



Goat Mortality Composting

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If you raise livestock,



you're going to have dead stock.

What will you do with your livestock mortality?

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Why Compost Goat Mortality?

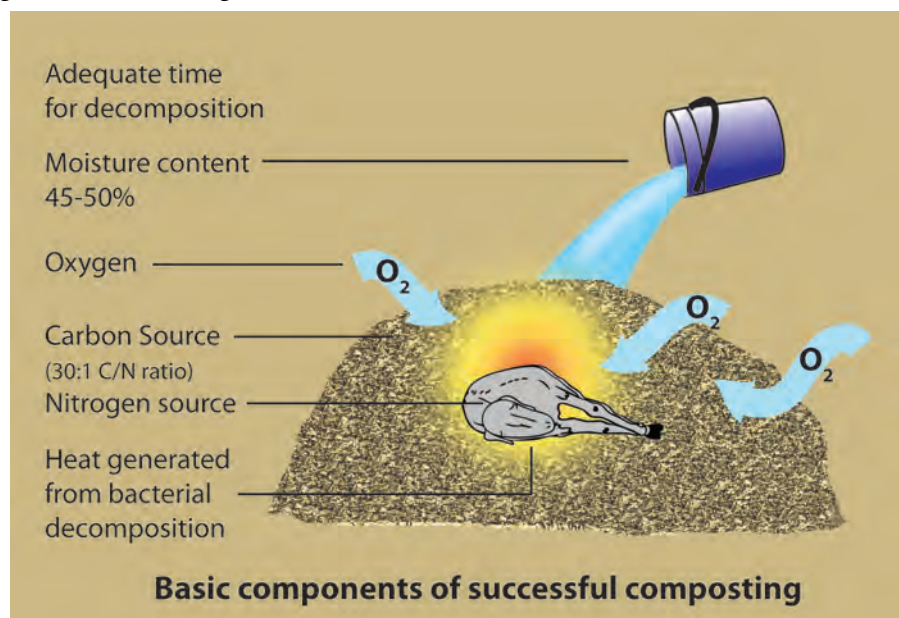
All livestock producers encounter mortality. Meat goat operations may experience annual mortality losses of up to 10% of young before weaning and 5% of adult breeding animals. For a producer with 30 breeding females, two-thirds of whom have twins, this would mean a yearly loss of about five young and two adults. Disease or internal parasite outbreaks may add to this total. Dead animals must be disposed of promptly as carcasses left on the ground have the potential to spread disease, contaminate surface and ground water, feed coyotes and other predators, and cause complaints by neighbors and passersby. Further, improper disposal is illegal. In Oklahoma, criminal statutes prohibit leaving a carcass to decompose in the open. Carcasses may not be deposited within one-quarter mile of surface water, dwellings or public highways, or be buried along streams or other waterways. Livestock owners have the duty to lawfully dispose of their goat mortality. Finding appropriate and cost-effective carcass disposal methods can be challenging.

There are five lawful options for animal carcass disposal: 1) rendering, 2) incineration, 3) landfills, 4) burial, and 5) composting. Finding a rendering service for goats is difficult. Due to rules and regulations concerning the handling of ruminant carcasses and offal with respect to bovine spongiform encephalopathy (BSE), many rendering facilities either do not accept goat carcasses or offal; or the disposal fees imposed may be prohibitively high for small scale producers. Open air incineration of goats is prohibited and producers wishing to use this option must purchase a closed incinerator. Some states mandate the types of incinerators allowed, such as in Minnesota where only incinerators approved by Minnesota Pollution Control Agency can be used. In addition to purchase and any installation costs, fuel costs must be considered. Not all landfills accept carcasses

and producers must pay disposal fees as well as trucking costs. Trucks hauling dead animals should be cleaned and disinfected after use.

Burial is a viable option for many producers who own the needed equipment; but if machinery must be leased the cost may be high. During winter, frozen soil can prevent prompt burial of mortality forcing producers to seek other disposal options. Further, there are state regulations on burial that must be followed. In Oklahoma, carcasses may not be buried less than 1 foot above flood plains or within 2 feet of the water table or bedrock. Burial cannot take place within 300 feet of water sources, houses, public areas or property lines, and carcasses must be covered with a minimum of 2.5 feet of soil. In Kentucky, carcasses must be buried at least four feet deep and burial sites cannot be within 100 feet of streams, sinkholes, wells, springs, lakes, public highways, residences, or stables. The carcass must be opened and covered with two inches of quicklime and at least three feet of soil. Because of differences among states regarding burial requirements, producers should contact their local extension service or state department of agriculture for information.

Composting is an inexpensive, environmentally friendly method of disposing of animal mortality that



All illustrations by K. Williams.

is commonly used in the poultry and swine industries. Mortality composting allows producers to legally dispose of carcasses, preventing contamination of ground or surface water and the feeding of predators that can occur with indiscriminate carcass disposal. Mortality composting can become part of a farm biosecurity plan to deal with disposal of dead animals and prevent disease spread.

When properly done, animal composting generates little to no odor and temperatures generated during composting are high enough to kill most pathogens. Animals suspected to have died from severe zoonotic diseases, i.e., diseases that can be passed to humans, such as anthrax, should not be composted. Sheep and goats that die from scrapie should never be composted as the agent responsible for this neurological disease is not killed at common compost pile temperatures. However, for most cases of mortality, composting is a safe, low-cost alternative to other carcass disposal options.

As with burial, producers are advised to seek out information on their state's rules and regulations regarding mortality composting. While some states only require concentrated animal feeding operations to obtain permits to compost mortality, other states require permits for any amount of mortality composting. For example, in Kentucky all mortality composting must be done in an approved facility with a permit issued by the State Veterinarian. If the compost product is to be distributed off-farm, another permit is required. The Cornell Waste Management Institute has a website on U.S. Mortality and Butcher Waste Disposal Laws that provides information on individual state requirements (<http://compost.css.cornell.edu/mapsdisposal.html>).

Mortality Composting Basics

In the same way that microorganisms degrade vegetative waste and turn it into a rich soil amendment, animal carcasses can be turned into an organic matter-rich material that can be spread on pastures and other agricultural land. To successfully compost animal mortality requires attention to the basics of any good compost pile: 1) proper carbon to nitrogen ratio (C:N), 2) moisture content, 3) available oxygen, and 4) temperature.

Carbon:Nitrogen ratio

Microorganisms that do the work of composting require nutrients in the form of carbon and nitrogen in a C:N ratio of roughly 30:1 or 30 parts carbon for each part nitrogen. Animal carcasses are high in nitrogen and the surrounding compost material should be high in carbon to create an acceptable C:N ratio. There are many suitable carbon sources for mortality composting. When deciding upon a carbon source to use, consider

year-round availability, needed amounts, and cost. One commonly used material is sawdust. Sawdust has a high C:N ratio, small particle size and the ability to absorb and retain moisture. Other carbon sources used in mortality composting include hay, crop residues such as straw and corn stover, silage, rice hulls, and ground corncobs, among others (Table 1).

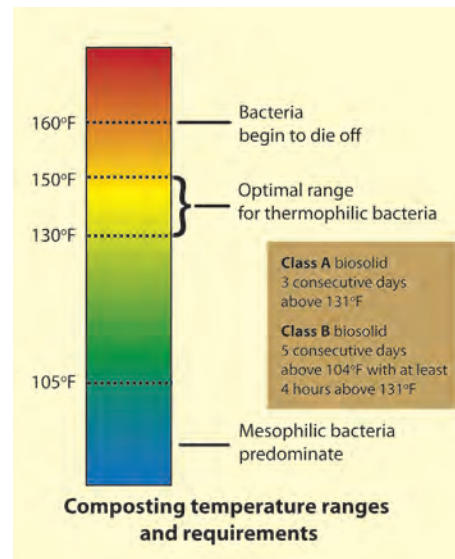
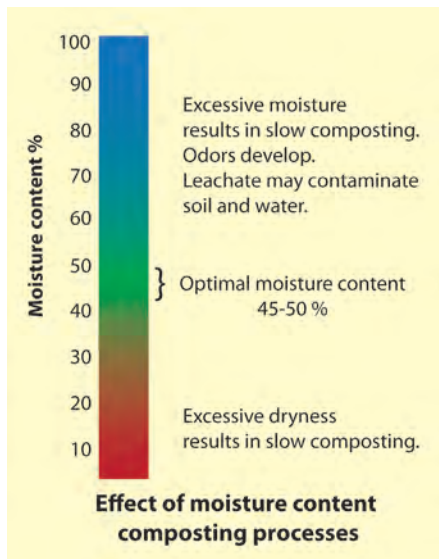
Material such as hay, straw, and corn stover should be ground prior to use to reduce particle size. A general guideline for particle size given in some publications is roughly 1/8 to 1/2 inch in diameter. Wood shavings and old hay or straw can be mixed with other material, such as manure or finished compost, in a 50:50 mixture and used. Mixtures of animal bedding and manure, such as that from horse stalls, work well as a carbon source. Used bedding after a livestock show at a local fairgrounds or horse arena can be an easily obtained, inexpensive carbon source. Poultry or turkey litter has been used in mortality composting as a source of nutrients and microorganisms but it is very high in phosphorus. Check state guidelines before composting with litter. Because of environmental concerns, the Oklahoma Department of Agriculture, Food and Forestry requires mortality composting piles using poultry litter to be covered and runoff prevented.

Table 1. Carbon:nitrogen ratio of some common composting materials.

Material	C:N ratio (weight basis)
Sawdust	200 – 750:1
Straw	48 – 150:1
Wood chips	40 – 100:1
Corn stalks	60 – 73:1
Finished compost	30 – 50:1
Horse manure	22 – 50:1
Cattle manure	19:1
Goat manure	16 – 21:1
Turkey litter	16:1
Broiler litter	14:1
Animal carcasses	5:1

Sources:

On-Farm Composting Handbook, NRAES-54, Natural Resource, Agriculture, and Engineering Service, Ithaca, NY, 1992. ISBN: 0-935817-19-0
EBAE172-93. North Carolina Cooperative Extension Service, Raleigh, NC. 1996.



Moisture content

Microorganisms require proper moisture conditions to work and the optimum moisture content for a compost pile is approximately 50%. If the compost pile material is too dry, the bacteria have insufficient moisture and composting will be very slow. If the material is too wet, water fills the pore spaces in the compost pile resulting in the desired aerobic bacteria being replaced by anaerobic bacteria that do not require oxygen. Decomposition by anaerobic bacteria is very slow, generates odors, and does not produce sufficient heat to inactivate pathogenic organisms in the compost pile. Too much water also increases the chance for liquid (called leachate) to run out of the pile potentially contaminating soil and water. Add water to the carbon material to obtain an adequate moisture level. While tap or well water can be used, pond or effluent water has the advantage of adding additional microorganisms and nitrogen to the pile.

To test for moisture content, squeeze a handful of the compost material. If water drips out, it is too wet. If none sticks to your hand, it is too dry. For a more accurate moisture level reading, use a portable moisture probe.

Available oxygen

In addition to proper carbon and moisture content, aerobic microorganisms require oxygen. The amount of oxygen available to microorganisms in a compost pile is largely dependent on the particle size of the carbon material. If the particle size is too small, there will be inadequate pore space to trap oxygen. If the material is too large, such as corn stover or unchopped straw, there can be too much air transfer and heat, odors, and moisture can escape the pile. Sawdust, mixtures of shavings

and manure, or bedding and manure all have good sized particles providing adequate pore space.

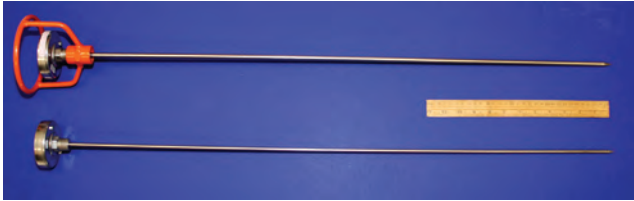
Temperature

Microorganisms working in a compost pile include bacteria, fungi, and actinomycetes with bacteria by far outnumbering other organisms. In initial stages of composting, mesophilic bacteria (those that work best at temperatures of up to about 105°F) dominate. But as temperature increases, thermophilic bacteria that grow at temperatures up to 160°F take over. Mortality compost piles work best in a temperature range of 130 to 150°F. A compost pile temperature above 131°F for a minimum of 3 days reduces pathogens below detectable levels and is needed to fulfill the requirements of a Class A biosolid allowing the completed compost to be used on public and private land. Requirements for Class B biosolids are less stringent and require a temperature in excess of 104°F for 5 consecutive days with a temperature of 131°F or greater for at least 4 hours during that period. Class B biosolids can be applied to agricultural land. For further information see <http://www.epa.gov/owm/mtb/biosolids/503pe/index.htm>. Temperature in excess of 145°F kills most weed seeds. A pile temperature that is too high, greater than 160°F, can affect bacterial survival, hampering the composting process.

It is best to monitor temperature using a 36" or 48" compost thermometer thrust into the pile's core. Compost thermometers range in cost from \$60 to over \$100. Potential sources include Novatech International dial thermometer for Soil and Composite testing (<http://www.novatech-usa.com/>)¹, REOTEMP Instrument Corporation, Heavy Duty Windrow Thermometers (<http://www.reotemp.com/>), and Omega Engineering

¹Listing of trade names, proprietary products, or vendors does not imply endorsement by Langston University of the products or vendors named or criticism of similar products or vendors not mentioned.

Corp., Compost Thermometers (<http://omega.com/>). If a thermometer won't be used, insert a long piece of metal rod, such as a piece of rebar, into the pile's core, withdrawing it occasionally to feel if the pile is heating. At temperatures above 130°F, the tip of the rod can be held in one's hand for only one or two seconds.



Compost thermometers are 3 to 4 feet long.

Site Selection

Producers should check with their state department of agriculture to determine if specific guidelines exist for mortality composting site placement. If there are no specific requirements, use guidelines for animal burial to properly situate mortality compost facilities. In general, the site should be 300 feet away from water sources, public areas, roads, and property lines. Do not compost in sites with poor drainage or excessively sandy soil. A firm surface near the pile is needed for equipment and vehicle access and for storage of the carbon source. Some states may require an impermeable base to any mortality compost pile. Water should be available for use in building piles. Mortality compost piles can be made with no surrounding structure; however, curious animals may dig into the pile so some type of surrounding wall or fence is beneficial.

Mortality Composting Bins

Depending upon state regulations, the level of mortality expected, the amount of funds available and the permanence desired, different types of bins can be constructed.

Permanent bins

Permanent bins are a good choice for farms with large numbers of goats where the annual mortality would exceed the capacity of one to two compost piles. Permanent bins are the most expensive to construct but provide the most control over the composting process and, once built, can be used for many years. Construction begins with a concrete pad of sufficient strength for the equipment to be used in building and turning compost piles, usually a tractor or skid steer with a bucket. The concrete pad helps prevent runoff and liquid seepage into the ground and provides a good working surface. A graveled area surrounding the pad helps when working in wet weather.

A permanent mortality composting structure should be large enough to accommodate enough bins to compost expected annual mortality. At a minimum, this will be three bins; one primary bin, one secondary bin where material is moved when turned, and a third bin to cure compost, store carbon source, or use as an additional working bin if needed. Permanent bins usually have a roof sheltering the pile from the weather allowing for better control of composting conditions. Should a roof not be constructed, covering bins with a tarp helps protect the pile from rainfall that could make the compost too wet resulting in poor decomposition and odor generation.

Individual bin size and number is dependent upon mortality estimates. Formulas are available to predict the number and volume of bins needed based upon the weight of average daily mortality calculated by totaling the estimated annual weight of dead kids, yearlings, and adults and dividing by 365. The average daily loss is



Permanent three bin wooden structure.

then multiplied by a factor and bin volume and number can be determined. Interested producers should refer to Anon, n.d.; Glanville and Harmon, 2006; Glanville et al., 2006, and Mukhtar et al., 2004 listed at the end of this chapter. These formulas will work for producers with large numbers of animals but for producers with few goats, it is best to think of bin size in relation to the expected numbers of carcasses and their size. For example, a goat operation that expects losses of 3 to 4 adults and 8 to 10 kids annually will have a very small average death loss so as to make the calculations of bin size unrealistically small. In most cases, a simple three-bin system will be sufficient.

In general, bin width should be six to eight feet or 1.5 times the width of tractor or skid steer buckets used in constructing and turning piles. Bin depth should be a minimum of six feet and is often equal to or greater

than the width, up to ten feet depending upon expected mortality. Bin height should be five to six feet to accommodate piles of layered carcasses. The front of the bin should be removable, such as wooden slats dropped into channels on either side of the opening, or hinged. A gate with mesh wire could be used to enhance air exchange. If the depth of the bin is sufficient, the bin front could be left open. Bin walls are commonly built from pressure treated wood. Spaces can be left between boards to encourage air exchange. Cement could also form the walls. A three bin, permanent structure will accommodate annual mortality from medium- to large-size herds.

Many producers may not want to invest in building a new structure for composting. Alternative structures to house permanent composting bins include unused machine sheds, corn cribs, hoop houses, and other structures with concrete or packed surface floors and sufficiently high ceilings to allow the use of tractor or skid steer buckets.

Low-cost alternatives

There are many low-cost alternatives to construction of permanent structures that will serve producers with small herds and minimal mortality. These low-cost bins can be placed on a concrete pad should state regulations mandate, or on a soil base. Two wire stock panels can serve as a bin by shaping them in a circle to enclose a mortality compost pile. Eight wooden pallets on edge can be held in place by t-posts or wired together to make an easy, low-cost bin. Small individual or paired wooden bins can be built from treated lumber. Wire with small openings or unused chain link fence held in place by t-posts or wired to stock panels will help hold compost material in piles and prevent disturbance from wildlife and dogs. Three large, round bales can be placed to form a three-sided bin in which mortalities can be placed. Wire or pallet bins should be made so they can be easily opened to build and turn compost piles, as well as for removing completed compost.

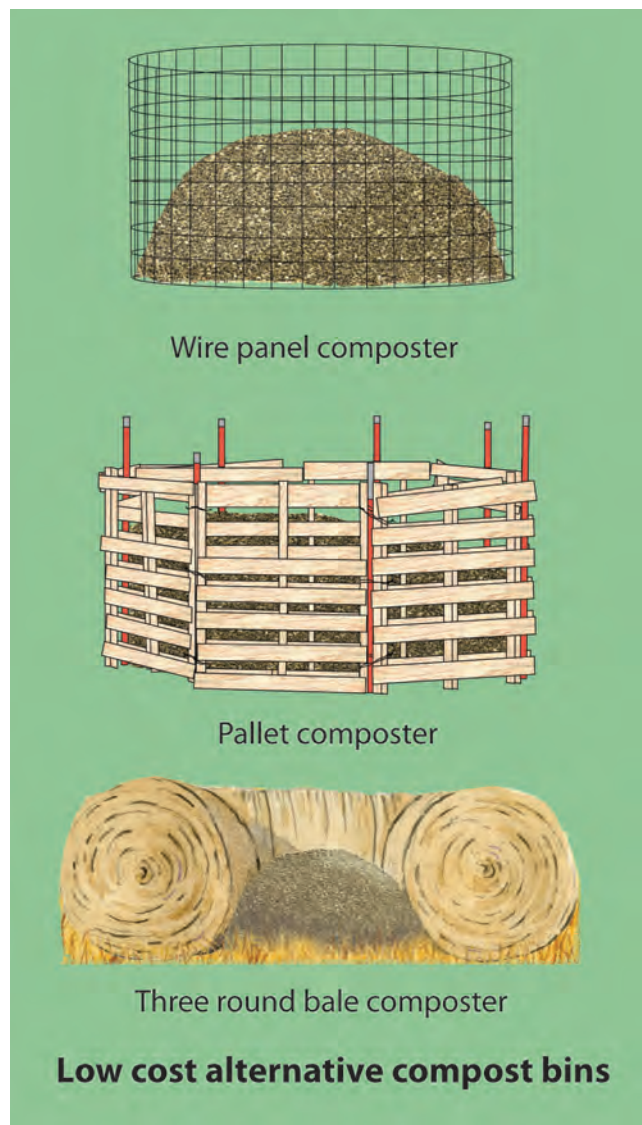
For producers with small herds, two or three small wire, pallet, or individual wooden bins may suffice for mortality composting. Bins six to eight feet in diameter can hold one to two adult goats and one to three kids, depending upon size, composted in two layers. Too small a compost pile will have insufficient insulating qualities and poor heat retention. The pile will not heat properly and composting will be slow. Avoid building piles less than six feet in diameter.

When building small compost piles in the open, the final covering layer of carbon source is piled into a cone shape to shed rainwater, preventing the pile from becoming too wet. A tarp tied to cover the pile is beneficial in areas with high rainfall or for solid-sided, single or double

wooden bins where rain can be trapped along the walls. It is better to prevent a pile from becoming too wet than to try and dry a pile that has become too moist and is not composting properly.

Windrow systems

Farms with very large numbers of animals may wish to consider a windrow system for mortality composting. In this system, successive mortalities are added to the end of the pile made for the previous mortality. Usually, a portion of the covering carbon source material is removed and the carcass placed and covered. This continues until the row is considered complete. The pile is turned based upon the date of the last carcass placed in the windrow. Windrow composting systems require more management than regular bin composting. More information on windrow systems is contained in many of the resources listed at the end of the chapter (in particular Bonhotal et al., 2002 from the Cornell Waste Management Institute and Mukhtar et al., 2004 from Kansas State University).

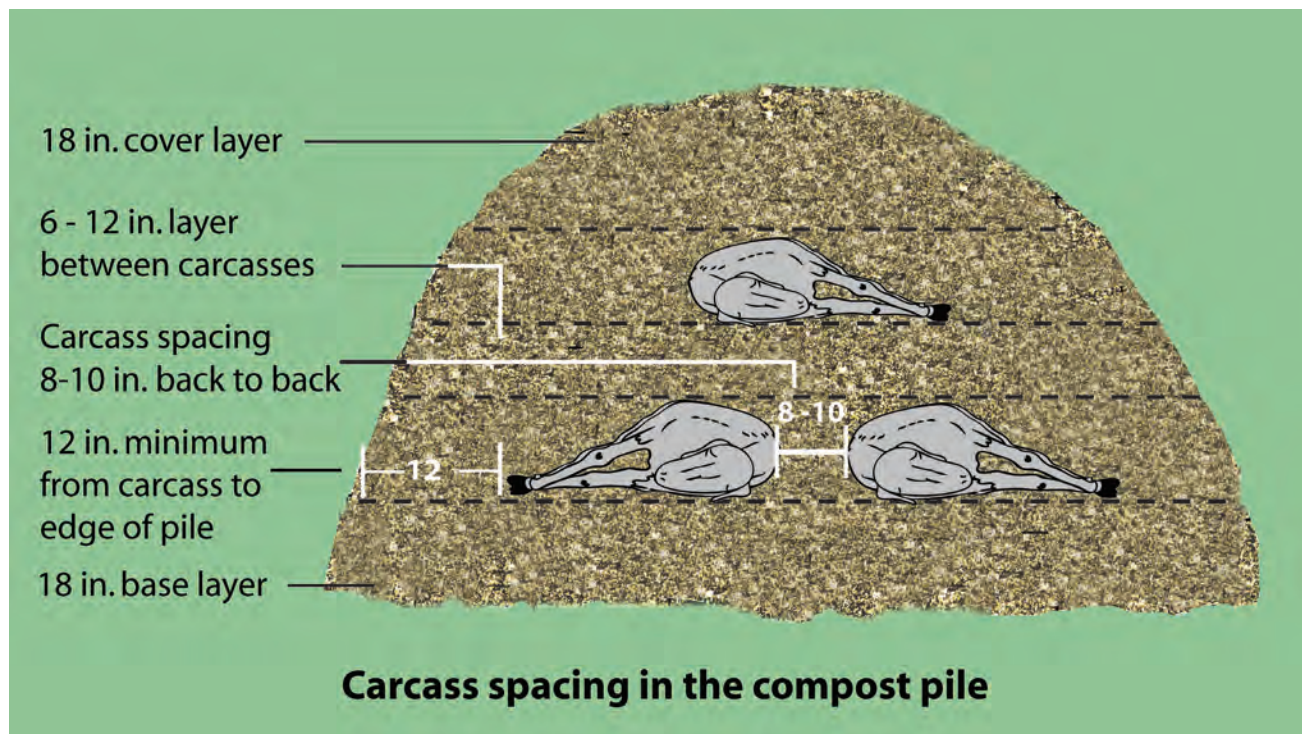


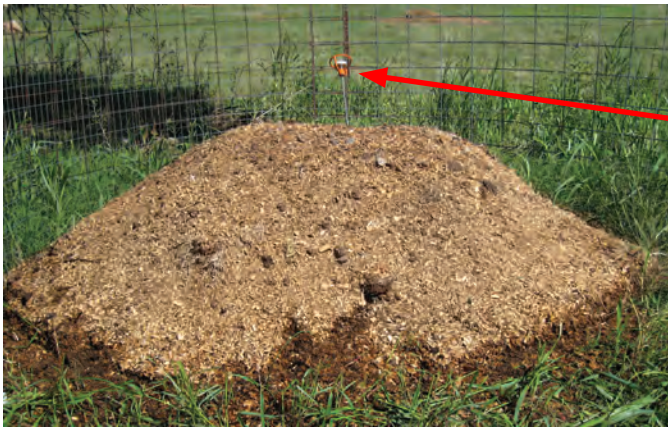
Mortality Composting Process

Ensure you have plenty of carbon source material before beginning mortality composting. The amount needed for wooden bin composting can be estimated from the volume of the bin. For alternative bins made from wire, pallets, round bales, or other material, the amount will depend upon the diameter of the bin and height of the final pile. However, a rule of thumb is approximately 100 ft³ (3.5 yd³) or 4 to 5 tractor buckets of the carbon source mixture for each 100 lbs of mortality. If two or three carcasses are layered in a bin, the total will be somewhat less on a per animal basis as the base layer will be used for more than one carcass. However, too thin a base or covering layer of carbon source will lead to poor decomposition, excessive leachate, or odors.

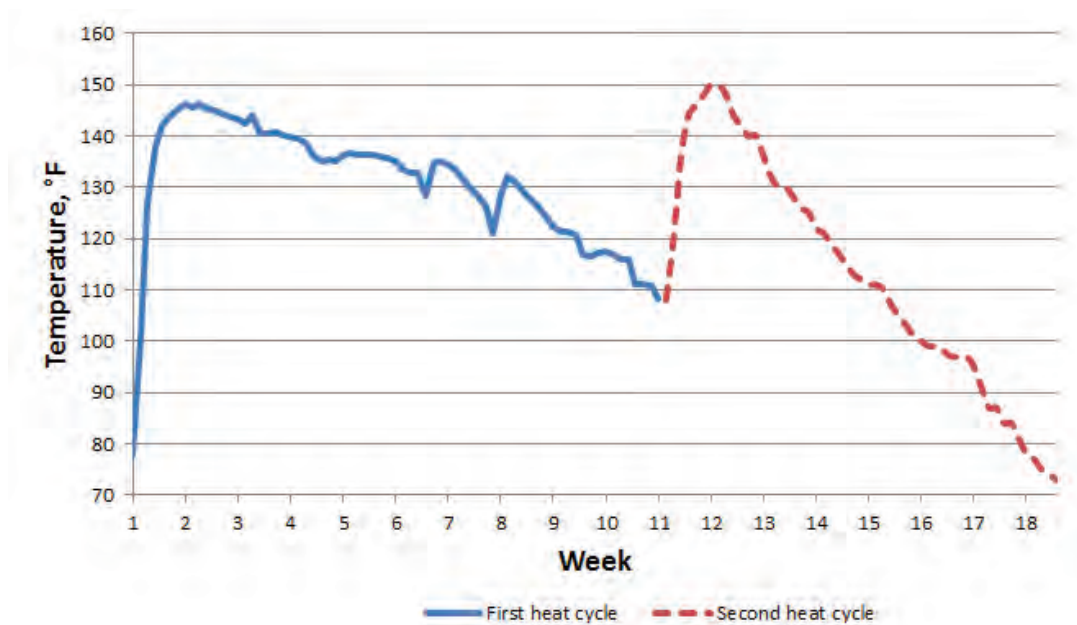
Building the pile

1. Cover the base of the bin with a minimum of 18 inches of carbon source material as an absorbent layer to trap liquid leached from the carcass during composting. The base layer can be laid down several days prior to adding carcasses so that it begins to heat. This will speed up the initial stage of carcass decomposition.
2. Add a carcass in the middle of the base a minimum of 12 inches from bin walls or sides. Limbs may be removed and laid next to the body if needed to keep away from bin sides.
3. If the bin is of sufficient size and two or more carcasses need to be composted, add a second carcass to the layer. Place adult carcasses back to back 8 to 10 inches apart and lamb or kid carcasses 6 inches apart with feet pointing to the pile's edge.
4. Use a knife to lance the rumen. This provides access by microbes to the inside of the carcass and prevents the rumen from bursting due to gas build up from ruminal microbes.
5. Add enough water to the surrounding carbon source to create a moisture content of roughly 50%. One to two five-gallon buckets of water may need to be added per 100 lbs mortality. Adjust the amount depending on the dryness of the carbon source. Do not get the layer too wet. The carcass contains significant water and this must be considered when adding additional water.
6. Cover the carcass layer with 6 to 12 inches of carbon source material if a second layer of carcasses is to be added. If not, proceed with the covering layer.
7. A second layer of carcasses can be added as mortality happens. Scoop out a portion of the layer covering the first carcasses and lay fresh carcasses on top. Maintain at least 6 inches between layers. Lance the rumen and add additional water as needed. If composting in deep wooden bins, complete layers in the back before beginning to compost in the front area of the bin.
8. After all carcasses have been added, top off the pile with a minimum of 18 inches of carbon source material creating a cone shape to shed rainwater if no roof or tarp covering will be used.





Compost thermometers should measure core temperature. Temperatures over 131° F kill most pathogens.



Temperature of a goat carcass compost pile made with a mixture of horse bedding and wood shavings turned at 11 weeks.



Bones of goats after 10 weeks of composting.

After a couple weeks, the pile will have shrunk and additional carbon source may be added to the covering layer. Check the pile occasionally to ensure animals have not disturbed it and that no portions of the carcass are visible. Also check for noticeable odors and pile temperature.

Heat cycles and aeration

First heat cycle

Mortality compost piles should undergo two heat cycles, the first phase after building the pile, and a second phase that occurs after turning the pile. After building the pile, bacteria will be working and generating heat. After three or four days, pile temperature should reach over 130°F and remain at that temperature for up to two weeks or longer before beginning a gradual decline. This heat is important to speed up decomposition and to reduce pathogens. Pathogens are destroyed due to the combination of pile heat and length of exposure. For this reason, it is important to monitor pile temperature. This need not be done daily but at a minimum temperature should be checked every three to four days.

The first heat phase continues until pile temperature begins to drop. By this time, all flesh and soft tissues will have decomposed and mainly large bones are left. In a well-working pile containing carcasses of adult animals, this occurs in roughly 10 weeks. Lamb and kid carcasses may take only a few weeks for soft tissues to decompose.

Turning compost piles (aeration)

When the temperature of the pile decreases to near ambient temperature the pile should be turned. For composted adult goat carcasses, after 75 days the pile can usually be turned; composted young animals can be turned more quickly. Use a tractor bucket to pick up material and either dump it back on the pile or into a secondary bin. Allow the material to fall from the bucket onto the new pile. This aerates the pile and mixes the contents. Use additional carbon source material to ensure enough covering layer is put on the turned pile. This will insulate the pile and trap any odors generated. Moisture can be added if the pile is too dry or the pile can be allowed to dry if it is too wet, from trapped rainfall, for example.

Second heat cycle

After turning, the pile will heat again and reach temperatures over 130°F. This is important in pathogen reduction as in the original pile not all parts may have reached high temperatures for a sufficient length of time. Redistributing pile contents via turning increases the probability that all portions of the compost will heat sufficiently. Monitor temperature of the pile as it heats. Temperatures over 130°F should be sustained for several days or a week or more in the second heat cycle. The second heat cycle should take approximately the same

length of time as the initial cycle. After a second 75-day period, the compost pile can be left to cure for several weeks before use. Any large bones left at this time should be added to a future compost pile for further break down.

Bones

During the first heat cycle most small bones will be degraded. When turning the pile, collect larger bones and place them in the pile center. At the end of the second 75-day period, these should be brittle and break easily. Those that are thicker, skulls for example, can be placed in a new compost pile to decompose further.

Cold Weather Composting

Composting can be done at any time of the year, even in winter. It can be difficult to establish a new compost pile in very cold weather, but active piles with sufficient covering layer insulation will continue to heat and decompose carcass material even if covered with snow and ice. Winter mortality composts best when added to an active pile or if hot, active compost from an existing pile is used as the main portion of the carbon source for a new pile. If possible, do not let carcasses freeze before adding to a working compost pile. Add additional cover layer to insulate the pile and retain heat when very cold. The composting process may take longer in winter, but the carcasses will degrade.



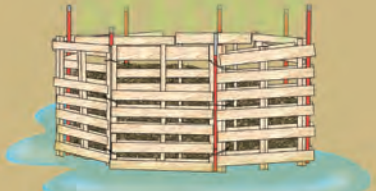

A well-insulated pile maintains heat during winter.

Troubleshooting Mortality Compost

Low temperature

Low temperatures are usually the result of either too little or too much pile moisture or an improper C:N ratio. Evaluate the carbon source mixture and adjust if needed. Remove some of the covering layer and check pile moisture using the handful squeeze method. If nothing sticks to your palm, add water. If water drips out, turn the pile allowing it to dry or mix in dry carbon source. Check the temperature a few days later to see if the pile has begun heating.

A pile will also not heat sufficiently if the carbon source material does not pack tightly enough, particularly in cold weather. For example, chopped cornstalks and long-stem hay or straw allows too much air movement to the extent that heat is lost and composting is poor.

Problem	Solution	
Low temperature	Adjust pile moisture content.	 <p>Odors can arise from compost that is too wet.</p>
Odor	Compost too wet. Add carbon source material.	
Leachate	Base layer too thin or compost very wet. Pile may require reconstruction.	
Failure to decompose	Improper C:N ratio. Add carbon source material. Ensure proper pile construction.	
Insects fly larvae	Insufficient cover layer or leaching liquids. Add carbon source material. Ensure proper pile construction.	
Scavengers	Add additional mesh wire around compost to prevent animal entry.	

Troubleshooting mortality compost

These materials should be mixed with manure or finished compost before using. Add additional covering layer of finer material to increase insulation.

Pile odor

Odors can arise from compost that is too wet. Turn the compost and add additional dry carbon source. Wooden bins may trap rainwater if not covered and composting material on the sides and bottom can become too wet. Too low a C:N ratio and too thin a covering layer also contribute to odor. Make sure there is a good C:N ratio, the covering layer is at least 18 inches thick, and carcasses are a minimum of 12 inches from the pile's edge. The covering layer not only acts to shed rainwater, it also serves as a biofilter trapping gasses and odors generated by the composting process.

Failure to decompose

Failure to decompose is due to improper C:N ratio or carcasses that were laid too thickly or too close to the edge of the pile. Add additional carbon source and ensure that the pile is properly constructed. Use fewer carcasses per layer.

Insect/fly larvae

Seeing insects or fly larvae is due to insufficient covering layer over carcass or liquids leaching from the pile creating odors. Build the pile with a thick absorbent base and ensure an adequate cover throughout the decomposition process. Make sure the pile is heating sufficiently. Maintain a clean area surrounding the pile.

Scavengers

Scavengers may disturb pile contents if the surrounding structure cannot prevent entry. For example, the openings between slats in a pallet may not stop wild animals from entering the pile, particularly if odors are present. If entry becomes a problem, additional wire surrounding the pile may be needed.

Leachate

Fluids seen running out of the pile indicate too thin a base layer, compost that is very wet, or a pile containing too many carcasses. In these cases, the pile may have to be rebuilt or split into two piles.

Compost Use

About one-half of the material from a mortality compost pile can be reused in a new pile and mixed with additional carbon source material. This reduces the amount of carbon source that needs to be on hand and also provides a source of bacteria for the new pile. The remaining composted material is a nutrient-rich medium that can be applied to pasture and other agricultural land. Mortality compost should be included in a total farm nutrient management plan and spread accordingly. *It is not recommended to use small stock compost on vegetables or areas where food is produced for direct human consumption.*

Summary

Mortality composting is an easy, lawful, low-cost alternative for producers to dispose of livestock losses. Select sites away from water sources and the public. Producers may wish to construct permanent wooden bins on a concrete pad or use simple wire or pallet enclosures in which to compost. A carbon source such as sawdust, wood shavings mixed with manure, stable bedding or other carbon-rich material is needed to combine with the carcass. Proper moisture content of approximately 50% is essential to ensure a working pile. Temperatures in a properly made pile will be high enough to kill most pathogens. A portion of the resulting compost can be reused and the remainder spread on pasture land.

Resources

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