ALABAMA A&M AND AUBURN UNIVERSITIES

ALABAMA COOPERATIVE Extension SYSTEM

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Sizing Swine Lagoons For Odor Control

With today's increasing concerns about environmental quality, on-farm lagoons have increasingly become the subject of discussions surrounding swine production and swine facility location. What is a lagoon anyway? Over the years it has become so commonplace that anytime we see an earthen impoundment containing manure, we automatically label it a lagoon. Usually we do not even realize how wrong our perception is. Unwittingly the non-farm public has also adopted this mind set. The result is that the perception exists that lagoons and odors go hand in hand—you can't have one without the other. This is unfortunate.

Inappropriate design and marginal management practices have resulted in the majority of these earthen structures producing or releasing unacceptable odors. The problem is our failure to recognize the differences between earthen storages, anaerobic lagoons, and a properly designed facultative lagoon. Building a structure of concrete or steel does not change the basic problem.

Storages vs Lagoons

Any impoundment which is regularly emptied is a storage. A lagoon will always have a permanent pool for residual volume that provides a bacterial seed bed for continual bacterial action at an elevated level. This bacterial action is not considered in the design of a storage. Essentially whatever goes into the storage is what is pumped out. A lagoon, though, is designed to promote decomposition of organic matter entering the lagoon. Any impoundment from which "black" or "dark brown" liquid or "slurries" are pumped, is functioning or being managed as a storage. Also any impoundment that is agitated to put settled or floating solids into suspension before pumping out the effluent, or the slurry, is also being operated as a storage.

Waste storage design is based on the manure volume produced by the animals, plus any washdown water or wasted feed. An impoundment outside in the weather must also have space for runoff which may enter the impoundment, and rainfall less evaporation, that will occur over the storage area. Additional space for a 25-year 24-hour rainfall event and required freeboard is also necessary. Lagoons must have volume for all of the above plus the minimum pool or treatment volume to allow biological degradation, and in some cases, volume for sludge accumulation.

Types Of Lagoons

Lagoons typically are designed as one of three distinctive types, aerobic, anaerobic, and facultative.

Aerobic Lagoon

A lagoon is aerobic when sufficient dissolved or free oxygen is available in the lagoon water to allow aerobic bacteria to flourish. These lagoons are generally shallow, 4 to 5 feet deep, have large surface areas, are biologically lightly loaded, i.e., the organic matter added per unit volume of lagoon per unit time is very low. These typically produce minimal odors.

Anaerobic Lagoon

Anaerobic lagoons are generally deep, have small surface areas compared to the organic loading rate, and contain anaerobic bacteria that thrive and grow without free oxygen. These bacteria are very efficient and effective at decomposing most kinds of organic matter. However, they frequently give off large quantities of unpleasant odors. Most of the lagoons in use on livestock farms today are either earthen bank storages or anaerobic lagoons. The primary design criteria is pounds of volatile solids per unit volume per day (volatile solids loading rate or VSLR). As this loading rate increases the likelihood of objectionable odors increases.

Facultative Lagoon

A facultative lagoon is a hybrid system and has both aerobic and anaerobic features. The anaerobic digestion of organic matter is maintained in the bottom zone of the lagoon. The top zone is dilute enough to allow dissolved oxygen to be present and maintain an aerobic layer.

This results in clarification of this surface layer and keeps odor release to a minimum. The intermediate zone favors the growth of facultative bacteria which are capable of operating, growing and thriving in either aerobic or anaerobic conditions as the lagoon characteristics change. Typically facultative lagoons generate minimal odor.

Increasing concerns about odors produced by livestock operations call for a change in lagoon design procedures. The results given in Table 1, from an EPA funded North Carolina research project, shows that the risk of unacceptable odor release increases as the organic loading rate (VSLR) of an impoundment increases. This has been the experience of most, if not all, Extension and university research personnel who have worked with animal waste lagoons for any length of time.

Several organizations publish recommendations for anaerobic lagoon design for animal waste. Alabama producers may be exposed to one or more of the following design procedures: Natural Resources Conservation Service (NRCS) Standard Design; NRCS Odor Control Design; Auburn University Ag Engineering Design (AU/AN); and Facultative Lagoon Design. Resulting lagoon size varies among these approaches based on the assumptions used to estimate the different volumes. Three primary differences standout: (1) Treatment Volume—the facultative lagoon design recommends a treatment volume four times greater than the standard NRCS design and two times larger the AU/AN or NRCS odor control design. The large volume is intended to minimize the risk of odor; (2) Sludge Volume—the facultative design does not include a sludge volume. NRCS procedures include a five year sludge volume accumulation while AU/AN's recommendation is a 7 to 8 year sludge volume; and (3) Clean Up Water Additions—flush and cleanup water volume, without recycle, can be as much as ½ to ⅓ of the total lagoon. This difference in volume varies between individual designers, due to differences in assumptions, or ability to accurately define water use for flushing and cleanup.

Table1. Probability Of Odor Detection vs VSLR

Treatment Volume (cu. ft./lb)	VSLR (#vs/1000 cu. ft. per da)	Probability of odor detection (%)
.20	24.56	80
.82	6.14*	60
1.64	3.07	20
3.28	1.53	Trace
6.56	.76	——-

* Reference value used in North Carolina EPA study.

Table 2. Probability of Odor Detection vs Lagoon Design

Type Impoundment/Organization	Size	Average VS Loading Rate (lb/1000cu.ft. per day)	Estimated Odor Probability
Storage			
- open	.89 ac	103	100
Anaerobic Lagoon			
- NRCS	2.4 ac	6.3	60
- NRCS ODOR	3.4 ac	3.2	20+
- AU/AN	3.6 ac	3.2	20+
Facultative	5.1	1.5	TRACE

Table 2 shows the probability of odor detection and volatile solids loading rate (VSLR) for these lagoon designs and a manure storage for a 3600-head swine finishing operation. It is instructive to note that the reference loading rate of 6.14 pounds of volatile solids per thousand cubic feet per day, which gives a 60% probability of unacceptable odor release, is very near the standard loading rate recommended in Alabama and the Southeast, to date, for typical anaerobic lagoons.

Differences among these methods and a manure storage are illustrated in Table 3 for a 3600- head swine finishing operation. Assumed flush and cleanup water is held constant for all designs. The differences observed are primarily due to treatment volume and sludge volume. All designs use a 210 day storage period.

Several important observations should be noted.

• While the facultative lagoon design requires a treatment volume 2 to 4 times larger than other designs the total volume is not 2 to 4 times larger. It is only 2.4 times larger than the standard NRCS design and only 1.6 times larger than the AU/AN and the NRCS odor control design.

• The greater difference in size is between the manure storage and other designs.

Odor is likely to be a significant concern, both from the lagoon and during land application of the effluent. Remember that both a manure storage and the NRCS standard design are established to maintain water quality standards, not minimize odor conditions. Eventually the discussion of size will come down to cost. When "ball parking" lagoon cost, one can assume the cost of $.80 to $1.00 per cubic yard for excavation. That is, the difference in volume between an

Table 3. Design Volumes (cubic yards) for an anaerobic treatment lagoon in Dallas County, Alabama on a 3600-head swine finisher facility. All structures are assumed to be 12 feet deep.

Pit Recharge Manure Removal System	NRCS Standard	NRCS ODOR	AU/AN	Facultative	Manure Storage
Storage Volume:					
manure	4,158	4,158	4,158	4,158	4,158
waste water	2,080	2,080	2,080	2,080	2,080
Treatment Volume	13,780	27,000	27,000	57,600	——-
Sludge Volume	5,812	5,812	8,136	——-	——-
Freeboard & Normal Rainfall + Storm Event - Evaporation	7,358	10,166	10,630	16,041	2,256
TOTAL	33,188	49,216	52,004	79,879	8,494
Inside Top Dimensions	420'x218'	420'x310'	420'x326'	420'x486'	200'x138'
Storage Period (Days)	210	210	210	210	210

NRCS standard design and a facultative lagoon design with recycle pit recharge system, of 46,691 cubic yards translates into as much as $46,691 difference in excavation cost and an additional 2.7 acres of land. Also note the difference between a manure storage and a treatment lagoon. A well functioning lagoon with a minimal odor risk comes at a price.

In summary there are differences in anaerobic lagoon size associated with different design procedures. The difference between an NRCS standard design and other lagoon designs is the most important difference to consider. With all the designs the difference in construction cost must be balanced against the potential of odor nuisances.

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