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# Alternative Methods for the Disposal of Swine Carcasses

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## Introduction

There is probably no one "best way" to dispose of swine mortality carcasses. The optimum system for any particular farm location would need to be selected based on a number of criteria, including the current state of the protein/oil market, the biosecurity required, the distance to processing sites, the local public's perception, and the government regulations that apply to that location. Regardless of the method of choice, the public's concern for the environment and increasingly restrictive regulations governing the disposal of dead pigs will continue to present new challenges for the swine industry. The tonnage of dead pigs produced annually is substantial. A typical 5000 sow farrow-to-finish farming system (with mortality losses of 7%, 10%, 5%, 1%, and 1% in the sow, neonatal, nursery, growing, and finishing herd, respectively) will produce over 200,000 pounds of dead pigs annually. In many farming systems in the USA, actual losses may be much higher. The integration of swine agriculture has concentrated these mortality losses into smaller and smaller geographic areas. A company in North Carolina responsible for handling most pig and poultry mortality carcasses in eastern North Carolina processes over 170 tons of mortality wastes per day. The disposal problem created in catastrophic situations, such as the hurricanes to hit North Carolina or a foreign animal disease outbreak such as foot-and- mouth disease, creates special problems and requires additional resources.

In the past, mortalities have typically been buried, incinerated, or rendered into fats and animal protein by-products for feed manufacturing. Now, each of these options is less acceptable or unavailable because of restrictive regulations or excessive costs. Buried animals have the potential to contaminate ground water and incinerator smoke can contribute to air pollution. In the USA, many rendering plants were closed when faced with heightened environmental regulations imposed by the Environmental Protection Agency (EPA), eliminating this disposal option for many hog operations. The industry's challenge is to find inexpensive, biologically safe, and environmentally friendly alternatives for the disposal of dead pigs.

## On-Farm Procedures

The means of carcass disposal is dependent upon the economic size and networking of commercial pig farms, their geographical location and land-base, and available infrastructure and utility service. In North Carolina, most swine mortality carcasses from company-owned or large contract farms are delivered to a rendering plant, whereas smaller operations dispose of carcasses on the farm. On-farm disposal techniques include trench burial, disposal pit, burning, and composting. The major advantage of an on-farm system is biosecurity. Outside mortality collection trucks are not required to visit the farm, nor do farm trucks have to risk contamination when delivering mortality carcasses to a rendering plant or central collection site.

## Trench Burial

Trench burial is used extensively because it is an inexpensive and efficient method of mortality disposal. Producers typically dig a trench with a backhoe to the width of the bucket and length dependent on the capacity required. After burial, the pigs slowly decompose until they are unrecognizable after a few years. The major disadvantage of burial is the possibility of contaminating groundwater, particularly in areas with sandy soils and a high water table. In colder areas it is difficult, if not impossible, to dig trenches when the ground is frozen. Also, predators can uncover carcasses if they are not buried deep enough, which is unsightly and increases the risk for the spread of diseases.

To our knowledge, every pig-producing region allows burial of dead pigs, although this is likely to change in the future for a few states in the USA. Because burial is such a basic technique for disposal of swine mortality carcasses, there is no research documenting its advantages or disadvantages, including whether or not it contributes to groundwater pollution. The burial requirements for various states' in the USA are reviewed in National Hog Farmer (Hermel, 1992).

## Disposal Pit

Disposal pits are most frequently used in poultry, but in the swine industry they have some advantages over other burial techniques, especially for the disposal of afterbirth and dead nursery pigs. Disposal pits are easily built with solid walls and top but permeable base so carcasses can be added continually (Wineland, 1990). Provided the pit is built to exclude the entry of rainwater, little water will leak from the base because the decomposition process produces little water. For a review of the construction and operation of on-site disposal pits for poultry read Sweeten and Thornberry (1984).

The digestion process in a disposal pit depends on the successive interaction of a variety of organisms (La Riviere, 1977). Although there is some aerobic activity at the top of the pile the carcasses mostly undergo anaerobic digestion. Microorganisms anaerobically digest the carcass into substrates for bacteria that produce methane, carbon dioxide, and many other compounds, some of which are malodorous. Anaerobic digestion can generate hydrogen sulphide in concentrations that can exceed human safety levels (Malone 1988). Decomposition rate of mortality is enhanced by a variety of insects that consume flesh and burrow through the surface of the skin to increase exposure to microorganisms (Rives et al., 1992). Temperature, pH, and oxygen also affect the composting process. If the environment favors the growth of acid-forming bacteria, then a decomposition-inhibiting fermentation can occur. This acid fermentation can be prevented by periodic application of hydrated lime. Lomax and Malone (1988) showed that decomposition of poultry mortality was faster at 350C than at 240C, allowing for higher loading rates. A major advantage of disposal pits is that producers are able to dispose of their mortalities on the farm rather than have someone collect them and thus create a biosecurity risk.

## Incineration

Among all the methods of mortality disposal, incineration generates the most public complaints in the USA and therefore is the least likely to remain an option (Murphy and Handwerker 1988). Incineration eliminates all pathogens but high operational costs and incineration's potential to contribute to air pollution (if not properly maintained and operated) decreases its usefulness for widespread use as a mortality carcass disposal option. Incinerators can be made from old low pressure (LP) gas tanks for less than $1000 (but last only about 5 years) or purchased fully insulated with afterburners to reduce emissions for less than $2000. Operational costs include grates that must be replaced every 2-3 years and the oil or gas fuel. A160-sow farrow-to-finish demonstration farm at Rocky Mount, NC averaged 844 gallons of fuel oil/year for the eight years ending 1990. If fuel oil costs $1/gallon, that alone is $5.27 per sow inventory per year. All major hog producing states in the USA allow for the incineration of hogs but specifically do not permit pigs to be burnt in the field. In the State of Missouri, farm incinerators must be inspected and permitted annually just as are industrial incinerators. The cost (about $2000 per year) to maintain an incineration permit is passed onto the farmer. The costs associated with this regulation are resulting in a rapid phase-out of farm incinerators in that state.

**Composting**

Many poultry producers are choosing composting as their disposal method of choice, but some find the labor costs prohibitive. Composting uses organic by-products such as dead pigs, straw, or sawdust and converts them into an odorless, inoffensive, generally pathogen-free product that can be used as a soil amendment or organic fertilizer. Composting pigs is very similar to composting garden waste. A succession of mesophilic and thermophilic microorganisms, including bacteria, fungi, and actinomycetes, feed on the organic substrates to produce carbon dioxide, water, minerals, and a stabilized organic matter called humus. The speed and efficiency of this aerobic process depends on the temperature, nutrients, moisture, availability of oxygen, and particle size.

**Temperature**

Some decomposition occurs at any temperature because of the diversity of temperature-sensitive organisms in a compost pile. However, the optimum temperature for microbial activity is less than 550°C (McKinley 1985). The temperature can be controlled by adjusting aeration and moisture and covering the pile with an insulating layer of the carbon source (e.g., straw or sawdust) each time pigs are added. In Missouri, decomposition of pig carcasses slowed considerably in winter but increased in the spring when temperatures rose. In North Carolina, our research compost piles containing swine mortality carcasses have consistently reached temperatures over 550°C, killing most of the Salmonella, and all of the Erysipelas, in broth cultures placed throughout the pile. Poultry compost piles routinely attain 700°C.

**Nutrients**

The microorganisms that decompose the pigs and produce the humus need appropriate nutrients to work effectively. The most important are carbon and nitrogen. Common carbon sources include sawdust, shavings, cotton gin trash, wheat straw and others. The primary nitrogen source when composting swine mortality carcasses is the carcasses themselves. A carbon/nitrogen ratio between 20:1 and 35:1 is optimal. Above that range, decomposition slows. Below 15:1, nitrogen is lost as ammonia, which reduces the value of the humus and creates an odor problem. Getting this ratio right is a major factor in successful composting. Phosphorous, sulfur, calcium, and trace quantities of other nutrients are also required for optimal cell growth during the composting process but are usually in adequate amounts in the carcasses and carbon source.

**Moisture**

The optimum moisture level is 45-55%. Since water is essential for nutrient solubility and cellular protoplasm, moisture content below 20% can severely inhibit the composting process. However, too much water will block air movement, causing the pile to become anaerobic, thus slowing the composting process and increasing the emission of odors associated with the process.

**Oxygen**

Decomposition occurs fastest in fully aerobic conditions. However, aerobic conditions probably exist only at the periphery of the 6X4X5 ft compost piles commonly constructed. Therefore, composting operators must mechanically aerate their piles by periodically turning the pile, inserting perforated tubes, dropping the piles from floor-to-floor or pumping air through them. Conversely, too much aeration can dehydrate the pile, waste heat, and fail to attain the temperature to operate successfully or to kill the pathogens. In practice, the piles are turned 2-3 days after temperatures peak. Turning aerates the piles and restarts the decomposition process.

**Particle Size**

The smaller the particle sizes of the compost the greater the surface area available on which microorganisms can work. However, some of the ingredients must be large enough to provide structural support and to trap the oxygen necessary for aerobic digestion. In practice, pig carcasses need not be cut open and the straw that we have used provides carbon, structural support and the aeration necessary. Murphy (1992) reported that by cutting into the thorax, abdomen, and muscles it is possible to compost pigs weighing up to 300 pounds. We have had similar success when we dismembered and cut into the thorax and abdomen of large sow carcasses.

**As Feed for Animals**

The opportunity to render dead animals into protein by-product meals and feed them to pigs in Europe is fast disappearing because of concerns with diseases, such as bovine spongieform encephalopathy (BSE). Minnesota specifically allows feeding carcasses to mink because of the large mink industry in the state. However, the hazard of feeding dead pigs to animals is well known by any farmer who has lost dogs and cats by allowing them access to pigs that died of Aujeszky's disease (pseudorabies). Regardless, the opportunities still exist for feeding unprocessed carcasses to animals. One 2000 sow hog farmer in Pasco county Florida has profitably feed processed dead hogs and poultry to alligators that are slaughtered for their meat and hides (Walker and others, 1992). A pig farm in Singapore fed all its dead pigs to crocodiles whose hides were sold to the local leather industry.

**Off-Farm Procedures**

Landfill and rendering are the two main opportunities for off-farm carcass disposal.

**Landifll**

Landfill opportunities are rapidly decreasing as municipal authorities refuse to accept carcasses. With landfill tipping fees of $10-50 per ton, costs are becoming prohibitive in areas that still allow this practice. Landfills are most often used when death losses exceed everyday disposal capacity or under disaster situations.

**Traditional Rendering**

For producers with access to a protein recovery plant, rendering has been, and will continue to be the best means for converting swine carcasses into a nutritionally valuable and biologically safe protein by-product meal. Unfortunately, the number of rendering facilities operating in the USA is decreasing, especially among small local plants that accept mortality carcasses. Many rendering plants have closed because of more stringent EPA regulatory action and/or because of the depressed world prices for fat, protein, and hides. As a consequence, the remaining plants are further apart making it cost-prohibitive to transport carcasses to these locations for disposal. To accommodate this transportation limitation, some areas have designated sites for the central pickup of carcasses. However, strict rules must be enforced to assure biosecurity when these central sites are used by many different producers (Parsons and Ferket, 1990). Other areas use technologies (freezing, fermentation, or acid preservation) that enable carcasses to be stored on-farm until enough accumulate to make a trip to the renderer more feasible.

Recently, a large poultry integrator has developed a purpose built freezer for holding dead broilers. They use it extensively for preserving carcasses before taking them to a renderer. Each freezer holds about one ton of dead broilers. The electricity costs at about $1.20 per day or $0.01 per pound of dead bird assuming $0.08 per kilowatt hour. These units are generally available for about $2000. Freezing may also become the storage method of choice for the preservation of small swine mortality carcasses.

Fermentation provides a system that can store carcasses for at least 25 weeks and produces a silage end product that is pathogen free and nutrient rich (Parsons and Ferket, 1990; Murphy and Silbert, 1992). Fermentation is an anaerobic process that can proceed in any size non-corrosive container provided it is sealed and vented for carbon dioxide (Parsons and Ferket, 1990); 55 gallon drums are commonly used. Daily, carcasses are ground to 1" or smaller particles, mixed with a fermentable carbohydrate (CHO) source and culture innoculant and then added to the fermentation container. The grinding aids in homogenizing the ingredients. For lactic acid fermentation, lactose, glucose, sucrose, whey, whey permeate, and molasses are all suitable as a CHO source. Under optimal conditions the pH of fresh carcasses is reduced from 6.5 to less than 4.5 within 48 hours. Properly prepared silage will remain biologically stable for months and is readily accepted for rendering. Fermented poultry offal, fed at up to 20% of growing-finishing pigs' ration, does not depress gains or increase feed-to-gain ratios (Tibbetts and others, 1987). But, no one has documented feeding hogs the silage from fermented whole birds or pigs and the practical application of feeding fermented mortalities is limited. The USDA Federal Swine Health Protection Act, which regulates garbage feeding, prohibits the feeding to swine of any mortality products that have not been either rendered, boiled for 30 minutes with agitation, or extruded at 284oC. Other potential uses for fermented carcasses are in mink or fox feed, extruded aquaculture feeds, and ruminant silage. Sanders (1990) reviewed the topic.

Fermentation with Lactobacillus acidophilus destroys many bacteria including Salmonella enterica ssp (Kahn 1969), Salmonella enterica Typhimurium (Slywester, 1968), and Clostridium botulin type E (Wirahadikusumah, 1968). Viruses labile to low pH do not survive fermentation and inactivation occurs rapidly at 400C, but more slowly at lower temperatures (Gilbert, 1983). Most importantly, in fermented silage, Aujeszky's disease virus (ADV) is rapidly inactivated at 200C to 300C but survives two days at 100C and nine days at 50C (Gilbert, 1983). The optimum temperature for fermentation is about 350C but silage temperature approximates ambient temperatures, indicating that ADV may not be inactivated in colder regions.

Ground mortality carcasses can also be preserved by the addition of inorganic acids. A 3.4% sulfuric acid solution added to ground, split, or punctured dead broilers preserves them for at least one month at a cost of $0.10 per pound of carcass (Malone 1988). When this acid-preserved product is rendered it has the same nutritive value as regular poultry-byproduct meal. In the past, sulfuric acid was used, and it worked well, but the inherent danger of handling the stock solution is a primary concern. Recent work at NC State University has demonstrated that phosphoric acid is a more practical acid for nutrient preservation and increases the nutritional value of the by-product meal by providing phosphorous and making the proteins more stable to microbial degradation. Middleton and Ferket (2001) reported that the inclusion of about 8% (w/w) phosphoric acid with ground poultry mortality carcasses eliminated coliforms and other spoilage bacteria, and prevented protein degradation as indicated by a rise in volatile nitrogen and silage pH over 6 weeks of storage. Only 5% phosphoric acid was needed to maintain the nutritional quality of silage for two weeks of storage. Addition of 500 ppm ethoxyquin to the phosphoric acid-preserved poultry silage was also found to significantly preserve lipid quality (Middleton et al., 2001). Phosphoric acid preservation of ground mortality carcasses with the antioxidant ethoxyquin resulted in superior protein and lipid quality in comparison to preservation by either lactic acid fermentation or freezing. Moreover, phosphoric acid preservation is technically more reliable than lactic acid fermentation, especially when the carcass grinding and acid application process is automated (Ferket et al., 1998).

### Non-Traditional Rendering

Instead of using conventional rendering procedures, ground mortality can be converted into a feedstuff by fluidized-bed drying, flash dehydration, or extrusion. These technologies studied at North Carolina State University's Animal and Poultry Waste Management Center may emerge as an economical and environmental alternative to conventional rendering of dead pigs.

In fluidized-bed drying or flash dehydration, the material flows along a channel of super-heated air. Flash dehydration can be used to dry many types of wet wastes, but it is most applicable for drying animal by-products and offals. Depending on the moisture and fat contents, ground swine mortality carcasses must be blended with an organic carrier to facilitate the flash dehydration process. The current equipment can evaporate 500 gal of water per hour, using approximately 1300 BTU's per pound of water evaporated. In drying dead pigs, higher efficiencies have been documented, perhaps because the equipment burns some of the more volatile fats in the pigs. The high temperatures and short dwell times of flash dehydration cause little damage to protein quality, resulting in superior protein digestibility. If sterilization of the product is required, the meal can be dehydrated to about 10% moisture and subjected to extrusion processing. The cost to dehydrate turkey mortalities to 20% moisture is about $27 per ton of final product and $40 per ton if followed by extrusion (Personal communication, Duncan Nesbitt, Ziwex Recycling Technology USA Inc. 1992). These costs assume $1.10/gal for fuel, 12 cents/kwh and 75 cents per ton maintenance.

Extrusion is not a new technique for the food industry. It has been used to process human foods for more than 50 years, producing 13 billion pounds of product with a market value of $8 billion annually. If extrusion is used to process carcasses it will most likely be done centrally because of capital costs. However, if it can also be used on site to extrude full-fat soybeans and creep feed, individual farmers may be able to justify the cost.

Finely ground high-moisture material is mixed with an organic carrier to a moisture content of about 30% and then subjected to processing by friction heat, shear, and pressure within the dry extruder barrel. In the extruder barrel, a screw (or screws) forces the material through a series of flanged steam locks where temperatures of 115-1550C and pressures of 20-40 atmospheres develop within 30 seconds. The sudden decrease in pressure as the product leaves the extruder causes it to expand and lose 12-15% of its moisture. The food industry mostly uses single screw dry extruders because they are about 50% less expensive, in terms of capital and operating expense (Hauck 1990). However, double-screw systems can better cope with the high moisture ingredients and therefore may be more appropriate for dead pig disposal. Bacteria, molds, and viruses are readily inactivated by extrusion (Reynolds, 1990).

### Summary

The age of the environment started in the 1980's and will continue into the 21st century and beyond. The swine industry has adopted, and will continue to adopt, those technologies that enable it to meet increasingly rigid environmental standards, particularly those that it can use to increase the value of its waste products. For farms that do not have ready access to rendering facilities, composting has been shown to be an effective method of disposal for swine mortality carcasses, particularly in the warmer, southern areas of the U.S. The cold northern winters may restrict outdoor composting, but it may be economical to provide composting space inside the hog units. Of all the techniques available to extend on-farm storage of carcasses, fermentation or acid preservation are the most attractive. Although it is not always possible, we need to adjust our thinking about dead pig disposal and consider how we can turn mortalities into a profit center. Recycling our mortality wastes will save the industry money, reduce the environmental impact of carcass disposal, and enhance the reputation of the swine industry.

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