Sustainable Agriculture

Composting dead livestock:
A new solution to an old problem

Livestock **I**ndustry **F**acilities & **E**nvironment

The following, based on research supported by the Leopold Center for Sustainable Agriculture and the Iowa Department of Natural Resources, describes how on-farm composting of dead livestock can save producers money and help protect the environment.

New Option can Save Money, Protect Environment

Although livestock and poultry production rank among Iowa's most important industries, disposal of dead stock is increasingly difficult.

Iowa's once extensive rendering service industry shrank from 26 plants in 1983 to only 7 in 1996. In a 1996 survey by the Iowa Department of Natural Reources, only 5 of the 7 facilities reported that they rendered animal carcasses. As a result, some producers have been forced into on-farm burial, which is both time-consuming and nearly impossible during winter. Research also has shown that burial poses a hazard to shallow groundwater.

Revised composting rules implemented by the Iowa Department of Natural Resources (IDNR) in July 1999 make it easier than ever for livestock and poultry producers to utilize composting for management of animal carcasses. On-farm composting of dead animals generated on the same farm as the composting facility is exempt from having a permit if operated in compliance with the seven rules shown in the box on the following page.

Two Iowa on-farm poultry research and demonstration projects have shown composting to be simpler than burial. Moreover, excessive nitrogen buildup can be a problem at burial sites, whereas composting produces a humus-like product containing nutrients and organic matter that can be recycled onto cropland.

The simple four-bin system shown in the photo at left composts more than 30 tons of broiler carcasses a year.

Inside:

The Leopold Center was created by the Iowa Groundwater Protection Act of 1987.

IOWA STATE UNIVERSITY

IDNR Rules for On-farm Carcass Composting

On-farm composting of dead animals generated on the same farm as the composting facility is exempt from having a permit if:

- Dead animals are incorporated into the composting process within 24 hours of death and covered with sufficient animal manure, animal bedding, crop residues or clean wood waste (free of coatings and preservatives) necessary as bulking agents and to prevent access by domestic or wild animals.
- Composting is done in a manner that prevents formation and release of runoff and leachate and controls odors, flies, rodents and other vermin.
- Dead animals are not removed from composting until all flesh, internal organs, and other soft tissue are fully decomposed.
- Storage of finished compost shall be limited to 18 months and shall be applied to cropland or pastureland at rates consistent with the nitrogen use levels necessary to obtain optimum crop yields and shall be applied in a manner as to prevent runoff to surface waters of the state. Application of compost to other lands shall require prior approval by the department.
- Composting must be done on an all-weather surface of compacted soil, compacted granular aggregates, asphalt, concrete or similar relatively impermeable material that will permit accessibility during periods of inclement weather and prevent contamination of surface and groundwater.
- If composting is done in a permanent structure, composter construction shall utilize weather and rot-resistant materials capable of supporting composting operations without damage. (Although not mandatory, a roof over the composting facility is recommended to prevent excess moisture accumulation that can lead to production of undesirable odors and leachate.)
- Composting must be done outside of wetlands or the 100-year flood plain and at least 100 feet from private wells, 200 feet from public wells, 50 feet from property lines, 500 feet from inhabited residences, and 100 feet from flowing or intermittent streams, lakes, or ponds.

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How It All Started

Poultry carcass composting first caught on during the late 1980s when research at the University of Maryland demonstrated that broiler carcasses could be fully biodegraded in as little as 30 days.

Composting was rapidly adopted by the poultry industry in southern and eastern seaboard states, but concern about its year-round practicality in colder climates slowed its acceptance in Iowa.

Subsequent on-farm trials conducted by the Department of Agricultural and Biosystems Engineering at Iowa State University, co-sponsored by IDNR and the Leopold Center, have shown that cold weather does not seriously affect the composting process as long as bins are adequately sized and properly loaded.

Furthermore, research on a commercial turkey farm in central Iowa confirms that composting works for birds weighing as much as 25–30 pounds. Although an additional 14-day heating cycle is recommended to give birds in the 15–30 pound range sufficient time for complete decay, the same fundamental composting methods work well for both small and large birds.

Not Just for Birds

Although carcass composting was pioneered in the broiler industry, recent work suggests it also can work for swine. The primary differences are in the decomposition time, facility size, and type of co-compost materials.

Because practical experience with swine composting in Iowa is currently limited, guidelines offered here are based on research done in Missouri. Research is under way to answer questions specific to Iowa conditions and production practices. The Missouri swine composting methods described here, for example, rely on use of sawdust, a material not widely available in Iowa. Iowa work is focusing on alternative co-compost materials more readily available to Iowa producers.

Basic Elements of Successful Composting

Composting speeds up normal decay processes conducted by naturally occurring bacteria and fungi. The rate at which these microorganisms do their work, and the quality of the end products they produce, are affected by their diet and environment. Poor conditions for these organisms result in slow or incomplete decay, foul odor, and release of highly contaminated liquids. To minimize problems and insure rapid decomposition, keep these key operating parameters in mind:

Moisture

Many factors affect the composting process, but moisture content often is the most crucial. Wastes that are too dry (less than 40% moisture content) decay slowly because they lack sufficient water for survival of bacteria. At moisture levels above 60%, small pore spaces that allow oxygen to move into the compost become filled with water. Lacking sufficient oxygen for rapid growth, aerobic microorganisms that produce relatively little odor are soon replaced by anaerobic organisms that produce highly odorous organic acids and hydrogen sulfide.

For optimum performance, maintain moisture content between 40 and 60%. The compost should be moist but not soggy. If moisture can be squeezed from a handful of compost material, it probably needs to be mixed with drier material.

Co-composting materials

Co-compost materials serve several key functions. They surround the carcasses, reducing their accessibility and attractiveness to insects and small rodents. They also provide additional carbon, which is necessary to sustain high levels of microbial activity. "Structural" co-composting materials, such as wood chips or ground corncobs, help to keep compost porous. This helps diffuse oxygen into the pile and permits escape of gases like ammonia that inhibit microbial activity.

Some co-composting materials, like sawdust, are particularly good for absorbing excess liquid released by decaying carcasses, an important factor in preventing undesirable environmental impacts. Poultry barn litter—a mixture of wood shavings and poultry manure—is the most common co-compost material for turkey and broiler carcasses.

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Carbon and nitrogen

Carbon and nitrogen are key compost ingredients. Without a proper balance of carbon and nitrogen, microbial growth is retarded, reducing the decay rate. While experts suggest that optimal carbon to nitrogen ratios are about 25 to 1, experience with a wide variety of materials indicates that composting will occur, although somewhat slowly, at C:N ratios as low as 10 to 1 or as high as 50 to 1.

Because carbon and nitrogen analyses are expensive, temperature and odor also can be used as general indicators of the C:N balance. If ammonia odors (caused by a low C:N ratio) become a problem, adding a high-carbon co-compost material such as sawdust can raise the C:N ratio.

Iowa research has shown that C:N ratios as low as 10 to 1 are not uncommon in poultry litter. The trend toward more frequent litter removal from commercial poultry barns, however, is resulting in litter with higher C:N ratios.

On the other hand, if moisture levels appear to be within the recommended range, strong ammonia odors are not present, and decay is still slow, insufficient nitrogen may be the cause. This is likely if sawdust, which contains very little nitrogen, is used as the co-composting material. In this case, additional nitrogen in the form of manure or granular fertilizer can be added to lower the C:N ratio.

Oxygen

To help avoid odor problems:

- ***avoid overly wet compost***
- ***periodically turn compost***
- ***use relatively coarse co-composting materials***

Composting traditionally has been defined as an aerobic (oxygen-using) decay process. Aerobic microbial activity is more desirable because its major byproducts are water, carbon dioxide, and heat. Anaerobic decomposition, by contrast, produces little heat and generates highly odorous products such as hydrogen sulfide and organic acids. To keep a composting process reasonably aerobic, minimum oxygen concentrations of 5% within the compost pile are sometimes prescribed. Maintaining this level of oxygen, however, requires nearly continuous aeration with fans, or frequent mechanical agitation of the compost.

Because oxygen monitoring and continuous aeration equipment are expensive, on-farm composting operators rarely go to such lengths, and on-farm composting proceeds more slowly than it could under optimal oxygen conditions.

Given adequate space and time, however, most producers are not overly concerned about the rate of carcass decomposition, and failure to maintain highly aerobic conditions is not a serious drawback. Avoiding overly wet compost, periodically turning compost with a loader, and using relatively coarse co-composting materials that allow oxygen diffusion into the pile can help avoid odor problems.

Heat retention

Heat is an important byproduct of bacterial activity. Internal temperatures within properly sized composting operations often reach 120–150° F. This temperature range stimulates rapid growth of thermophilic (heat-loving) bacteria that promote decay. As an added benefit, exposure to high temperatures helps to kill disease-causing microorganisms, improving the safety of the finished compost.

Studies conducted in Iowa and elsewhere indicate that land application of composted poultry carcasses is reasonably safe. During the Iowa study, approximately 90 samples collected from secondary composting bins were compared with an equal number of samples from stacks of broiler and turkey barn litter.

Although the composting bins typically contained nearly a ton of decayed carcasses, coliform bacteria densities in the compost were not significantly higher than those in poultry litter. Nor did results differ between warm weather and winter. Tests for salmonella showed no occurrences in litter or finished compost.

Since land spreading of poultry barn litter traditionally has been considered a safe practice, the fact that composted carcasses did not have significantly higher bacteria numbers is a good indicator of compost's safety.

Since on-farm composting usually is done in unheated bins, it is important to make the facilities large enough that sufficient internal heat will be generated and retained during cold weather. As Fig. 1 shows, temperatures measured in compost

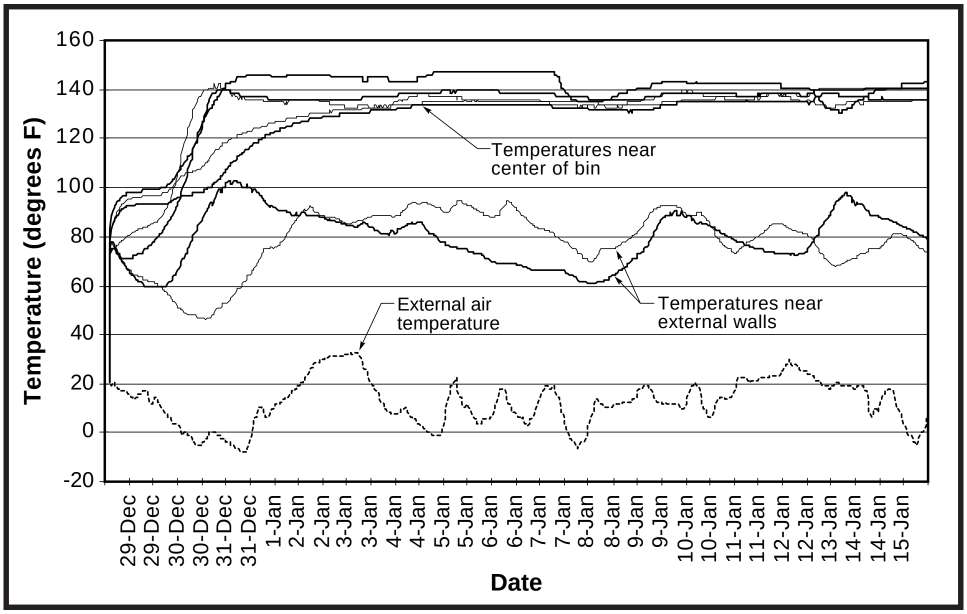


Figure 1. Temperatures near external walls are suppressed during subfreezing weather, but core temperatures remain high.

located near external sidewalls are noticeably cooler than in the "core" area of the bin. Potential effects of the cool zone can be minimized by keeping the carcasses 9–12 inches away from the bin edge and constructing bins large enough (typically 6 feet x 8 feet minimum floor dimensions) to have substantial "core" volume.

Composting Facilities for Poultry and Other Small Carcasses

On-farm composting of small carcasses usually is done in simple uninsulated bins constructed outside of livestock production buildings. By keeping a relatively large mass of material in a compact form, bins help to retain internal heat, thereby promoting rapid decay. Bins also reduce blowing and scattering of compost materials and make carcasses less accessible to predators and rodents.

Because of widespread adoption of composting in leading poultry-producing states, composting facilities and operating procedures for small carcasses are well established and reliable. As noted earlier, these methods have worked well in Iowa on birds up to 30 pounds, despite cold weather. Although additional on-farm trials are needed for species other than poultry, the same fundamental approach should work for other small carcasses.

Composting facilities intended for long-term use are usually built from treated lumber or concrete. Like the simple structure pictured on p.1, pole-shed construction is typical. Though not required by the IDNR rules, a roof over the bins is recommended to prevent excess moisture accumulation that can lead to production of undesirable odors and leachate. An all-weather base constructed of relatively impermeable material is required to minimize contamination of surface and groundwater.

Bin design

Bins that will be unloaded using a skid loader normally have floor dimensions of approximately 6 feet (front-to-back) by 8 feet (wide). Larger tractor-mounted loaders often require a wider bin. Widths at least 4 feet greater than the bucket reduce the likelihood of damaging sidewalls and doors during loading.

Steam rises as compost is transferred from primary to secondary bin. Note in this case that top of door folds down for easier loading.

Normal bin wall height is five to six feet. Wooden bin walls typically are constructed using treated 2 x 6 or 2 x 8 lumber, or 1-inch treated plywood backed with 2 x 6 stiffeners. Although the dimension lumber will be more rugged than plywood, bin walls in the facility shown in the photos were constructed of plywood, and they have held up well to continuous use for more than four years.

Since small carcasses are placed inside the primary composting bins by hand, the front of the bin should be designed so carcasses need not be lifted over a five-foot-high door. This can be accomplished with removable drop-boards that slide into a vertical channel at each end of the bin or with doors that split horizontally.

Both systems have advantages and drawbacks. Drop-boards are simple to construct, but they are likely to warp and must be stacked out of the way of daily traffic patterns when not in use. The vertical channels that hold drop-boards in place must also be kept clear of compost material to prevent binding.

To avoid damage, hinged doors should be designed to swing back flat against adjoining bins. The door shown in the photo above, designed by a central Iowa turkey producer, has worked well for several years. Removable hinge pins at both ends permit the door to swing open from either end. Horizontal hinges allow the top of the door to fold down for easier loading of the lower portion of the bin.

To assure adequate composting capacity, the combined volume of the bins must be based on anticipated daily losses during the production cycle and time required for complete carcass decomposition.

Bin capacity

As a rule of thumb, bin systems constructed for composting poultry typically have about two cubic feet of total bin volume (one cubic foot of primary bin volume and one cubic foot of secondary bin volume) for each pound of average daily loss. A broiler or turkey farm averaging 200 pounds of loss each day, for example, would need approximately 200 cubic feet of primary bin capacity and the same amount of secondary bin space.

While some producers find that they can manage with less capacity, the extra space costs little and provides valuable operating flexibility for contingencies such as short periods of higher than average mortality, busy seasons when bins cannot be emptied on schedule, or occasional batches that require additional time to achieve complete decay.

The total bin volume recommendations given here accommodate only average daily death losses. Catastrophic losses due to disease, ventilation failures, or other unpredictable events would require considerably larger facilities.

The number of bins in a composting system will depend on individual bin dimensions and the total required bin volume. Bins with 250–300 cubic feet of capacity (bin floor areas of about 50 square feet) are recommended for small carcasses. Extremely large bins that take a long time to fill are undesirable since they lead to unnecessarily long heating cycles for the first carcasses placed in the bin.

When planning a bin system, it also is desirable to include space for co-compost material storage. Materials stored in unsheltered piles can lead to wet compost and serious odor problems during rainy seasons.

Although bin layout is not critical to composting success, locating primary and secondary bins close to each other can be helpful in minimizing transport time as compost is moved through the system.

Heat loss during cold weather can be reduced by selecting a bin layout that minimizes the length of exterior walls. A six-bin system with central alley, like that illustrated in Fig. 2a (next page), has 120 linear feet of exterior walls. The same six bins arranged with common interior walls (Fig. 2b) have only 72 feet of external wall exposed to outdoor air temperatures.

A broiler or turkey farm averaging 200 pounds of loss each day would need approximately 200 cubic feet of primary bin capacity and the same amount of secondary bin space.

Poultry Composting Operations

Poultry composting is begun by placing a 12-inch layer of dry poultry litter (co-composting material) in the bottom of the bin as shown in Fig. 3 (page 9). When carcasses release excess moisture, this absorptive base layer helps prevent release of highly odorous leachate.

Carcasses are placed on top of the base layer at least nine inches from bin walls. Placement closer to the wall can lead to seepage of liquid through the walls. Keeping carcasses away from side walls also helps to maintain them at temperatures that speed decay and kill disease-causing microorganisms.

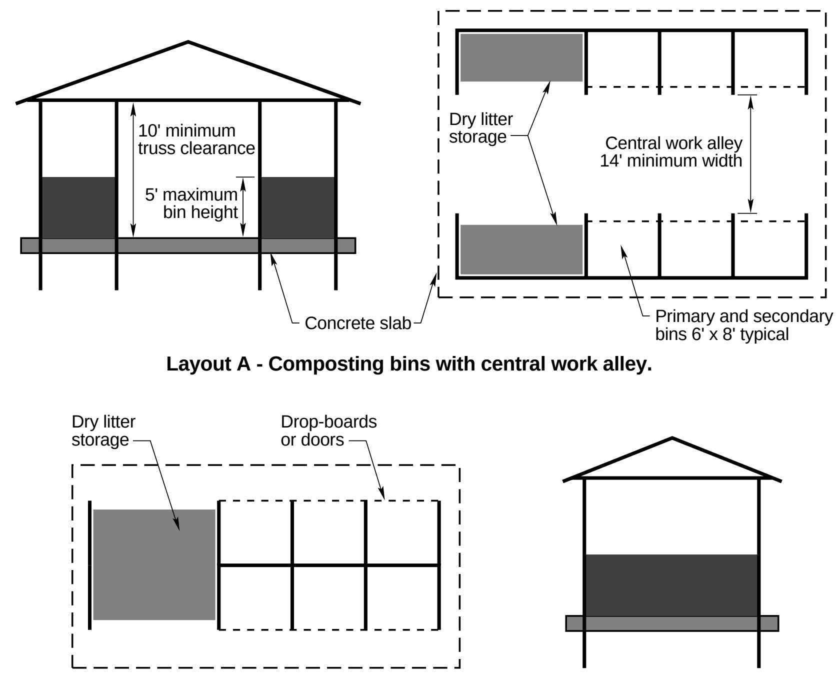
Carcasses should not touch each other; too many carcasses in one spot leads to localized wet spots and poor decay.

After the carcasses are positioned inside the bin, they are covered with 4 to 6 inches of co-compost material. Incomplete coverage can lead to fly problems.

Layering of carcasses and co-compost material continues until the bin is filled to a depth of about five feet. In a properly operating compost process, new material added to the bins reaches temperatures of 120-150° F within 24–48 hours.

Internal temperatures can be monitored with a long-stemmed thermometer to insure that microbial activity is reasonably uniform throughout the composting bin. To obtain an accurate picture of internal conditions, be sure to probe the bin at several locations. As shown in Fig. 1, it is not unusual to find hot and cool spots within the same bin, so a single temperature measurement can be misleading. If a bin fails to heat up, moisture excess or deficiency is the most common cause, and

Figure 2. Two typical composting unit layouts.



Layout A - Composting bins with central work alley.

Layout B - Composting bins with common center wall.

it will be necessary to unload the bin and mix in compost from an active (hot) bin.

During cold weather, warm co-compost material can help to initiate decay. Two Iowa demonstration sites using stacked poultry litter showed that wintertime temperatures at least 18 inches below the surface of outdoor stacks ranged from 100–140° F. To take advantage of this, it is important to maintain a stack of co-compost material large enough to retain heat. Again, use a long-stemmed thermometer to monitor internal co-compost temperatures, and take material from the interior of the stack when covering new carcasses added to the compost bin.

Heating cycles

After a bin is completely filled, it must undergo a primary heating cycle lasting 10–14 days. During this time, rapid microbial action depletes the oxygen within the bin, the rate of decay slows, and temperatures may begin to fall.

Following the primary cycle, the partially composted waste is removed from the primary bin and placed in a secondary bin. The mechanical action of moving the compost breaks up the pile, redistributes excess moisture, and introduces a new oxygen supply. Once this takes place, a secondary heating cycle occurs, accompanied by further decomposition.

By the end of the secondary heating cycle, carcasses as large as 15–20 pounds are normally reduced to bones that are reasonably clean and free of tissues that cause odors and attract insects and predators.

Large birds (15 pounds or more) may need a third heating cycle to achieve complete decay, particularly if compost moisture content falls outside the optimal 50–60% range. If large birds do not constitute a major portion of daily flock losses, it is advantageous to compost large and small carcasses separately. This minimizes the amount of bin space tied up in a third heating cycle that is not needed for small carcasses.

As noted earlier, two cubic feet of total bin volume for each pound of average daily loss generally provides some excess capacity that can be used to accommodate a third composting cycle. If half or more of the birds to be composted are large, however, it may be necessary to use additional bins, increasing the total bin volume to three cubic feet per pound of average daily loss.

Moisture control

If co-composting materials cannot be covered with a tarp or stored under a roof, extra precautions will be necessary during rainy seasons. Poultry litter stored in open piles can develop a very wet cap that is a foot thick or more during rainy weather. The wet material should be scraped aside so that drier material from the interior of the stack can be used in the composting bins. If the cap material is not too sticky, it sometimes can be mixed with material from the interior of the pile to achieve desired moisture levels.

Analysis of stacked turkey and broiler litter has shown that average moisture content is often in the 30–40% range. While this is slightly drier than desired for rapid composting, additional water is released during the decomposition process. As a result, finished compost moistures usually are in the 40–50% range.

Litter quality can vary substantially from operation to operation. If lack of moisture is a persistent problem, adding supplemental water may become necessary. Water addition can be a time-consuming task, however, and it can lead to wet spots and odors unless it is done sparingly and uniformly. As an alternative to moistening carcasses and co-compost material, consider using a mixture of finished compost and litter as the co-composting material. Finished compost tends to have higher moisture levels than litter, and fresh compost also will contain active microorganisms that can rapidly initiate the decay process.

Swine Composting Facilities

While many of the planning considerations for swine composting facilities are the same as those outlined for poultry, there also are some important differences. Key among these is facility size.

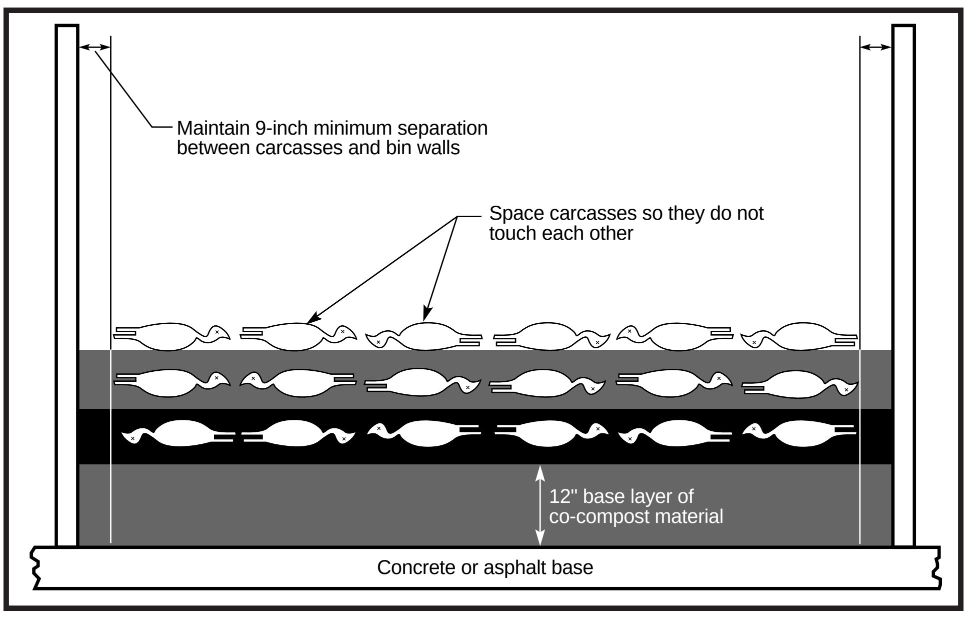


Figure 3. Composting bins are loaded in layers; each carcass must be surrounded with co-compost materials.

As carcass size increases, so does the time needed to achieve complete decay; 500 pounds of pig carcasses can take considerably longer to decompose than 500 pounds of poultry carcasses.

To accommodate increased composting times, it is necessary to increase the total volume of the composting system. For sows, boars, or feeder pigs, the University of Missouri recommends at least 20 cubic feet of total primary bin capacity for each pound of average daily loss. An equal amount of secondary composting bin volume is also needed. As with poultry, the composter sizing recommendations for swine are intended only for normal death losses.

As with permanent composting structures for poultry carcasses, concrete or treated wood construction is recommended for swine composting facilities (as noted earlier, IDNR rules require that composting be done on an all-weather surface—*see p. 2*). A roofed facility is recommended to help exclude excess moisture, the most common cause of composting failures. Additional bins or open floor area for dry storage of co-composting materials also are beneficial.

Bin sizing

Recommended bin dimensions for swine are larger than for poultry. University of Missouri recommendations suggest individual bin volumes of 500 to 1,000 cubic feet (5-foot maximum depth and floor areas of 100–200 square feet), with minimum bin widths of 10 feet.

While many of the planning considerations for swine composting facilities are the same as those outlined for poultry, there are also some important differences. Key among these is facility size.

Since large carcasses normally will be placed in a bin using a loader, three-sided bins may be less prone to loader damage than bins with doors or drop-board fronts. If three-sided bins are used, the distance from the front of the bin to the back should be increased to provide floor space for the sloping front face of the compost pile. Other bin layout and location considerations are similar to those described for poultry.

Missouri researchers also report success with temporary composting facilities constructed using large round bales of low-quality hay. This composting method originally was developed as a low-cost method for disposal of swine carcasses, and it also proved effective in handling large numbers of turkey carcasses on an emergency basis following Missouri's devastating flooding in 1993.

Missouri research showed that bin dimensions of about 12 feet x 18 feet (two bales x three bales—see Fig. 4) work well for swine. The additional time needed to fill larger bins leads to unnecessarily long treatment cycles for the first carcasses placed in the bin, wasting space and reducing operational flexibility.

Although bins constructed with bales are somewhat less expensive and time-consuming to construct, Iowa producers considering this method should be sure to include the expense of constructing a suitable base in their cost estimates. IDNR rules require that this on-farm carcass composting method, like any other, must be done on an all-weather surface.

The success of the large round bale composting method relies heavily on use of sawdust as a co-compost material. When properly mounded, weathered sawdust forms a surface "crust" that sheds rain. This, coupled with sawdust's excellent absorbency, makes it possible to compost without a roof in climates having moderate seasonal rainfall.

If sawdust or poultry litter is not available, use of more permeable (and less absorbent) co-compost materials, such as straw, may require a roof or tarp to prevent compost saturation and discharge of odorous leachate.

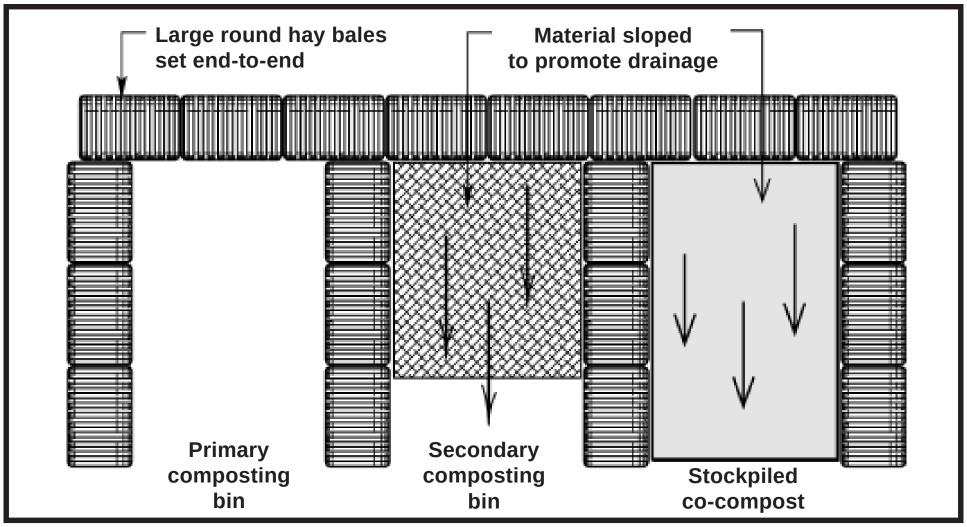


Figure 4. Low-cost temporary composting facilities constructed using large round bales. ***Again, IDNR rules require that such structures be built on an all-weather surface.***

Swine Composting Operations

While many of the poultry composting operations described earlier also apply to swine, a few modifications are needed.

Unless large carcasses are cut into smaller pieces, the number and/or length of the heating cycles will need to be increased beyond the two or three 10–14 day cycles normally recommended for poultry.

University of Missouri researchers suggest minimum primary and secondary heating cycles of three months (up to six months for market weight hogs or breeding stock). As noted earlier, it may help to segregate large and small carcasses into separate bins. This allows smaller carcasses to move through the treatment process quickly, minimizing the bin space tied up in lengthy treatment cycles.

Since large carcasses may release considerable moisture during decay, the amount of sawdust or other co-compost material placed beneath and around the carcasses is important. Again, Missouri recommendations suggest at least a foot of sawdust beneath, between, and over large carcasses to prevent seepage. If a less absorptive co-composting material is used, the amount of material placed over and around carcasses will need to be increased.

As with poultry composting, maintaining plenty of cover over composting carcasses is essential to discourage rodents and insects. To insure good coverage, it may be necessary to add more co-compost after the original material settles. To avoid discharge of leachate (prohibited byIDNR rules), operations that are not covered must be mounded to prevent ponding of water on top of the compost.

There is much to be learned about the practical aspects of composting large carcasses using co-composting materials other than sawdust. Until other, more readily available co-composting materials are studied, Iowa producers considering composting for management of large animal carcasses are encouraged to try small-scale composting operations on a trial-and-error basis before investing large amounts of time and money in composting facilities.

Land Application

To fulfill the recycling potential of composting, the stabilized compost must be applied to land. With this in mind, producers contemplating composting for carcass management also must assess how such a system will match their manure spreading equipment, land base, nutrient management program, and labor supply.

A loader and solid manure spreading equipment are needed to apply compost. Swine producers equipped with liquid manure handling systems will need to secure additional spreading equipment or services to land-apply compost.

While a properly operated composting system will rapidly decompose internal organs and other soft tissues, complete decay of bone will take longer. Bones from small carcasses are generally not a problem when land applied, but burial is recommended for bones and skulls from large carcasses because they may jam spreading and tillage equipment and attract scavengers.

Like animal manure, compost is a valuable source of crop nutrients. As such, it should be sampled and analyzed for nutrient content and applied to cropland at rates consistent with crop requirements.

Other Sources of Information

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File: Environmental Quality 2

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