Pile Characteristics for Effective Animal Mortality Composting

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Introduction

Animal producers and veterinarians have limited options for managing dead animals. For example, some states prohibit the burial of routine poultry mortality, and rendering services are becoming expensive and harder to access in the rural areas. Other mortality disposal methods such as incineration and chemical digestion may be expensive and complicated to use on the farm. Animal mortality composting is a simple, low-cost disposal method and its end product can be land applied as fertilizer and soil amendment. In a carcass compost pile, the animal is concealed under a blanket of organic material to promote decomposition at elevated temperatures by naturally occurring microbes such as bacteria and fungi. This paper discusses the carcass compost pile characteristics such as composition, porosity, structure, and other factors that influence the conditions for proper carcass biodegradation, inactivation of pathogens, and prevention of environmental pollution.

Composition and Structure of a Carcass Compost Pile

The aim of on-farm carcass composting is to decompose dead animals naturally in an above-ground pile or windrow. The carcasses should be completely surrounded by organic material to enhance microbial activity, reduce odors, prevent predator attraction, reduce the loss of heat and moisture, and absorb leachate caused by a flush of moisture from precipitation or a collapsing carcass. The pile foundation should be an impermeable surface, preferably a concrete pad rather than a temporary plastic liner (Figures 1 and 2).

The compost pile is composed of a three-phase system of solids, water, and air or gases. Depending upon the type of composting feedstock (also known as co-composting material, substrate, or feed mixture for the microbes), the solids in the pile vary by particle size, geometry, and organic (volatile), fixed (volatile), and chemical [carbon (C), nitrogen (N), and phosphorus (P), etc.] contents. Voids or pore spaces among the solids in the pile are filled with air, water, or both. To initiate the carcasses composting process, the substrates must be well-balanced in C to N ratio, free air space, and moisture. The carcass in the pile is a non-homogenous mixture of dead animal mass with organic matter, high N, low C, low porosity, and relatively large amounts of water. Porosity is the volume of voids divided by total volume. Feedstock such as grass clippings, municipal sludge, and similar materials that tend to compact under their own weight are unsuitable for carcass composting, especially for piles that are not turned for a month or more.

Bulking agent

An important component of a carcass compost pile is the feedstock used as a bulking agent, also known as a drying and structural amendment. This material may be the main substrate used for carcass composting or an addition to excessively wet compost piles to reduce their bulk weight and moisture content. The feedstock is also added to provide structural support to increase air spaces (voids) and allow proper aeration during active carcass decomposition (Figures 1 and 2). For on-farm composting of carcasses, an ideal organic material is animal manure mixed with spent horse bedding that includes manure and wood shavings or wood

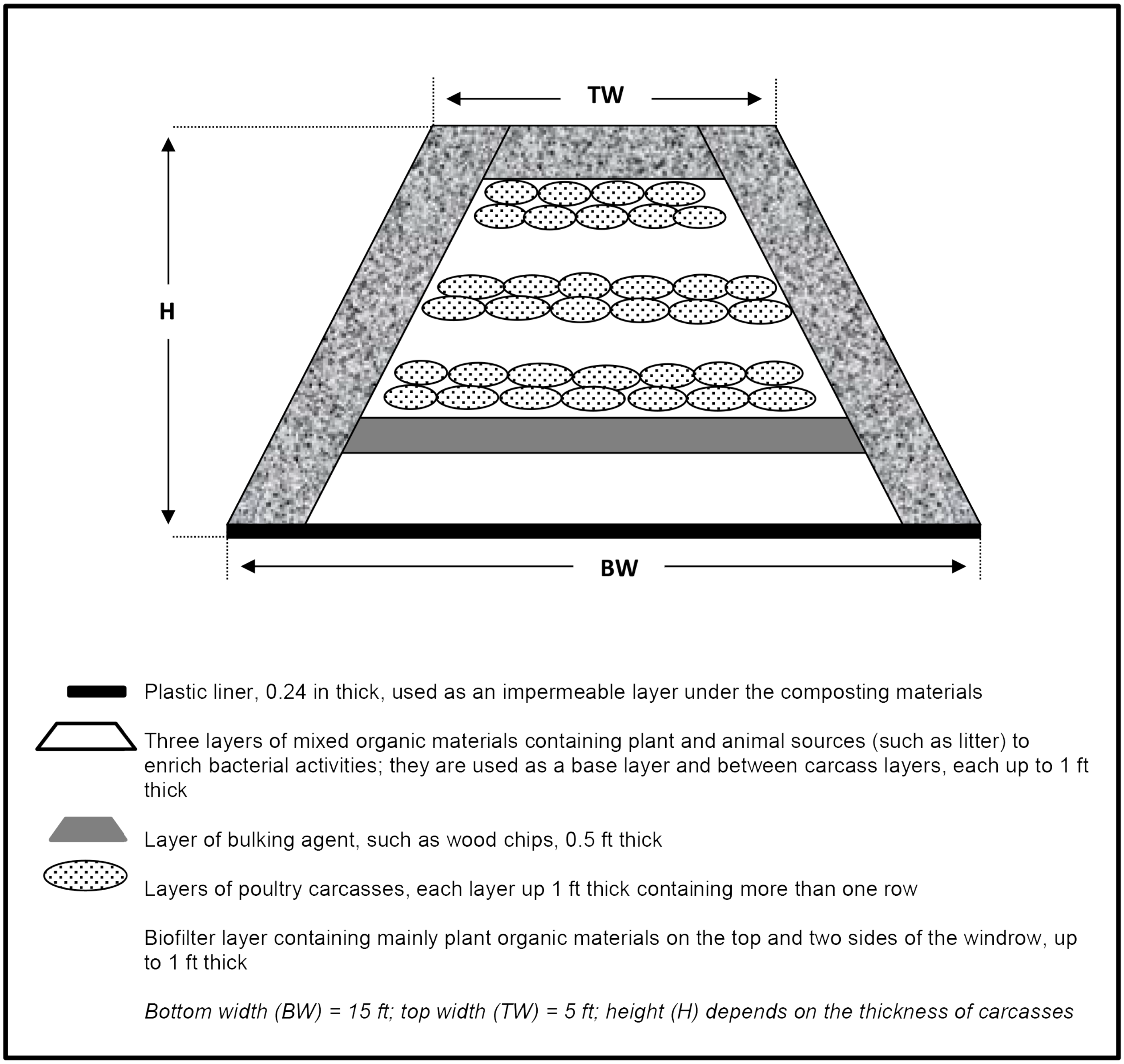
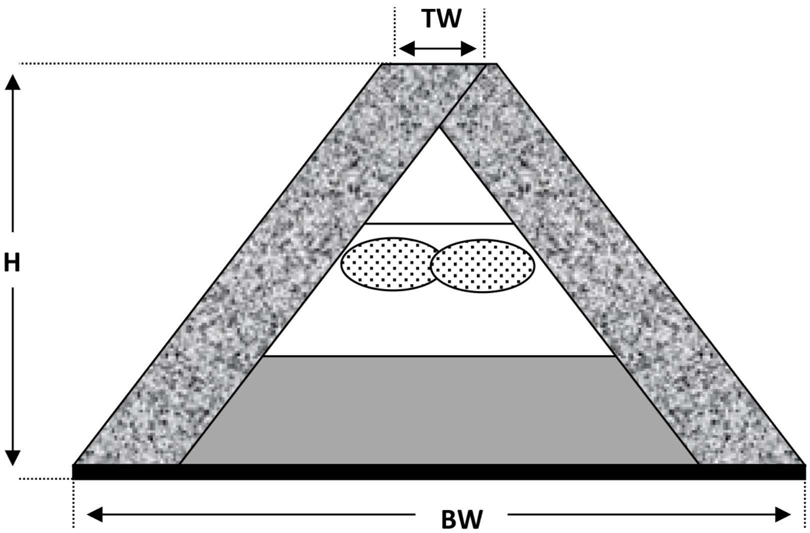


Figure 1. Cross-sectional dimensions (not to scale) of a trapezoidal pile for small carcasses such as poultry.

chips of less than 2 inches in size. These materials serve as a bulking agent, increase the quantity of biodegradable organics in the pile, and provide feed or energy to the microbes for effective carcass composting. Other amendments may include organic materials such as sawdust and straw to improve biodegradability or to increase the initial C:N ratio of the pile to between 25 and 35.

Biofilter

A biofilter is a layer of carbon-rich organic material that is relatively dry and has small particle size and large surface area. Examples are sawdust and other plant organic materials that neutralize odors and absorb excessive moisture. In a windrow system for carcass composting—generally situated in open spaces exposed to the weather—a biofilter cover (Figures 1 and 2) will reduce odors, preserve moisture and heat, and limit predator access.



Plastic liner, 0.24 in thick, used as an impermeable layer under the composting materials

Two layers of mixed organic materials containing plant and animal sources (such spent horse bedding) to enrich bacterial activities; they are used as a base layer and top of carcasses, 1.5 and 1 ft thick for medium carcasses such as sheep and swine, and 2 and 1 ft thick for large carcasses such as cattle and horses

Layer of bulking agent, such as wood chips, 1 and 2 ft thick for medium and large carcasses, respectively

Layer of medium-size or large carcasses

Biofilter layer containing mainly plant organic materials on the top and two sides of the windrow, up to 1 ft thick

Bottom width (BW) = 13–15 ft; top width (TW) = 1 ft; height (H) depends on the thickness of carcasses

Figure 2. Cross-sectional dimensions (not to scale) of a trapezoidal pile for medium and large carcasses such as sheep, sows, horses, and cattle.

Pile shape and dimensions

As shown in Figures 1 and 2, depending upon the size and type of on-farm animal mortality, the pile should contain various thicknesses of layers of biofilter, base material, bulking agent, and mixed organic materials. In general, the recommended height for a carcass compost pile is 5 to 7 feet. In wetter climates, the pile should be designed with steep pointed crowns and sloping sides to shed rain as quickly as possible. In semi-arid regions, the pile can be built with a flat or slightly concave top to capture scarce precipitation to prevent excessive drying, which can slow the composting process or cause it to go dormant.

Effects of Moisture, Porosity, and Free Airspace on Animal Mortality Composting

In a compost pile, the pore spaces between the solid particles are filled with air, water, or both. The most efficient microbes in a compost pile are the aerobic thermophiles, which require oxygen and water in proper balance to generate heat and consume nutrients (C, N, etc.). Therefore, animal mortality composting must be an aerobic and exothermic (heat-generating) process. If the piles are dry, the biodegradation activity of aerobic microbes will be markedly reduced; in wet piles, the anaerobic or oxygen-free conditions will enable anaerobic microbes to outcompete the aerobic microbial communities for nutrients. The anaerobic decomposition of organic matter, including the carcass, is responsible for foul odors.

Moisture content

Water transports nutrients to the microbes to facilitate the production of certain enzymes that decompose organic matter during the composting process. However, if the pore spaces contain excessive moisture, oxygen transfer is restricted, which impedes the aerobic composting process. The optimum moisture content (or, more appropriately, the acceptable moisture range of a pile) creates a balance between the moisture requirement of the microbes and their need for an adequate moisture supply. Table 1 shows the maximum recommended moisture contents of several composting feedstocks or substrates to be placed in a pile, windrow, or other type of composting system to begin the composting process.

Table 1 also shows that fibrous or bulky materials such as straw or woodchips can absorb relatively large quantities of water and still maintain their structural strength and porosity. However, for animal mortality composting, some organic materials such as sludge and grass clippings may not be suitable substrates because of their relatively weak structure, which will result in greater compaction, especially if they are placed under larger carcasses. The recommended range of moisture content for initiating animal mortality composting in a pile is between 50 and 60%.

Table 1. Maximum recommended moisture contents for various composting materials.

Type of waste	Moisture Content (% of total weight)
Theoretical	100
Straw*	75-85
Wood (sawdust, small chips)	75-90
Rice hulls*	75-85
Municipal refuse	55-65
Digested or raw sludge	55-60
Manures	55-60
"Wet" wasts (grass clippings, garbage, etc.)	50-55

**Serves as a moisture absorbend and source of carbonaceous material. Requires that nitrogenois material be added to reduce the C/N ratio to a proper level.*

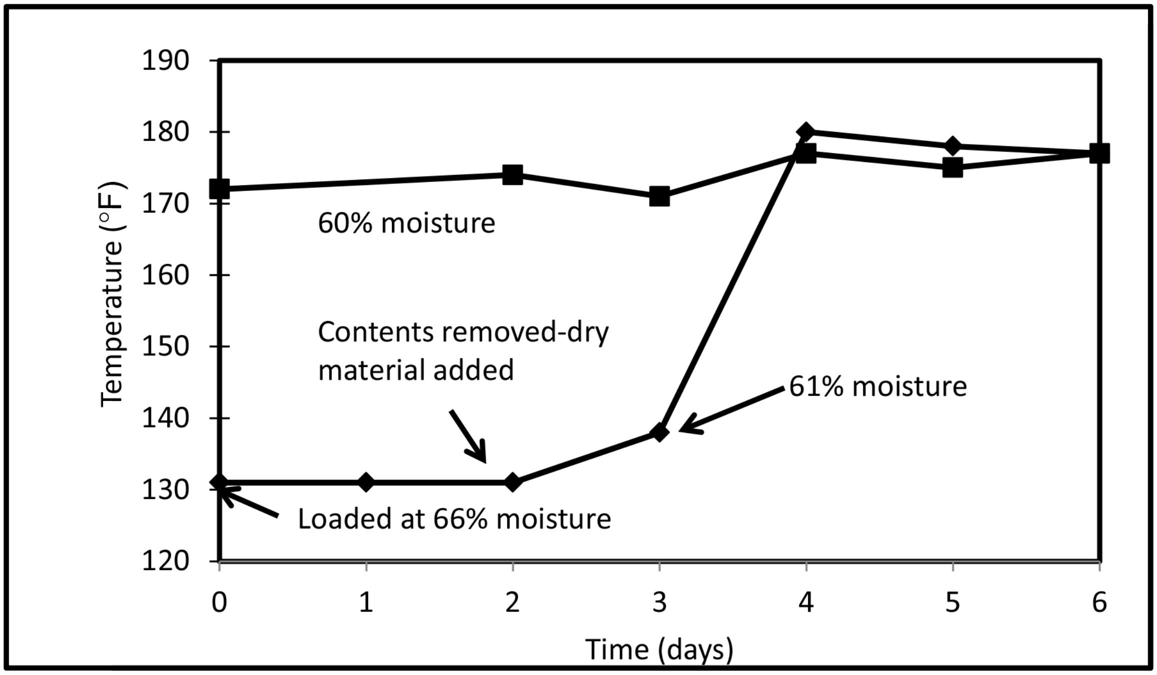


Figure 3. Effect of the initial moisture content on the temperatures developed during composting of dairy manure in deep bins.

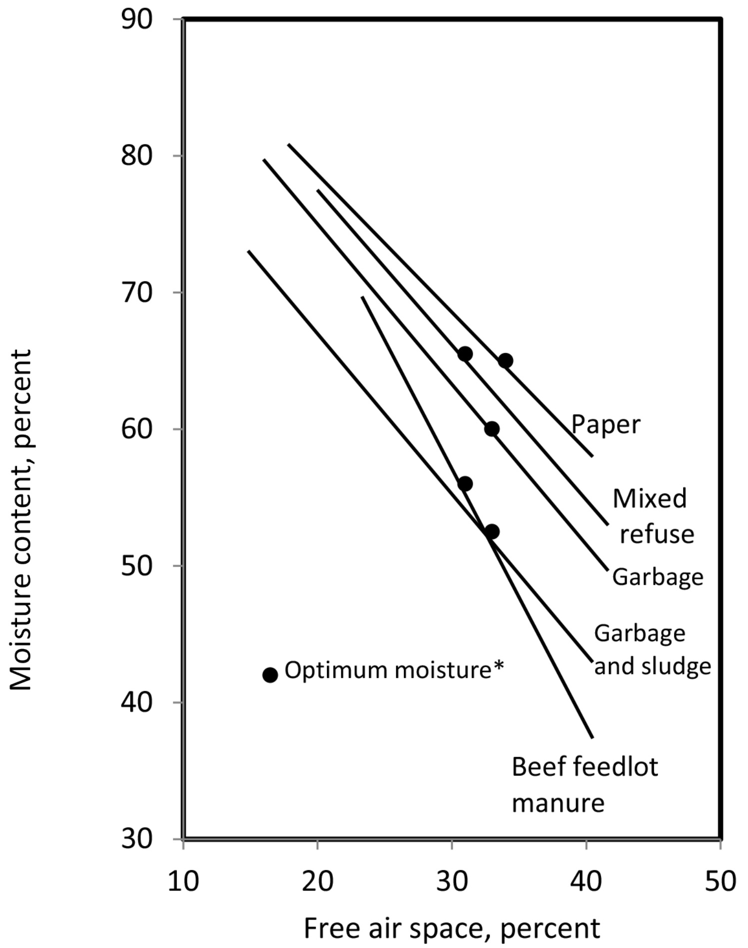
The moisture content of the compost feedstock influences the pile temperature, which indirectly measures microbial activity. Figure 3 illustrates this influence, showing the temperature of dairy manure being composted simultaneously in separate bins at two initial moisture contents of 66 and 60%.

At 66% moisture, the temperature of the compost rose to just above 130°F (55°C) for two days. The temperature of the compost in this bin began to rise above that value only after the bin was unloaded, dry material was added, and the new mixture was reloaded at an initial moisture content of 61%. The temperature then rapidly increased above 170°F (77°C). In contrast, the temperature of the dairy manure at an initial moisture content of 60% rose quickly to about 170°F (77°C) and remained there for several days. It was clear that the higher moisture content slowed the composting process because the excess moisture reduced the void spaces, impeding air movement and the availability of oxygen to the microbes.

Porosity and free airspace

The porosity of a composting pile is the ratio of the volume of the voids to the total volume of the composting mass, including the animal mortality. The free airspace of the composting mass is the ratio of the gas volume to the total volume.

A mortality compost pile that is high in total porosity does not have adequate free airspace if most of the volume of voids is filled with water. Figure 4 illustrates the effect of moisture content on free airspace for various feedstocks. As shown in this figure, the optimum moisture contents of the different materials fall within a narrow free airspace range of 30 to 40%. Therefore, the porosity of animal mortality compost piles should be about 35% air-filled. Figure 5 illustrates the importance of free airspace and oxygen consumption rate by microbes. Also, for oxygen consumption for microbes in fresh, 5- and 10-day-old mixed refuse piles, the optimum conditions are about 67% moisture and 30% free airspace. Figure 5 also shows that the microbes maintained nearly 95% of the maximum oxygen consumption rate when the free airspace ranged from 20 to 35%.



*Reported optimum moisture contents tend to fall within a reasonable narrow range of free airspace.

Figure 4. Free airspace as a function of moisture content for various feedstocks.

Conclusions

To compost on-farm animal mortality effectively, a pile or windrow must have specific physicochemical characteristics. During animal mortality composting, the carcass and organic matter are degraded naturally by aerobic, thermophilic microbes. The activity of these microbes is affected by pile height, moisture content, porosity, free airspace, the types of feedstocks or composting materials, and the location of the animal carcasses. When planning to compost animal mortality on the farm, the following recommendations should be considered for best results.

- The C:N ration of the co-composting material should range from 25 to 35.
- If bulking agents are needed, the particles should be less than 2 inches in size and strong enough structurally that the carcass weight will not compact them and impede air movement.
- To prevent excessive odors, use carbon-rich biofillers.
- Build trapezoidal piles to 5 to 7 feet tall and with steep side slopes. In in wetter climates, make the pile tops pointed; in semi-arid climates, make them wider and flatter.
- The initial pile should be between 50 and 60% moisture and should not dry below 40% during the active composting (heating) stage.

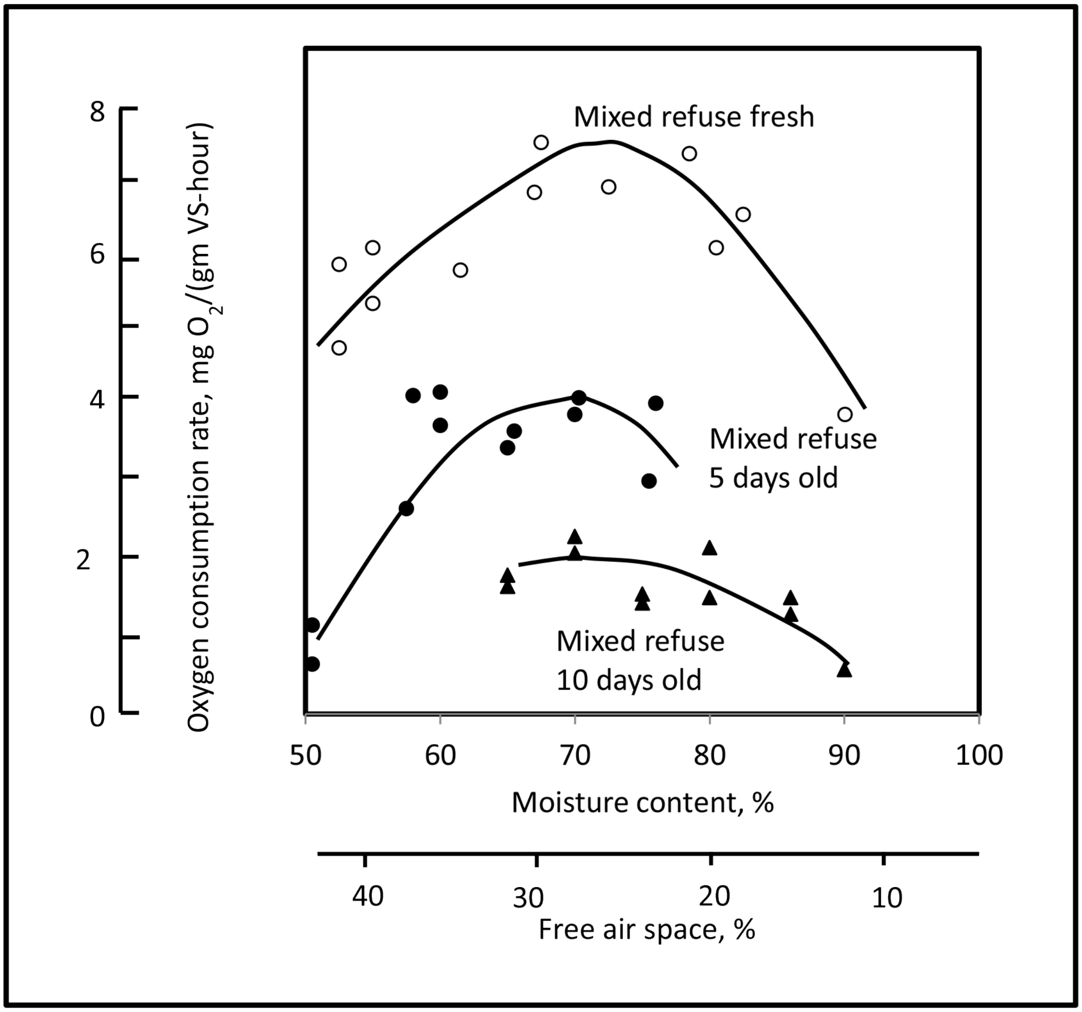


Figure 5. Effects of moisture and free airspace on the oxygen consumption rates of mixed refuse samples.

- Free airspace of 30 to 40% should be maintained during composting by selecting the proper feedstocks and by turning the pile when needed.

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