Economic Costs of Open Static Pile and In-Vessel Systems for Routine Mortality Management on Swine Farms

Dale W. Rozeboom, Professor \ Extension Specialist
Department of Animal Science
Michigan State University
474 S. Shaw Lane, 2209 Anthony Hall
East Lansing, Michigan 48824-1225
rozeboom@msu.edu

Gerald A. May, Extension Educator
Gratiot County MSU Extension
214 E. Center Street
Ithaca, MI 48847
mayg@anr.msu.edu

Darrin M. Karcher, Poultry Extension Specialist
Department of Animal Science
Michigan State University
474 S. Shaw Lane, 1287 Anthony Hall
East Lansing, MI 48824-1225
dkarcher@msu.edu

Abstract. *In the U.S. the use of composting to manage on-farm swine mortality has increased from 10.5 to 35.9% from 1994 to 2006 (USDA:APHIS, VS, CEAH 2001 and 2007). Traditionally, the most popular method of composting has been the open static pile (OSP) in bins, piles, or windrows, with management of primary, secondary and curing stages. In recent years, in-vessel (IV) systems have been used increasingly; of which the most popular are rotating drums. The objective for this work was to estimate the economic costs of the OSP and IV animal tissue composting systems and compare them to the costs of other methods of managing routine mortality. The economic costs of OSP and IV mortality composting systems were evaluated using a case study approach involving two Michigan farrow-to-wean operations of 3300 and 2500 sows, respectively. At the time of this writing both operations are in full production. The OSP system used on the one farm consists of six 3.66 x 6.71 x 1.83 m, three-sided bins with concrete floor. The IV system used on the other farm is a horizontal rotating drum system (1.22 m in diameter and 12.8 m long). There was no roof over the bins. Using the $ per unit of weight of mortality estimates derived and stipulating that the composting system would be sized appropriately, sited efficiently, and operated at maximum capacity, a 2000-head finishing operation would generate about 9435 kg of mortality annually and have annual costs of $1,012 or $1,416 if an OSP or IV system was used, respectively.*

Keywords. Mortality, composting, in-vessel, open static pile, energy consumption and economic costs.

Introduction

Unfortunately, mortality is a reality of any livestock operation. Some 2 to 10% of all animals hatched or born on the farm, or brought onto the farm to be grown-out, do not leave the farm destined for market to become a food product. Proper mortality management is critical for sustainable animal production. State laws and regulations stipulate legal means of mortality management and in recent years more options for routine on-farm mortality management have become available including: burial, incineration, rendering, landfill, composting, and anaerobic digestion. Furthermore, within composting, producers must determine which composting system is most suitable for their enterprise. Traditionally, open static pile (OSP) composting has been done in bins. In-vessel (IV) composting of mortality has become available more recently and offers benefits not realized with OSP composting. Cost comparisons for various mortality management systems, including OPS and IV composting, help animal owners make informed decisions about what management approach would best fit their operation.

Materials and Methods

The economic costs of OSP and IV mortality composting systems were evaluated using a case study approach involving two Michigan farrow-to-wean operations of 3300 and 2500 sows, respectively. Information was gathered directly from the two farms currently utilizing the different composting systems.

The OSP system used on the first farm consists of six 3.66 x 6.71 x 1.83 m, three-sided bins with concrete floor and a 7.62 x 22.86 m concrete apron in front of the bins. There was no roof over the bins. Bulking agent is stored in one of the bins. Compost batches are initially established in 2 bins over a 30-day period. Employees separate carcasses of young and adult pigs in to different compost batches when at all possible. Bins with small pig carcasses are turned twice, at 30 days, and again at 60 to 90 day of composting. Bins or batches with adult pigs are turned three times, 30, 60 and at 90 to 120 days of composting. With the last turn, the material is moved to a temporary in-field stack; to be spread on the fields at a future date. Bones are collected and recycled at all turns and composted further, until brittle. Since the composting facility is not covered and subject to precipitation, runoff is collected and directed to earthen manure storage.

The IV system used on the second farm is a horizontal rotating drum system, being 1.22 m in diameter and 12.8 m long. It is located about 30 m from the animal buildings. It is operated continuous flow with mortality loaded and compost material discharged from the unit on a daily basis. Clean dried-wood shavings are added in proportion to the amount of mortality added (0.0044 m^3 of shavings per kg of mortality). However, most of the time, finished compost is also used, and then the ratio is 0.00094 m^3 of shavings and 0.0034 m^3 finished compost per kg of mortality (about 1 bag of new shavings, which is 0.252 m^3 or 0.33 yd^3, per 272 kg or 600 lb sow carcass). The stainless steel insulated (R8) drum has openings for aeration. To obtain optimal aeration during operation, filling to more than 75% of capacity is avoided. The number of daily rotations varies by season, more in summer and less in winter (average about 10 per day annually). Consequently, retention time also varies, about 7 days in summer and 14 days in winter. Likewise, electrical use would be twice as much in summer. If too much moisture has been added or not enough shavings, then moisture can leak out of the unit. The number of revolutions and amount of added moisture are adjusted by the operator and is based on the temperature of the product within the drum and the appearance of the compost being discharged. Material reaches the discharge end in less than a week. Compost material is screened when exiting the IV unit to separate bones from fine, carbonaceous material. The bones are reintroduced into the IV unit for further composting. The remainder of the compost is stacked in the open-sided pole building with mono-slope roof. It stays there for about 5 to 6 months, where it is turned inconsistently, before being spread on cropland as a soil amendment. If mortality rate is greater than “normal” and IV unit capacity is exceeded for a short period, the farm places extra mortalities into a short-term OSP. When mortality rate decreases once again and within the IV unit’s normal loading recommendations, the farm puts compost material from the short-term OSP into the IV unit.

Fixed costs include depreciation, interest (5%) on the remaining (un-depreciated) value, insurance (0.005% of replacement value of equipment - IV unit and tractor, and 0.01% of the OSP and IV unit physical structures), repairs (0.01% of purchase price), and taxes (average 23 mills). For our estimations, both systems were given an estimated useful life of 15 years. To provide a legitimate comparison to the estimate of Henry et al. (2010) a similar definition of fixed costs was used. These authors stated that fixed costs included: depreciation, interest on the un-depreciated balance of the item, repairs, property taxes, and insurance.

Operating costs include: tractor loader fuel, electric (IV system only), custom tractor and manure spreader, labor and bulking agent.

The tractor loader is used for the removal of mortality from the production facility, the loading of bins and the IV unit, the movement of compost material from bin to bin for aeration, and from IV unit discharge to piles for further composting, the movement of recycled compost to new batches of compost, and for loading the manure spreader when moving compost to fields. Fuel used by the tractor loader differs only because of hours this equipment is used on the two farms; 182.5 verses 273 for the IV and OSP systems, respectively. For this estimate, an 80 hp tractor at 65% maximum power 50% of the time and idle speed the remainder, will use 10.6 L per hr. Fuel was priced delivered to farm (a.k.a. off-road) at $0.898 per liter ($3.40 per gallon) on April 24, 2012.

No electricity was used in the OSP system. Electricity cost for operating the IV unit was estimated using a run time of 20 minutes per revolution and 10 revolutions per day. This is the summer operation plan, with fewer rotations completed in the winter in order to retain more heat in the compost. A 1 hp motor drives the movement of the drum. An electrical use of 1216 kwh was estimate using the default 82% efficiency rating (Productive Energy Solutions, 2012). Electricity was priced at $0.11/kwh.

The labor cost per hr is $15.75 and includes the employer’s portion of SS, Medicare, health insurance, and other monetary benefits. The amount of labor used per year was 273 and 182 hr, for OSP and IV farms, respectively.

On a per unit of mortality or finished compost weight or volume basis, the costs associated with the removal of mortality from the production facility and those for the use of a tractor and spreader for hauling finished compost to cropland, are assumed to be equal for all composting systems. Custom compost spreading (tractor and spreader) is $75/hr and 6.0 t spread per hour, using a weight reduction ratio of 0.83 (i.e. every 1.0 kg of mortality results in 0.83 kg of finished compost; Henry et al., 2010). Spreading compost on the field requires about 13.9 hr and 16.8 hr per year for the two farms and is directly a reflection of size of the operation and mortality rate.

The only other cost incurred by both farms was that of bulking agent. Turkey brooder bedding is used as the primary bulking agent (approximately 0.75 m^3 per day) in the OSP system. The cost of this material is estimated to be $2.68 per m^3. The farm does not buy new sawdust for mortality composting, but if it were to do so, the price of clean dried sawdust was priced at $8.50 m^3 (bulk) on April 24, 2012. The IV system uses approximately 1 bag of new shavings per day.

Price of amendment per bag is $3.50 per bag (0.252 m^3), with bags being used exclusively for in-vessel composting.

For the purpose of comparison, the costs of using other mortality management systems were determined using recently published extension materials and by interviewing two Michigan dead animal dealers and the management of two Michigan animal enterprises. This case-study information was gathered in 2011 and 2012 using hand-written or electronic correspondence, and phone interviews.

Results and Discussion

The cost comparison of these two systems and to the "low investment" OSP system of Henry et al. (2010) is shown in Table 1. Using a 15-yr life for both systems, the annual cost per lb of mortality is less for the OSP systems as compared to the IV system. Both Michigan case farms were operated less expensively (per unit of mortality) than the Nebraska system described by Henry et al. (2010). Energy cost was $0.003 less for the IV system. Energy use is greater with use of a tractor loader and diesel fuel.

Table 1. Budgeted annual costs for two different mortality composting systems (in-vessel and open static pile) and the low investment composting bin system as reported by Henry et al. (2010).

	In-vessel	**Open static pile**	**UNL-2010**
System description			
Mortality per year, kg	99,337	121,939	18,144
Composting system	IV unit, concrete pad, 7.32 x 7.92 m open-sided pole building with mono-slope roof, concrete floor, 1.83 m high concrete walls	6 bins, each is 3.66 x 6.71 x 1.83 m, concrete floor, no roof and 7.62 x 22.86 m concrete apron	bins, concrete floor and bin walls 1.83 m high, no roof, no apron (low investment)
Capital investment	$62,000	$21,150	$7,465
Machinery needed	Tractor loader	Tractor loader	Skid steer loader, tractor and manure spreader
Labor, hr per year	182.5	273	125.9
Bulking agent	92 m^3 @ $13.90/$m^3$	209 m^3 @ $4.58/$m^3$	61.2 m^3 @ $9.81/$m^3$
Annual costs			
Fixed costs			
Composting system	$6,706.00	$2,488.50	$1,020.22
Tractor loader	$1,152.05	$1,152.05	$622.57
Operating costs			
Fuel and (or) electricity	$1,866.47	$2,598.96	$415.05
Custom tractor and manure spreader	$1,030.62	$1,265.12	Included above; not separated out
Labor	$2,874.00	$4,300.00	$1,888.20
Other	$1,277.50	$1,277.50	$600.00
Total annual cost	$14,906.65	$13,082.13	$4,546.04
Cost/kg mortality	$0.1501	$0.1073	$0.4793
Energy cost/kg mortality	0.0188	$0.0213	Not estimated

Using the $ per kg of mortality estimates derived in the case study, and stipulating that the composting system is sized appropriately, sited efficiently, and operated at maximum capacity, a commonly operated 2000-head finishing operation would generate about 9435 kg of mortality annually and have annual costs of $1,012 or $1,416 if an OSP or IV system was used, respectively. This estimation was made assuming that 2.6 groups would be fed annually, mortality rate would average 2.5%, and the average dead animal weight would be 72.6 kg.

Costs on other farms may vary because of differences in mass of mortality (rate and weight), differences in composting system (composting facilities and equipment and siting relative to production units), and management (frequency of aeration and carbon sources utilized).

The cost of routine on-farm mortality management is an important consideration when choosing a plan to follow. The assessment of the costs associated with other routine on-farm mortality management systems follows, and is intended for comparison to the swine systems evaluated herein, and to help animal owners make informed decisions about what mortality management method may best fit their operation.

Anaerobic digestion. There are no farms in Michigan, or any other known in the U.S., who are using anaerobic digestion as their sole mortality management system. Thus, an annual cost or cost per unit of mortality is not available. Processing is recommended prior to introduction into the anaerobic digesters in order to reduce dead animal size. Particle size reduction to less than 2 inches in size improves heat transfer and exposes surface area for biological activity.

Burial. Estimating a cost of burial per unit of mortality is difficult as the factors to be considered (daily amount of mortality, availability of equipment, distance to the grave site, and season, and site selection) vary substantially. Often burial on the farm may just be one carcass on a daily or less frequent basis. An individual or a common grave may be used, and Michigan's Bodies of Dead Animals (BODA) Act 239 of 1982 (Michigan Department of Agriculture, Animal Industry Division, 2008) requires that carcasses must be buried within 24 hours of death and beneath two feet of soil in either type of grave. In Table 2 the costs of three different approaches to managing burial are shown for the commonly operated 2000-head finishing operation described above. The advantage of a common grave is less backhoe operation time to dig a large trench. From start to finish, it is assumed to take 0.5 hr to bury a carcass in an individual grave, 0.25 hr to bury a carcass in a common grave, and 1 hr to dig a common grave each month.

Table 2. Estimated costs of burial for 2000-head finishing operation using variations of custom hire and owned equipment.

Item	Custom backhoe, individual graves	Custom backhoe and owned loader, common grave	Owned backhoe with loader, common grave
Backhoe time, hr (0.5 hr per carcass)	65	12	44.5
Custom backhoe cost,$84.50/hr[a]	$5,492.50	$1,014.00	-
Tractor loader time, hr (0.25 hr per carcass)	-	32.5	-
Tractor loader annual operating cost[b] (purchased used at $25,500)	-	$461.29	-
Own backhoe annual operating cost[b] (purchased used at $15,000)	-	-	$1,240.64
Labor, $15.75/hr	-	$511.88	$700.88
Total annual cost	$5,492.50	$1987.17	$1,941.52
Cost/kg mortality	$0.5821	$0.2106	$0.2058

[a] Iowa State University Custom Rate Bulletin (2012)

[b] Includes 15-yr depreciation, interest (5% of value and 25% allocated to burial), insurance (premium - 0.01% of replacement value), repairs (0.01% of purchase price), taxes (avg. 23 mills), and fuel (10.6 L per hour at $0.898/L at the farm on April 25, 2012).

Dead animal dealers. This service is provided in parts of Michigan depending on volume and consistency of mortality. Dealers are paid for the cost of their service (including transportation and disposal in either rendering or landfill). The typical minimum charge was $50 to $100. Size of animal was described as a price consideration. For example the following additional specific pick-up price per carcass was noted: horse = $80 to $90; cow = $60 to $70; hog = $15 to $25; and calf = $10 to $20.

Incineration. For a farm with 18,144 kg of mortality per year the University of Nebraska (Henry et al., 2010) has provided guidance in estimating the cost of mortality management using incineration to be $0.3385 per kg or $6,144 total annually. Specific costs were: new incinerator cost of $7,626; 10 minutes of labor per day; and $3857 of diesel fuel used each year ($0.898 per liter at the farm on April 25, 2012).

Landfill. Depending on local and the willingness of the landfill company to accept animal carcasses, the “land filling” of mortality is an option for some animal producers. This would be a direct arrangement with a garbage hauler and the landfill, and not involve a dead animal dealer. In order to follow the 24-hour rule, as written in Michigan’s BODA, on-farm storage is required using a freezer, refrigerator, or temporary composting dumpster or rolloff. Most farms use a tightly sealed dumpster to temporarily compost the mortality for 2 to 4 days prior to pickup by the garbage hauler. Carcasses are covered with a bulking agent as they are added to the dumpster. Typically the temporary composting dumpster is picked-up twice a week during the summer and once a week during the months of November through March as the colder temperatures limit decomposition and the emanation of odors from the dumpster. The cost per pick-up ranges from $60 to $100 depending on the volume or dumpster size.

For a turkey farm with about 1.1 million total birds and rearing to an average of 19 kg, an annual cost of $26,000 was provided in response to our survey, and included the bulking agent, pickup and tipping fees. This equates to about $0.0251 per kg of turkey mortality in this farm system. For a 3,200 head grow-finishing hog farm, the cost of this mortality management system was approximately $3,250 annually, or about $0.2418 per kg of mortality experienced; again this reported cost included the bulking agent, pickup and tipping fees.

Producers pay the monthly hauling and landfill fees regardless if mortality is delivered or not. Utilizing a local garbage hauler results in a smaller tipping fee at the landfill since they can coordinate the hauling of full truck loads and since the temporary composting dumpsters are received as normal garbage and not sorted-out specifically as mortality. This system is very convenient and minimal operating costs. There are no capital investments. Alternatively, the farmer may choose to deliver mortality directly to some land fills and be charged a mortality fee. Direct farmer delivery rates vary and are typically greater than standard tipping rates used for garbage haulers and a system involving temporarily composted material. For direct delivery, the farmer would need to own a truck and appropriate containers for the “enclosed” hauling of carcasses. In this system and all others, it is important to have strict biosecurity practices in place to prevent movement of disease back to the farm. The cost of doing so is assumed to be part of the labor contribution to operating expenses.

Implications

The costs of open-static pile composting in bins and composting in-vessel have been compared and the in-vessel system found to be 28.5% more expensive on a unit of mortality basis. The costs of composting in open static piles formed in windrows or overlapping piles on a surfaced pad were not considered in this study. Both of these approaches would likely require less facility cost and be less expensive. Incineration, removal by dead animal dealer, burial, and the temporary composting of small carcasses for landfills are estimated to be slightly-to-significantly more expensive per unit of mortality than composting. Convenience remains a major consideration when selecting a management system for routine mortalities on the farm; as does avoidance of aesthetic nuisance to neighbors. Key factors influencing this cost will be economies of scale, management and maximizing throughput, and the longevity of the system.

Acknowledgements

This work was supported in part by *The National Pork Board* (grant number 09-078).

References

Henry, Chris, Extension Engineer; Robert Wills, Extension Swine Veterinarian; and Larry Bitney, Professor of Agricultural Economics University of Nebraska – Lincoln, 2010 Disposal Methods of Livestock Mortality, G1421. Available at: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1078&context=extensionhistAccessed 25 April 2012.

Iowa State University. 2012 Iowa Farm Custom Rate Survey, File A3-10.Available at: http://www.extension.iastate.edu/agdm/crops/html/a3-10.html. Accessed 29 April 2012.

Michigan Department of Agriculture, Animal Industry Division. 2008. Bodies of Dead Animals Act. Act No. 239 of the Public Acts of 1982, as amended in 2008, being S287.677 of the Michigan Compiled Laws. Available at: http://www.michigan.gov/mdard/0,4610,7-125-48096_48404---,00.html. Accessed 29 April 2012.

Productive Energy Solutions. 2012. Online Electricity Usage Calculator. Available at: http://www.productiveenergy.com/calculator/motor.asp. Accessed on 1 May 2012.

USDA. 2001. Part I: Reference of Swine Health and Management in the United States, 2000, National Animal Health Monitoring System. Fort Collins, CO. #N338.0801.

USDA. 2007. Swine 2006, Part I: Reference of Swine Health and Management Practices in the United States, 2006 USDA:APHIS:VS, CEAH. Fort Collins, CO #N475.1007.