The Cost of Regulating Hog Manure Storage Facilities and Land Application Techniques

Bruce A. Babcock, Ronald Fleming, and Dwaine S. Bundy

Briefing Paper 97-BP 17
June 1997

Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa 50011-1070
www.card.iastate.edu

Questions or comments about the contents of this paper should be directed to Bruce Babcock, 578 Heady Hall, Iowa State University, Ames, Iowa 50011-1070; Ph: (515) 294-6785; Fax: (515) 294-6336; E-mail: babcock@iastate.edu.

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Published in June 1997 by the Center for Agricultural and Rural Development (CARD), 578 Heady Hall, Iowa State University, Ames, Iowa. U.S.A. 50011

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For additional information and analysis, see CARD Working Paper 97-178 "Resource or Waste? The Economics of Swine Manure Storage and Management."

THE COST OF REGULATING HOG MANURE STORAGE FACILITIES AND LAND APPLICATION TECHNIQUES

Executive Summary

This report estimates the financial costs of implementing two regulations regarding the storage and disposition of manure from Iowa livestock operations. The first regulation would require that all outside earthen storage basins and anaerobic lagoons be covered. The second would require that manure applied to crop acreage be immediately incorporated into soil. Both proposals reduce odor by preventing release of volatile products into the atmosphere.

While hogs, cattle, and poultry are all produced in confinement in Iowa, most storage basins and lagoons are associated with swine production. Hence, hog production is the focus of this work.

Storage basins can be covered in two ways. The first way is to cover them with industrial-grade plastic sheeting supported by polystyrene floats. A less expensive alternative is to cover basins with a thick layer of chopped straw. Covering lagoons with chopped straw is not feasible, however, because lagoons are not entirely emptied and the straw would greatly increase sludge buildup. Thus, for lagoons, the only cover we evaluated is the plastic cover supported by polystyrene floats.

Covering a storage basin with a durable plastic cover would cost $2.99 per year per breeding sow and $1.02 per year per market hog. Covering a storage basin with chopped straw would cost $2.19 per year for a breeding sow and $0.75 per year for a market hog. Covering a anaerobic lagoon would cost $11.07 per year per breeding sow and $6.15 per year per market hog. The costs of covering a lagoon would be decreased by one-third if the regulation would mandate coverage of only stage one of a two-stage lagoon. The incremental cost of requiring incorporation during land application would be $1.39 per year per breeding sow and $0.68 per year per market hog for lagoon storage. The incremental costs would be $0.49 per year per breeding sow and $0.17 per year per market hog for manure stored in basins or pits. Of course the incremental cost of this regulation would be zero for producers who already are incorporating their manure.

Any regulation that increases the cost of producing hogs in Iowa producers, but not the cost in other states, decreases the competitiveness of Iowa's hog producers. Thus, requiring producers to cover manure storage structures and incorporate manure would decrease the attractiveness of raising hogs in Iowa. The cost of these two regulations would fall disproportionately on those producers who use lagoons because of the larger volume of liquid associated with well-functioning lagoons.

THE COST OF REGULATING HOG MANURE STORAGE FACILITIES AND LAND APPLICATION TECHNIQUES

Introduction

The new manure standards contained in House file 519 did not decrease the demand by many Iowans for regulations covering livestock production facilities. Most of the recent public concern over Iowa livestock production is focused primarily on hogs, although other important livestock industries in Iowa include beef cattle, dairy herds, and egg-laying operations. Furthermore, most of the concern over hogs is the manner in which hog manure is stored and land applied.

The objective of this report is to estimate the costs of two regulations that would change the way that liquid manure is stored and applied to cropland. The regulations would potentially apply to all livestock operations that store and/or apply liquid manure. But, because hog production facilities are by far the greatest producer of liquid manure in Iowa, this report focuses solely on the impact of the regulations on affected hog producers.

The first regulation would require that all outdoor manure storage facilities, which include earthen storage basins and anaerobic lagoons be covered. These facilities are used to store and, in the case of lagoons, treat hog manure until it can be land applied. Storage basins contain undiluted raw manure in a concentrated slurry. Manure stored in these basins can generate offensive odors, particularly in warmer months. With lagoons, manure is diluted and allowed to break down in an anaerobic environment. Mature, well-managed lagoons release less offensive odors than storage basins except, perhaps, in the spring and fall when lagoons "turn over."

Storage basins can be covered in two ways. The first way is to cover them with industrial-grade plastic sheeting supported by polystyrene floats. Such a cover would last about 10 years. A less expensive alternative is to cover basins with a thick layer of chopped straw. Recent work at Iowa State University (ISU) suggests that such a cover could last an entire year; at that time the straw could be hauled off with the manure and applied to a farmer's field.

Covering lagoons with chopped straw is not feasible because lagoons are not entirely emptied and the straw would greatly increase sludge buildup. Thus, for lagoons, the only cover we evaluated is the plastic cover supported by polystyrene floats.

The second regulation would require that all manure be soil incorporated when land applied. Soil incorporation reduces odor by preventing the release of volatile gases into the atmosphere. Incorporation, however, destroys vegetative cover, making it necessary for manure to be applied to crop acreage prior to planting or after harvest. Furthermore, it is difficult to incorporate manure on land with permanent cover, such as pasture, or where a high level of crop residue is maintained to reduce soil erosion. Thus, requiring soil incorporation reduces the time period that a farmer has available for spreading manure and reduces the acreage available or suitable for spreading.

This report estimates the financial impact on Iowa hog producers of implementing the two regulations. In addition, the report estimates the possible aggregate impact of the two regulations on the competitiveness of the Iowa hog industry.

Background Data

Covers for Lagoons and Basins

The first regulation considered in this report would require that all outdoor manure storage facilities be covered. Volatile gases rising from the stored manure would be captured under the cover and eliminated by combustion (burning) or vented at a high

altitude rendering the gases less offensive. Hog housing facilities constructed over deep pits would not be subject to this proposedregulation because deep pits are, in general, already covered by the hog house. Hence, this regulation affects only hog-production facilities that use storage basins or lagoons for manure storage.

Information concerning the number of Iowa producers affected by the first regulation was obtained from the Iowa Department of Natural Resources (DNR). The types of hog production facilities that use storage basins and lagoons in Iowa are typically so large that they have had to obtain a DNR permit prior to construction. Thus DNR permit records provide a fairly good estimate of the number of basins and lagoons that would be subject to this regulation. Since 1987, 415 storage basins and 180 lagoons have received permits. In addition, from 1970 to 1986, DNR issued 220 permits. Unfortunately, DNR does not segregate these 220 permits by type of storage. However, if we apply the proportion of basins to lagoons observed after 1987 to the earlier data, we would have a total of 568 basins and 247 lagoons being built in Iowa since 1970.

The DNR data does not provide information about outdoor steel and concrete storage basins, which would also have to be covered under this regulation. Hence, the exact number of structures in Iowa that would be affected by this type of regulation is not known.

The total cost of covering a storage unit depends on the size of the storage unit and the cost of the material used to construct the cover. One way to cover basins and lagoons is to use industrial-grade plastic sheeting supported by polystyrene floats. This cover is estimated to cost $2.75 per square foot but is durable and has an expected life of 10 years. Furthermore, this cover can be used on any type of manure storage.

A second cover, chopped straw, is also considered, but this cover is only appropriate when using earthen storage. Specifically, a 10-inch layer of chopped straw is applied to the surface of the manure. This cover costs only 30 cents per square foot but is not durable. In time, the straw sinks into the manure or is blown away. Because manure odors are suppressed in the cold months, a straw cover is applied in the late spring and then removed with the manure in the fall. Recent research results suggest that the efficacy of a chopped straw cover in reducing odors can be up to 80 percent. It is not feasible to cover lagoons with chopped straw, however, because the long-term operation of lagoons would be compromised by an accumulation of straw residue.

The cost of covering a lagoon or basin is proportionate to the surface area to be covered, which in turn depends on the depth of the lagoon or basin and the amount of manure generated. The volume of manure generated per pig space in Iowa depends on whether a lagoon or basin is used and on whether the manure comes from a finisher or a breeding sow. We present cost estimates per pig space for both basins and lagoons and for both sows and finishers. We base our estimates on information provided by data that ISU Extension Engineers (ISU Extension, 1995) collected.

On average, a fully mature sow will produce l.243 gallons of raw manure daily. This daily production is equivalent to an annual storage requirement in a storage basin of 73 cubic feet (assuming 20 percent water wastage). By comparison, a market hog only produces an average of 0.9 gallons of waste per day throughout its life span (170 days) or roughly 25 cubic feet of annual storage. Assuming once a year removal of manure, storage basins would be constructed according to these volumes. Given a depth of 10 feet, the surface area corresponding to these volumes is 7.3 and 2.5 square feet, respectively, for each sow and each market hog.

Anaerobic lagoons are much larger than storage basins because of the volume of water needed for proper operation. Both one- and two-stage lagoons are common in Iowa, however, the exact proportion of one to two-stage lagoons is not known. The advantage of a two stage lagoon over a single stage is that

water in the second stage can be used in a "flushing" system. Furthermore, only water from the second stage is moved to surrounding fields, eliminating the need to disturb the more odorous material in the first stage. Here, the average depth of a single-stage lagoon is assumed to be 14 feet. Because there are more edges with a two-stage lagoon, the average depth at 13 feet is shallower. Design information assumes once a year dewatering and volatile solids production greater than 6,000 pounds per day.

For a sow facility, the storage volume per sow in a single-stage lagoon is 367 cubic feet. For a two-stage lagoon, the storage volumes per sow for the first and second stages are, respectively, 214 and 143 cubic feet. A similar calculation for market hogs is difficult because lagoon are typically sized according to a particular age range and average weight. Furthermore, these hogs are moved to market 170 days after weaning. The storage volumes reported for a market hog is a weighted average where the weight is the portion of a year that a hog spends in a nursery and then a finishing facility[1]. Using this weighting scheme, a market hog will require 208 cubic feet of lagoon space if a one- stage lagoon or 132 and 70 cubic feet of storage in the first and second stages of a two-stage lagoon.

The two covers that we selected for analysis in this report were chosen for two reasons. First, both covers are available to Iowa producers and both have demonstrated effectiveness in controlling odors. Second, the cost of other covers that might be available in the future probably fall between the costs of these two covers.

Some other covers that might be available soon include leka rock, a lightweight material that is used in some European hog operations; an "oxygen cover" whereby a layer of air bubbles forms a layer on top of the stored manure; and chopped cornstalks.

Soil Incorporation

The second regulation considered in this report would require that all manure spread on crop acreage be incorporated into soil. This incorporation can be performed by direct knife injection or by cultivation immediately following broadcast application. In this case volatile compounds or gases arising from manure decomposition are held by the soil and not immediately available for release into the air. The cost of this regulation depends on the amount of manure hauled, the difference in cost between broadcasting and soil incorporation of manure, and the number of producers affected by the policy.

Results from a survey (Lorimor 1995) of Iowa firms hired to haul manure shows that the average cost of injecting hog manure from a deep pit or earthen basin is 0.09 cents per gallon more than broadcasting the manure on the soil surface. The cost differential is larger in areas of Iowa with limited land suitable for injection, such as hilly areas of southern Iowa.

The Lorimor survey also asked firms for their costs of pumping lagoon gray water and either surface applying it through an irrigation system (usually a traveling big gun) or knife injecting the water with an umbilical system. Survey results indicate that the cost increase for injection is 0.13 cents per gallon. Again, the cost differential is typically greater in areas with less land suitable for injection.

Requiring producers to incorporate manure only affects those producers who currently broadcast manure. As noted above, the cost increment for soil incorporation differs for lagoon-treated manure and untreated slurry. Thus, calculation of the aggregate impact on Iowa would require knowledge of the proportion of producers who currently broadcast their manure, the proportion of manure that is currently stored in slurry form, and the proportion of manure stored and treated in lagoons. Anecdotal evidence suggests that a majority of producers

[1] For a single cell lagoon, total volume is 4.03 and 3.98 cubic feet per pound of body weight for nursery and finishing weight hogs. The average weight of a nursery hog is 35 pounds and a finishing hog 150 pounds. Hogs spend 56 days (0.1534 of a year) in a nursery facility and 114 days (0.3123 of a year) in a finishing facility. Using this information, the average total storage volume of a hog throughout its life is 4.03*35*0.1534 + 3.98*150*0.3123 or 208 cubic feet.

currently broadcast and perhaps less than 20 percent of manure is handled by lagoons. However, data to estimate these proportions reliably is not available for Iowa. Thus, we do not estimate the aggregate impact of this regulation. Instead, we estimate the cost per pig (sow or finisher) for a producer who currently broadcasts manure.

Results

Covers for Lagoons and Basins

Table 1 reports the cost of covering anaerobic lagoons and earthen storage basins in Iowa. Total cost per pig (sow and market hog) is calculated by multiplying the surface area of manure storage per pig by the cost per square foot of the cover. Because the plastic cover can be reused (has an anticipated life of 10 years), the total cost for plastic coverage is annualized over the life of the cover.

Specifically, annualized cost is the annualpayment that would be made on a loan to cover the total cost over the life of the cover. This is not the case for chopped straw which is replaced annually.

Note that one of the alternatives in Table 1 is to cover only the first stage of an anaerobic lagoon (17 and 10 square feet per sow and market hog). This alternative is offered because evidence suggests that little odor is released from the second stage. Furthermore, water from the second stage is considered clean enough to be re-circulated for use in manure flushing systems. Finally, since the total surface area of a two-stage lagoon is nearly equal to the surface area of a single-stage lagoon (27 and 15 square feet per sow and market hog), the total cost of fully covering both lagoon types is assumed to be the same. To put these costs into perspective, suppose that a hog producer has a 500-sow operation that markets 9,000 hogs per year. If this operation is on a two-stage lagoon, the annual cost of covering the lagoon would be $60,885, an amount that represents about 5.4 percent of annual market revenue from the marketed hogs at a price of $50 per hundredweight. If only the first stage of the lagoon were covered, the cost would fall to $40,385, or 3.6% of the market revenue. If an earthen storage basin were

Table 1.Cost of covering manure storage facilities in Iowa

	Cost Per Sow	
	Total Cost	Annualized Cost[a]
Anaerobic Lagoon		
Full cover with plastic	$74.25	$11.07
Cover first stage with plastic	$46.75	$6.97
Earthen Storage Basins		
Full cover with plastic	$20.08	$2.99
Full cover with chopped straw	$2.19	$2.19

	Cost Per Market Hog	
	Total Cost	Annualized Cost[a]
Anaerobic Lagoon		
Full cover with plastic	$41.25	$6.15
Cover first stage with plastic	$27.50	$4.10
Earthen Storage Basins		
Full cover with plastic	$6.88	$1.02
Full cover with chopped straw	$0.75	$0.75

[a] Assuming a 10-year life for the plastic cover and 8 percent interest rate.

used to store the manure, the annual cost would be $10,675 if a plastic cover were used, and $7,845 if chopped straw were used. These costs represent 0.95 percent and 0.70 percent of market revenue respectively. Clearly, the costs of this regulation would fall most heavily on operations that use lagoons.

Soil Incorporation

The cost of incorporation depends on the amount of manure hauled, how the manure is stored, the difference in cost between broadcasting and soil incorporation, and the number of producers affected by the policy. Unfortunately, the amount of manure hauled in slurry and liquid form and the quantity of manure currently broadcast is not known for the state of Iowa, making aggregate analysis difficult. Instead, Table 2 reports the cost per head (sow and market hog) of

The figures in Table 2 assume that the entire content of an earthen storage basin (73 and 25 cubic feet or 546 and 186 gallons per sow and market hog) and the second stage of an anaerobic lagoon (143 and 70 cubic feet or 1070 and 524 gallons per sow and market hog) are moved to crop acreage. These volumes and the convention that producers pump from a lagoon and haul from a deep pit or earthen storage basin follow ISU Extension recommendations (ISU Extension 1995; Lorimor 1995). Again, the cost increase associated with manure incorporation is 0.09 cents per gallon if manure is hauled and 0.13 cents per gallon if gray water is pumped. The annual cost of this regulation to the 500-sow operation that markets 9,000 hogs annually would be $6,815 if the operation were on a lagoon and $1,775 if the operation were on an earthen storage basin or a deep pit. Again, the cost of meeting this regulation would fall disproportionately on hog operations that use lagoons.

Table 3 reports the economic impact on a per head basis of both regulations considered in this report. Clearly, the policy to incorporate manure will only impact those producers who currently do not do so. Furthermore, the policy to cover manure storage facilities does not affect facilities using deep pits or other facilities using covered slurry storage or solid manure.

Impact on the Competitiveness of Iowa's Hog Industry

Iowa's hog producers are in competition with hog producers in other states and other countries. Any regulation that raises the cost of producing hogs in Iowa while not affecting the cost of production elsewhere will decrease the competitiveness of the Iowa hog industry.

The two regulations considered in this report would raise the cost of production for hog producers who store and/or treat their manure in outside earthen storage basins or anaerobic lagoons and for hog producers who do not soil incorporate their manure. Thus, the two regulations would decrease the attractiveness of producing hogs in Iowa unless other states follow Iowa's lead on this issue. One must be mentioned. Currently the most formidable impediment to the growth of Iowa's hog industry is not the cost of producing hogs. Rather, it is the generally negative attitude that Iowans display toward hog production facilities, which makes siting new production facilities quite difficult and costly.

Iowa's competitive position in hog production would increase if Iowans' attitudes toward hog production facilities became more positive or at least less negative. If the proposed regulations resulted in an improved image of the Iowa hog industry, then any loss of competitiveness from the regulations' extra costs would be partly offset by lower siting costs.

Regardless of the effect of these regulations on Iowans' attitudes, it is clear from the results that lagoons would plan a greatly reduced role in Iowa's pork industry. The cost of complying with both regulations

would fall most heavily on operations that use lagoons. Furthermore, the magnitude of the costs involved are large enough to make the lagoon operation unprofitable in Iowa.

An indirect consequence of the loss of lagoons would likely be an acceleration of the decline in Iowa's sow population. Modern breeding operations are quite large because of economics of scale. These large operations generally prefer to use lagoons and utilize the second-stage effluent as water for flushing. The flushing helps to control odors inside the sow buildings which tends to enhance productivity. If lagoons are no longer economically viable in Iowa, it is more likely that modern sow operations will locate in other states. The loss of sow farms in Iowa would have a large impact on the value of Iowa's hog industry. Hayes, Otto, and Lawrence (1996), in a study of the economic importance of a major Iowa swine producer, estimate that sow farms and nurseries together account for about 54 percentof the total value added from hog production.

Table 2. Cost of field incorporating manure in Iowa

	Cost Per Sow	Cost Per Market Hog
Pump from Anaerobic Lagoon	$1.39	$0.68
Haul from Earthen Storage Basin	$0.49	$0.17

Table 3. Cost of covering individual manure storage facilities and field incorporation in Iowa

	Annualized[a] Cost Per Sow	
	Already Incorporate	Must Incorporate
Anaerobic Lagoon		
Full cover with plastic	$11.07	$12.46
Cover first stage with plastic	$6.97	$8.36
Earthen Storage Basins		
Full cover with plastic	$2.99	$3.48
Full cover with chopped straw	$2.19	$2.68
Other storage (already covered)	$0.00	$0.49

	Annualized[a] Cost Per Market Hog	
	Already Incorporate	Must Incorporate
Anaerobic Lagoon		
Full cover with plastic	$6.15	$6.83
Cover first stage with plastic	$4.10	$4.78
Earthen Storage Basins		
Full cover with plastic.	$1.02	$1.19
Full cover with chopped straw.	$0.75	$0.92
Other storage (already covered).	$0.00	$0.17

[a] Assuming a 10-year life for the plastic cover and 8 percent interest rate.

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