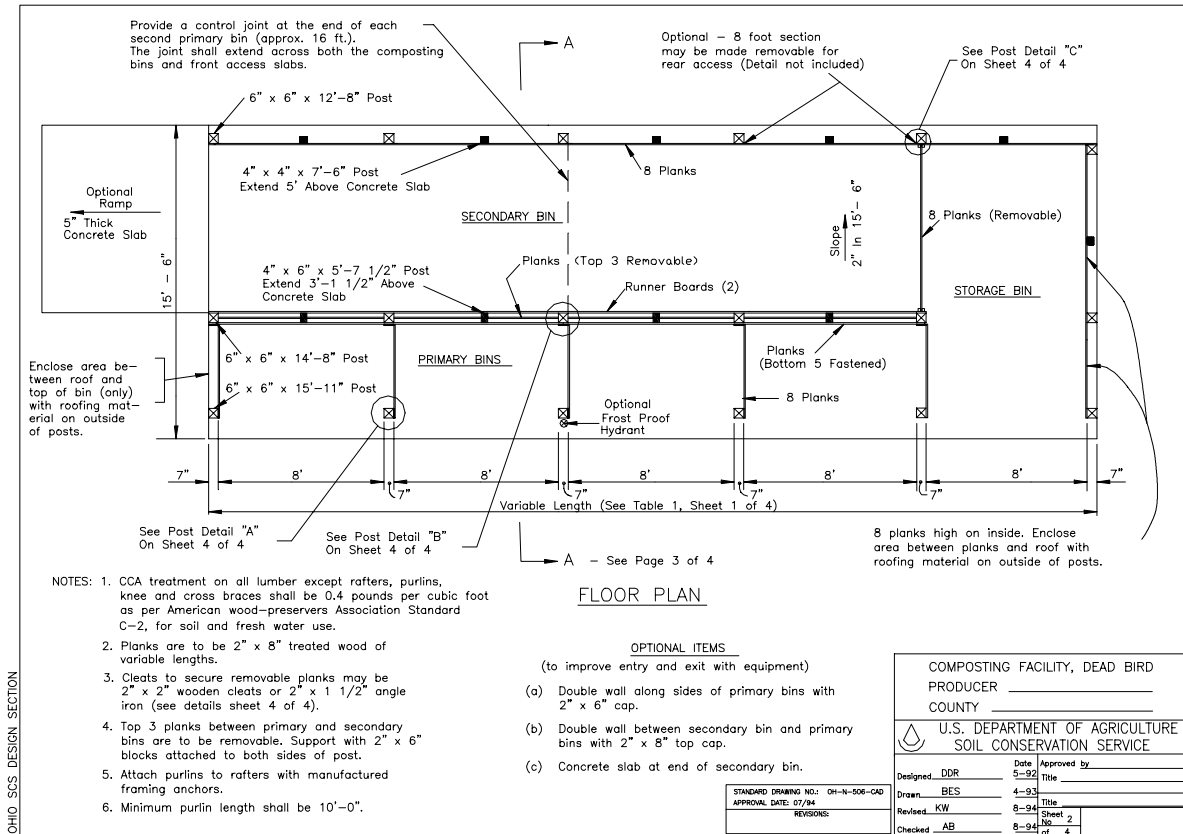
\* Includes one 8' wide storage bin.

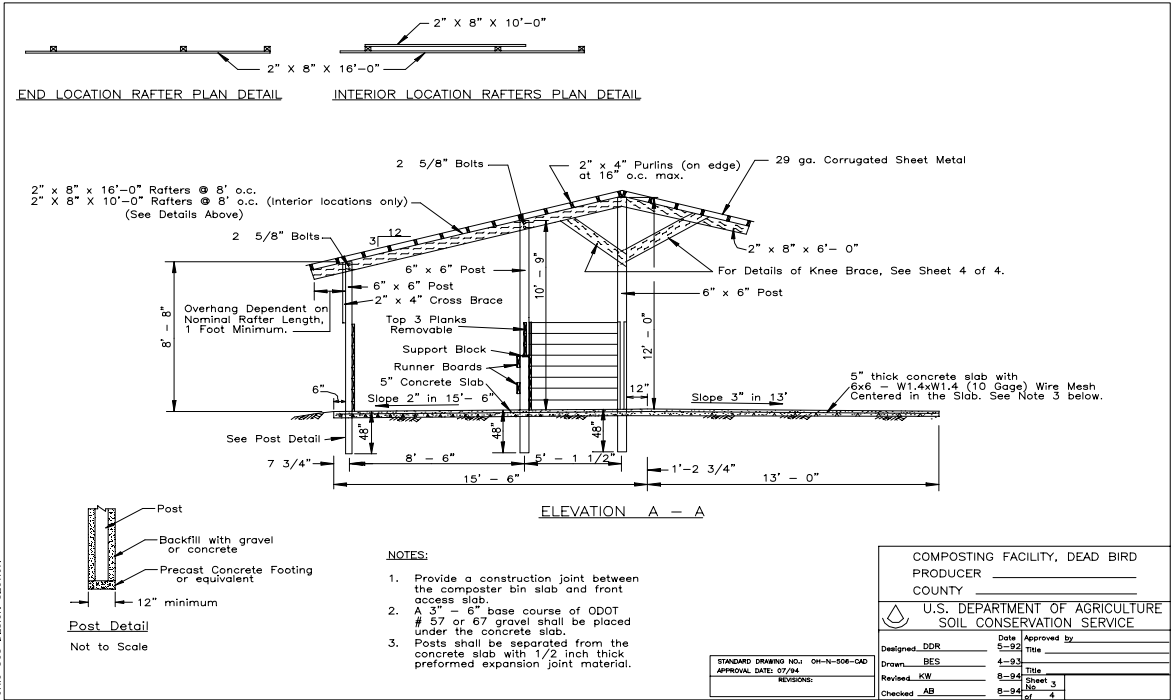
COMPOSTING FACILITY, DEAD BIRD PRODUCER \_\_\_\_\_ COUNTY \_\_\_\_\_

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

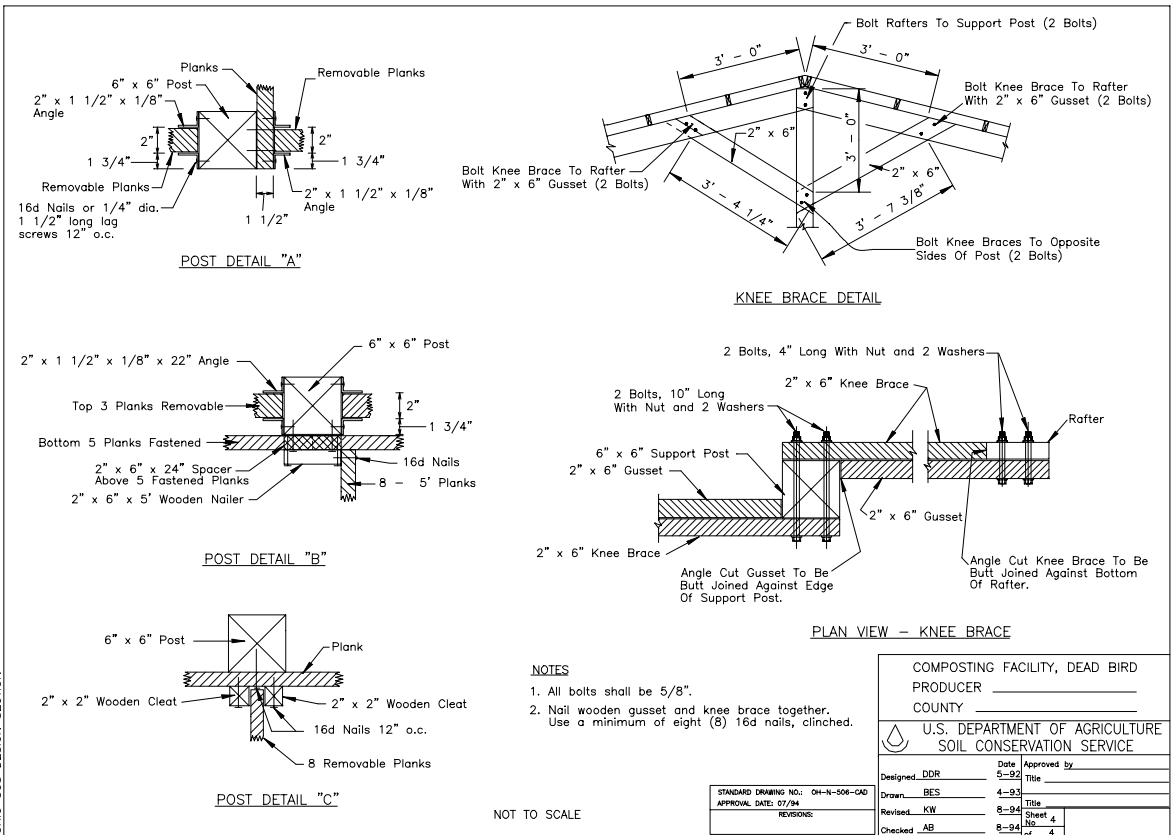
STANDARD DRAWING NO.: OH-N-506-CAD  
APPROVAL DATE: 07/94  
REVISIONS:

Designed_DDR	Date	Approved by	Title
BES	5-92		
KW	4-93		
AB	8-94		
			Sheet 1 of 4





OHIO SCS DESIGN SECTION



OHIO SCS DESIGN SECTION

## Appendix B

### Temperature –monitoring device sources

Suggested Temperature Probe Suppliers (This is not intended to be an inclusive list and a recommendation for any particular brand is not intended.)

Name	Address	City	State	Zip	Phone	Phone
Atkins	3401 Southwest Fortiers Drive	Gainsville	FL	32608	904-378-5555	
Camx Scientific	Box 747	Rochester	NY	14603-0747	716-482-1300	
MAC Associates	2532 Zollinger Road	Columbus	OH	43221	614-459-0223	
Meriden Cooper Corp.	112 Golden Street Park, Box 692	Meriden	CT	06450-0692	800-466-8448	203-237-8448
Omega Engineering, Inc.	One Omega Drive, Box 4047	Stamford	CT	06907-0047	203-359-1660	800-826-6342
Reotemp Instrumentn Corp.	11568 Sorrento Valley Rd. #10	San Diego	CA	92121	619-481-7737	800-648-7737
Walden Instrument Supply Co.	910 Main Street	Wakefield	MA	01880	617-245-2944	

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