# How to Fail (Miserably) at Composting Large Animal Mortalities

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## Failure Has Its Rewards

Livestock producers and large-animal veterinarians face a growing problem in rural areas: what to do with dead animals when the rendering truck doesn't come around any more? Or, if the carcass collector still comes around, he charges a leg and a hoof for the service. In either case, rendering services are getting more expensive or harder to come by for just about everyone who makes a living by keeping large animals up on all fours and belching greenhouse gases as they were designed to do.

If you're one of them – the producer or veterinarian, that is, not the carcass – you've got a pretty short list of options. For now, if you're not producing poultry, you can still *bury* your dead animals as long as you don't pollute the ground water or that nearby stream, and as long as you don't just turn 'em over to the coyotes and the buzzards. If you don't mind the air-quality regulators getting involved with your business, and if you've got cash lying around to subsidize the gas companies, you can go the *incineration* route. Those of you bored, independently wealthy types who moonlight as mad chemists and lab rats can try *biodigestion* or *chemical digestion*. (Those methods are fine and dandy, we're sure, but we're not going to deal with them here).

For the rest of you who have a life and a budget, however, you might consider *composting* those dead animals so you have something useful you can spread on your pastures to make the weeds green up a little faster in the spring. And if you play your cards just right, you can mess it up just enough to make those pesky neighbors think twice about breathing *your* air and drinking *your* ground water. It'll serve 'em right for pitching their beer cans in your bar ditch.

## The ABCs of Messing Up a Compost Pile

OK, admit it, you're hooked: there's nothing quite as fascinating and gratifying as disposing of a dead animal on your own property. So where do you start? As always: with the basics.

### Do Bacteria Really *Have* Knees?

Unfortunately for you, composting is a pretty robust, natural process. Screwing it up takes some doing, so the best way to ensure failure is to understand how it all works, how all the ingredients work together to make good compost, and then sabotage it. The first thing to realize is that composting relies on naturally occurring microbes like bacteria and fungi. (See, we told you this was gonna be fun!) These little guys eat and breathe just like we do, and they generate heat just like we do. If they have a well-rounded diet, some air, some water and some shelter, they thrive, turning their food into useful humus-like materials that double as organic fertilizer. (The most efficient ones are the *thermophilic* microbes, which grow the best when the temperature is up above 131 degrees F.) Take away one of those favorable conditions, however, and you can cut 'em off at the knees and, as a bonus, drive your neighbors either (a) batty or (b) straight to the ER.

## Atkins™ vs. South Beach™

Every living being does the best when it eats a properly balanced diet, and compost microbes are no exception. The most important characteristic of a compost diet is the relative abundance of carbohydrate and protein. Academic types usually refer to this as the *carbon-to-nitrogen (C:N) ratio*, and if it's around 30:1, well, life is peachy – but the microbes can handle anything from 15:1 all the way up to 50:1 and higher. Of course, *tolerating* a low or high C:N ratio is not the same thing as living large, but if the ratio's slightly on either side of 30.00000:1, they'll do fine.

## Air and Water

In a compost pile, air and water are in competition for the empty *pore space* between the solid particles. The most efficient microbes, which are *aerobic* (requiring oxygen), need both of them, in the proper balance, so that they can eat the nutrients dissolved in the water but still breathe enough oxygen to digest the nutrients and harvest energy for essential functions. A moisture content of about 50-55% is just about right, although they can survive a bit above or below that. If the pore space dries out too much, the microbes will starve, the process will shut down and your neighbors will never be the wiser. But if the pore space floods with water, a different set of microbes – the dreaded *anaerobes* – will out-compete the aerobes for food, and that's when the fun begins, because anaerobes are the ones that generate those lovely essences of dead fish, rotten eggs and locker rooms. When it comes to offending your neighbors through the air, the anaerobes are the best allies you've got.

## Some Like It Hot

You'll recall that the most efficient compost microbes are *thermophilic* and even generate their own heat. But they're way too small to stay warm on their own. What they really need is a heavy coat. A porous mixture of compost materials is a super insulator, and a 5-foot-deep layer of compost is thick enough to keep the microbes warm even in the most brutal Minnesota blizzard. In the Texas Panhandle, even 3-4' is plenty of insulation for the core of a compost pile to stay in the thermophilic range.

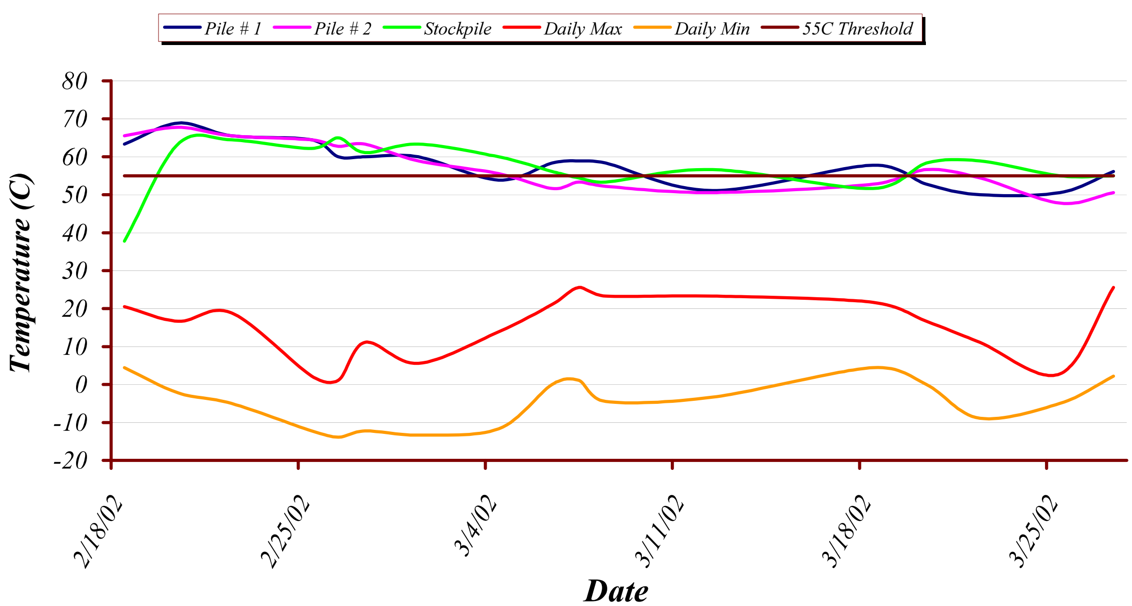


**Figure 1.** Average temperatures in two compost piles with 500-lb beef carcasses. Note that the average temperatures stayed in the thermophilic range (> 55C) for more than two weeks.

## Try *This* at Home!

Let's face the facts: your piddly little 2,000-lb quarter horse – may she rest in peace – is child's play when it comes to carcass disposal. Those of you who have ever tried to get rid of a 56-foot whale that beached itself in your backyard know what we're talking about.

In January 2004, one such whale beached itself on the coast of Taiwan. Because its 50-ton body was a bit conspicuous, "authorities" tried to arrange for its delivery to a local university, where it presumably would fit in better. But university officials and security guards, ever suspicious and vigilant, refused to let the tractor-trailer onto the campus. Plan "B" was to take it back through town to a special research location, but the "authorities," not well versed in the physics, biochemistry and time-critical nature of a massive carcass rotting in the tropical sun, soon found themselves trying desperately to explain to a local businessman why he would have to roll his legally parked scooter out of this crimson sea of warm whale guts.

**Figure 2.** One of the most spectacular failures ever in carcass management: A 50-ton sperm whale carcass explodes in the streets of Tainan City, Taiwan, while being trailered to an autopsy. (Yes, friend, those lovely items on the pavement in the foreground are *entrails*.) Kudos and thanks to the *Taiwan News* for making this photo publicly available for educational use.

We can learn a few relevant lessons from the Taiwanese:

1. Left to their own devices, large, intact carcasses will rot from the inside out.
2. Rotting carcasses generate lots of nasty gases.
3. Intact skin makes a pretty decent balloon.
4. The larger the carcass, the more spectacular the failure.

If you've read this far without losing your cookies, it's pretty clear you've got some issues with large carcasses and want to know how to compost them. You've come to the right place.

## Tool Time

Unfortunately, most of you are not going to have much difficulty finding the right tools and materials to compost your carcass successfully. At a minimum, you need (a) a big pile of some carbon-rich material, (b) a big machine to move stuff around, (c) some kind of water source, (d) a long-stemmed thermometer and (e) a weapon.

(a) Carbon-rich material can include lots of different things. Southerners and Easterners will not find it too hard to locate some sawdust, which is splendid stuff if you can get it. Wood shavings will work well, too, if they're small enough – the larger they are, the less effective they are in a compost pile. Community brush-chipping sites often make a very nice material for composting. Rotten old hay bales, cotton gin trash, shredded sugar beets, peanut hulls and other brown-colored crop residues will work nicely – and even better if you can mix two or three types of carbon-rich material together. (The wider the variety of particle sizes in your pile, the better balance you will strike among air movement, insulation, pile strength and surface area for the microbes to feed on.) You will need about 3-5 cubic yards of the material for every 1,000 pounds of carcass; less if the material yields its carbon easily, more if it does not. "Seeding" the pile of material with some manure or unfinished compost will kick-start the composting process even before the carcass shows up. (We think that's a pretty good idea, in fact.)

(b) You will also need some kind of front-end loader or other machine that can move the carcass, assemble and turn the pile and load the finished compost into a spreader truck. You won't need the loader every day, but you will need access to it to build the pile, to turn it every three to six months, and also to turn it in emergencies, such as if rainfall drenches the pile or it gets too hot for safety. The larger the loader, the faster you'll be able to get the job done.

(c) Water availability is critical, especially for those of you out West. Mixing water into the pile will be needed every couple of months as the high interior temperatures dry out the pile. If you have a nearby well or water line already, a polyethylene tank can be rigged with a float valve so that it stays "topped off" with water and ready for action. If one of your stock tanks stays wet year 'round, you can simply lay a suction line with a foot valve into the middle of the pond – hang it from an inflated inner tube if there's a chance the water level will drop significantly during the year – and run the suction line into a small, gasoline-powered water pump. A high-pressure nozzle, especially one with an adjustable spray pattern, will give you extra flexibility and improve your efficiency. All other things being equal, if you have a choice between pristine drinking-quality water and some sort of non-potable water, use the non-potable water, as long as your pump will handle it.

(d) Some people say that a long-stemmed thermometer is optional. We don't. Spend the money and get one. (More on that later.)

(e) Weaponry? You betcha. You saw what happens when you leave large, intact carcasses to their own devices. The point here is that there's usually no obvious need to leave the carcass intact, unless you suspect a zoonotic disease risk (that is, a disease that can be transmitted from livestock to humans or other animals) associated with it – in which case you need to contact your local health authorities for disposal advice instead of putting the carcass in the compost pile. But if the animal passed away in some routine way, opening up the carcass will (1) prevent the well-known Taiwanese Sperm Whale Syndrome (TSWS) and (2) increase contact between the carcass and the carbon-rich materials around it, speeding up the process. Weaponry suitable to prevent carcass explosions would include a 12-gauge shotgun, large shears or a hunting knife. If you want to go a step further, or if you need to limb the carcass for some reason, then a big hacksaw of some kind will also help.

Opening up the carcass is optional, of course. We have yet to observe any TSWS occurrences with beef cattle, dairy cattle or horses. Typically, we put the carcass in the pile long before it has a chance to ripen, and then the compost microbes perforate the carcass for us. If you do that, you will notice that the pile seems to have collapsed not too long after you assembled it. If you are there to witness the carcass "yielding," that's what we call a *bonus*.

## Building the Pile

The first thing to recognize when you're learning to build a compost pile for carcasses is that these animals are more than 50% water, much of which is contained in the gut and the blood stream. When the carcass "yields," then, there will be a flush of liquid that drains from the carcass shortly thereafter. You don't want that stuff percolating into the ground or running downhill into a creek or a stock tank or a wellhead. Two key principles for establishing a carcass pile are (a) good site selection and preparation and (b) dry, absorbent base material.

***Site Selection.*** You are more likely to get your neighbors riled up if you select a site that:

1. *Is right next to the road.* This goes without saying, perhaps, but messing with dead animals in an area that is highly visible to neighbors and passers-by is an excellent way to get complaints, even if nothing improper is going on.
2. *Is unvegetated.* Vegetated land interferes with environmental impact by soaking up and using the nutrients that are contained in liquids that may leach from the compost pile, converting them to plant matter and keeping them from draining into the water table or running off into the stream. Root systems help by maintaining soil porosity, which in turn reduces runoff.
3. *Features light, sandy soils with lots of permeability.* Soil permeability, a measure of how fast water can move through the soil under given conditions, is one of those soil conditions that is desirable in moderation but may cause problems in excess. Those of you with shallow ground water beneath the property may end up polluting your neighbor's ground water if you build a compost pile on highly permeable, sandy soil. In the first place, these soils do not have a lot of structural strength, which means that heavy machinery will easily disturb them. Second, they drain very quickly, reducing the opportunity time for plant roots to capture the nutrients and other dissolved solids contained in pile "leachate" before it reaches the shallow water table. Clayey soils, caliche, crushed "bottom ash" (a cement-like residue from coal-fired power plants) or other less-permeable material can be used to pave the site or can be mixed into the soil and compacted in place to reduce seepage into the ground water.
4. *Is sheltered from the wind.* All other things being equal, higher wind speeds cause odors to disperse more readily. When winds are light, odor intensity persists further downwind than when stronger winds mix odors into the upper air via turbulence. Choosing a sheltered site in a valley frequently decreases exposure to the higher wind speeds as compared to a site on a hilltop.
5. *Is right across the fence from their water troughs, stock tanks, stables, residences, guest houses or picnic areas.* This is just common sense. If you want to insult your neighbors and friends by polluting their air, water or soil, move your dead carcasses closer to their highest-value property features.

***Dry, absorbent base material.*** To ensure efficient composting, the main bulk of the compost pile will need to be maintained at an optimum moisture content of between 45 and 60% by mass (wet basis), but precipitation and/or a collapsing carcass may yield a flush of moisture that saturates the pile locally and then drains by gravity through the base of the pile. Capturing that "leachate" before it reaches the soil or pavement surface is the job of a dry, absorbent base layer. This layer should be thick enough and strong enough to support the full weight of the carcass without being significantly compacted; the heavier the carcass, the thicker the base layer should be. This layer will need to be a minimum of 18" thick. It should also be dry, absorbent and carbon-rich. Examples of excellent base materials include ground hay or straw, gin trash, finished compost, nut hulls or sawdust – excellent, that is, if you're not interested in creating an environmental mess. If you are, though, just omit this base layer; it's as simple as that.

After laying down a base layer to capture leachate before it escapes, we then prepare to surround the carcass with the optimum composting mix. Step 2 should be adding a 12-inch layer of moistened, well mixed, co-composting materials. This is the stuff that should be at its optimum moisture content (45-60%) and carbon:nitrogen ratio (25-45) with a well-graded distribution of pore sizes. With highly carbonaceous materials like wood shavings or sawdust, mixing in some manure or spare nitrogen fertilizer will accelerate composting. The better approach is to have this material mixed up, moistened and already composting in a pile off to the side somewhere close by – then bite into that pile with a loader, spread a bucketful atop the dry base layer, and away we go. The pile is now ready for the carcass.

Inviting varmints like buzzards, rodents, raccoons and badgers to drag indescribable pieces of the carcass over to your neighbor's front porch – what fun! – is simply a matter of refusing to surround the carcass on all sides with at least a foot of co-composting material. Having a hoof, a tail or an ear sticking out of the pile is a great signal to predators in its own right, but a more subtle approach is to minimize the depth of cover material on all sides, whether flesh is showing through or not. (Once a predator has discovered the presence of an animal carcass, he will return again and again to the same site in eager expectation no matter how well you cover the carcass after he discovers it. At that point, predator-control options are limited to traps, fences or a stakeout.) A 12-inch layer of co-composting material around all sides of the carcass will ensure thorough, uniform heating of the carcass, reduce odorous emissions and discourage predator access.

To reduce odors and predator access further, some composting specialists recommend covering the entire pile with dry co-composting materials similar to that which was used as the absorptive first layer. Although this approach has its merits, at some point it becomes a matter of balancing economics and the Law of Diminishing Returns. This approach still may not reduce odorous emissions and predator signals to zero, and although it will improve pile insulation and heat retention, it will reduce oxygen transfer and increase the overall requirement for compost feedstocks. Merely covering a poorly constructed pile with additional dry feedstock will obscure a problem rather than solving it; what you can't see *can* hurt you and your neighbors.

### Nature Can Help You Blow It

Rain, snow and cold are all potential allies in messing up a carcass-composting enterprise. Those of you in the East and South, where rainfall is normally plentiful, will have a relatively easy time getting your piles to go anaerobic and generate the nastier odorants unless you design your piles and structures to shed rainfall rapidly. Conversely, folks in the semi-arid regions of the state will find it more likely that the pile will dry out and go dormant if the pile is left to the whims of nature.

Shedding excess rainfall is a matter of either putting a roof over the pile or building the pile with a steep, pointed crown and sloping sides. Construction plans for covered compost bins are beyond the scope of this article, but you can still get them from the MidWest Plan Service (MWPS; see www.mwpshq.org) or the Natural Resource, Agriculture and Engineering Service (NRAES; see www.nraes.org). A pile with a triangular cross section will shed water more efficiently and will increase the rate of loss of heat and water vapor as compared to a pile with a rectangular, trapezoidal or semi-circular cross section. Capturing scarce rainfall or snow, by contrast, is usually accomplished by building the pile such that its top is flat to concave, a geometry that also retains more heat and dries out more slowly. Where rainfall is scarce, efficient composting will require a ready source of supplemental water as the piles dry out over time.

It is possible to compost carcasses successfully even in the northern latitudes. An active compost pile will melt snow accumulations provided that it is sufficiently large to insulate itself and retain heat in the core of the pile. The larger the pile, however, the greater the threat of spontaneous combustion as biological self-heating gives way to chemical oxidation, which does not require microbes. Allowing a hot pile to dry out is a reliable way of increasing the risk of fire by spontaneous combustion, but those fires can be prevented by careful management using a long-stemmed thermometer and a rule of thumb concerning compost moisture.

### Animal House™

Like frat boys, compost piles need attentive supervision, or else they are liable to create havoc. The most important diagnostic tool in the composter's tool chest is a long-stemmed thermometer. An alternative for the techie and the computer geek is an electronic thermometer than can be buried in the compost pile and can be read without disturbing it. Long-stemmed thermometers provide the flexibility of using the same device to measure temperatures in several different locations to evaluate temperature uniformity in the pile. Although we are not in the business of recommending individual brands or manufacturers over other suitable thermometers, a reference model that has given us good service is the Reotemp 48" Heavy-Duty Windrow Thermometer (www.reotemp.com). Other manufacturers marketing good quality probes include Geneq (www.geneq.com), Omega (www.omega.com), PTC Instruments (www.ptc1.com) and Tel-Tru (www.teltru.com). Select a probe length that will reach at least all the way to the center of your pile, and be sure to read the instructions carefully for techniques to insert the probe without bending or breaking the stem. Typical retail prices for a 48" probe are in the $150 range (2004 dollars).

We have also found some success with automatic, electronic devices that can be buried in the pile and that collect temperature data continuously for weeks or months. Of course, the downside of this approach is that once you install them in the pile you cannot move them without disturbing the pile, but even so, if you install enough of them at different locations in the pile you can get a sense of the temperature uniformity. With a little creativity and a soldering iron you can also improvise an electronic cable that allows you to download the temperature data from these units using a laptop computer without removing them from the pile. To date, we have placed HOBO dataloggers (Model H8, Onset, Inc.; www.onsetcomp.com) inside custom-made vessels of PVC pipe, attaching a steel wire tether to the housing and tying the free end of the tether to a fencepost next to the pile. The navy-blue and fuschia temperature traces in Figure 1 actually represent the averages of the measurements from several HOBO units installed around and within the carcasses during pile assembly. Clearly, unless you improvise a serial cable to each one, data from the HOBO units cannot be used for real-time diagnostics; the data will only be useful for after-the-fact analysis. So it might be better just to take the plunge on a long-stemmed thermometer anyway.

Now that you have temperature data, though, what do you do with it? If the temperature remains below 131 degrees Fahrenheit (131F), or 55 degrees Celsius (55C), more than three days after pile assembly, you've built a poor compost pile that may do a very good job of annoying the neighbors. Temperatures above 131F indicate that the core of the pile has reached conditions favoring our thermophilic aerobes, and odor nuisance is much less likely. A properly built pile should reach thermophilic conditions within 2 or 3 days and remain above that threshold for at least two weeks. But pay attention! If the temperature gets much above 150F (66C), the risk of spontaneous combustion increases dramatically, and the pile will need to be turned and moistened some.

To sum up, then, temperatures in the pile core need to remain between 131F and about 150F for a couple of weeks to ensure that the pile is composting properly. If the temperature does not reach 131F, it probably means that the pile is either too wet or too small, and/or its carbon source may be either too large-grained to insulate well or too small-grained to permit oxygen to enter the pile and keep the thermophilic microbes happy.

Moisture is the other major influence on composting efficiency that can be measured rather easily. The base layer should be very dry, but aside from that, the rest of the co-composting material covering the carcass should be between 45 and 60% moisture by weight. Checking compost moisture is a pretty simple matter. Grab a handful of the mixed material and squeeze it – if you're about to stuff a turkey or something, you may want to put on one of those thin, latex or nitrile gloves to do this – and look for droplets coming out of your fist. If they do, that sample of material is too wet. If not, then drop the material and look at the palm your hand or your glove, and if it does not have an obvious sheen of water on it, the sample was too dry. Material that is too wet may also smell rancid, sour or otherwise offensive; material that is too dry may not smell at all.

OK, now that your pile is cooking right along, leave it alone for a few months except to check the temperatures and moisture content. The larger the animal, the longer it will take for the soft tissue (muscles, viscera, ligaments, cartilage, fat) to be converted to humus. A 1,400-lb dairy cow or a 2,000-lb horse may need 6 months of active composting to clean off the bones; a 500-lb calf may need only 3-4 months. If the temperature gets too high, though, and the compost is drying out, turn the pile thoroughly and add water to get the moisture back up to near 60%. If any soft tissues are exposed in the process, you will need to add more of the carbon-rich feedstock to meet the 12" cover requirement again. Phase I, the active composting phase, ends when the soft tissues are degraded and the bones are clean, and it's time to turn the pile and add water again. Even though the carcass itself is history, the compost ought to heat up again and continue where it left off during Phase II.

This secondary phase is the time during which the microbes finish off most of the available carbon and nitrogen and convert it into *microbial biomass*. At this point, except for the presence of a skull, a pelvis, a couple of femurs and some other large bones, the compost pile is just like any other compost pile. Let the Phase II pile sit for a couple more months until the temperature drops to within 10 degrees or so of the air temperature. At this point, it is ready to be turned one more time and allowed to "cure," which means that the remaining, undegraded organic compounds – for example, foul-smelling plant-killers like acetic acid – may still need some time to degrade all the way to carbon dioxide and water vapor. This curing phase isn't really composting any more, but it does help ensure that the compost can be safely applied to pastures, gardens or cropland.

By the way, we don't necessarily recommend that you try to sell the finished product to someone else. It's one thing to market manure-based compost, but it is another thing entirely to market a material derived from dead animals. If your neighbors are interested in taking some of your compost, make sure you are clear with them about what the "ingredients" were. In general, it's probably wiser to use the stuff on your own property.

## Wrapping it Up

Contrary to popular belief, *failure is an option* when we're talking about composting large animal carcasses. A sure-fire strategy: Scrape off a piece of bare, sandy ground, pile up the carcass with whatever nasty waste materials you have on hand, wet it all down until it's soaked, leave body parts exposed to the elements (and to public view), and walk away from it for months without paying it any more attention. If you have questions, write them down, and promptly forget about them. Presto!

If, however, you want to get along with your neighbors and protect the air, water and soil resources around you from environmental insult, it's going to take a little more thought, planning and effort than that. Composting large carcasses successfully is not difficult, but neither is it automatic. Your land-grant universities undoubtedly have someone you can call for region-specific advice that will be relevant to your particular circumstances. If not, feel free to call on any of us:

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