factsheet
Pork Information Gateway

Swine Manure Storage and Handling Practices to Minimize Odors*

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Introduction

Odor from swine production systems is generated at three primary sources on the farm: animal housing, manure storage and handling, and during land application. This publication addresses controlling odors during the storage and handling of swine manure. While odor from manure storage and handling is emitted continuously, the amount of odor generated can vary. Increased odor release may occur during certain times of the year and during certain events, such as during agitation prior to land application. Odor reduction methods vary by type of manure storage structure and manure system management. Odor reduction may be achieved by management practices that minimize the formation, release and transport of odorous compounds.

Objectives

The objective of this fact sheet is to discuss the potential odor control methods for swine manure storage and handling in practices that reduce the (1) formation, (2) release or (3) transport of manure odors.

Odor Formation Prevention Methods

Storage System Type

The type of manure storage system used can influence odor production and release. Systems that store high-solids manure slurries typically produce more odor than systems that store more dilute manure. Additionally, systems that are protected from the wind will release less odor than those that are exposed to airflow across the manure's surface. For example, a high-solids manure slurry stored under a cover would be expected to release less odor than a similar manure slurry stored in an open top outdoor structure exposed to wind. Solid manures that are stacked will quickly generate and release odors unless covered or composted.

**This fact sheet has been adapted from the National Pork Board funded publication, "Swine Manure Land Application Practices to Minimize Odors".*

Anaerobic Treatment

Complete anaerobic treatment of manure is very effective at controlling odor. Two types of anaerobic manure treatment systems are used with swine manure; anaerobic digesters and anaerobic lagoons. Of the two systems, anaerobic digesters are by far the most effective. Because anaerobic digesters use biogas collection systems that require a cover, odors are collected with the biogas. A properly designed and operated anaerobic digester will produce very little odor. To date, the sale of electricity from anaerobic manure digesters has not proven to be profitable unless the electrical power produced can be sold to a utility at a subsidized electrical rate far in excess of the wholesale electricity price. Since the cost of manure anaerobic digesters is typically greater than any revenue generated from the system, producers who choose to operate digesters often do so primarily for the excellent odor control that they provide. Some swine producers operating anaerobic digesters use the biogas directly to heat water used to heat the floors in farrowing units rather than to produce electricity.

Anaerobic lagoons are designed to reduce odor by storing manure with additional dilution water. If designed and operated correctly, anaerobic lagoons will reduce odor generation; however, anaerobic lagoons that are improperly designed and managed can become very odorous. Anaerobic lagoons also have some disadvantages from a nutrient management standpoint. If lagoons are not covered, large amounts of manure nitrogen will be lost from these systems in the form of ammonia gas. Because correctly designed anaerobic lagoons require diluting manure in very large volumes of water, manure solids and associated nutrients settle to the bottom of the lagoon and can be difficult to remove.

Aeration

The complete aerobic treatment of manure is very effective at eliminating odor. Unfortunately, because of the high organic content of manure, complete aerobic treatment of manure is not currently economically feasible. It is difficult to predict if partial aeration will provide meaningful odor control because there are several variables involved. The first is the manure organic content. The more dilute a manure is a greater benefit can be expected from aeration. For very thick slurries, the air addition requirement is so large that this approach is not economically feasible. The use of aeration, however, may provide benefit in a dilute system, such as an anaerobic lagoon that is not functioning correctly. The second variable is the amount of oxygen introduced by the aeration system. The more oxygen introduced, the better the odor control and the greater the cost to operate the aeration system. There has been research on using sequencing of aeration "on" for a period of time, then "off" for a period of time to affect the forms of nitrogen and phosphorus, called intermittent aeration or the sequencing batch reactor (SBR). This system has a potential to reduce odor. However, more research is needed on the impact of odor reduction with these types of systems.

Composting

Composting is the most commonly used treatment method for solid manure. Composting systems that are correctly designed and operated provide excellent odor reduction compared to solid manure that is simply stacked. When considering a composting system give careful thought as to where and how the materials to be composted will be stored prior to composting. Many odor complaints associated with compost systems are based on odors generated by stockpiles of materials waiting to be composted.

Additives

Manure additives can be broken down into three functions: biological, chemical or masking. Biological additives include enzymes or bacteria intended to increase the performance of either aerobic or anaerobic bacteria and thereby reduce odor. Chemical additives are typically oxidizing compounds intended to reduce the organic content of the manure by chemical oxidation. Masking agents are typically chemical agents designed to "mask" or cover manure odor. Unfortunately independent scientific research to date has not identified manure additives that can effectively, reliably and economically reduce odors from swine manure. A recent research study completed in 2001, tested 35 manure additives and found that none decreased odors.

Odor Release Control Methods

Impermeable covers

Covers are a very effective method of reducing odor release from manure storage structures. Covers can be constructed of rigid or flexible impermeable materials or from flexible or natural permeable materials. Impermeable covers that do not leak virtually eliminate odor release. Since it is difficult to build an air-tight cover, most impermeable covers can be expected to reduce odors by 80 – 95 percent. Impermeable covers usually have higher cost and a longer lifespan than permeable covers. Rigid impermeable covers can be constructed of concrete, metal or wood. Flexible impermeable covers are constructed of geosynthetic thermo-plastics and rubber materials such as high-density polyethylene (HDPE) and ethylene propylene diene monomer rubber (EPDM). Unlike some flexible cover materials used a decade ago, the geosynthetic cover materials currently available are very durable and have life spans in excess of 10 years. The cost of impermeable covers on a square foot basis will vary greatly based on the size of the structure to be covered. It is important to remember that impermeable covers require both water and gas management systems. This is especially true when using flexible impermeable covers. Biogas generated by the stored manure must be collected from beneath the cover and released or flared. Similarly, rainfall onto the cover must be collected and removed to avoid sinking a flexible cover into the manure storage. In very windy areas care must be taken to avoid allowing loose cover material to flap in the wind and become damaged.

Permeable covers

Permeable covers are a lower cost alternative to impermeable covers. Permeable covers typically have a much shorter life span than impermeable covers. Materials that have successfully been used as permeable covers include straw, cornstalks, lightweight clay balls, geotextile materials and ground rubber. Permeable covers reduce odor by sheltering the manure surface from air as well as providing an aerobic layer above the manure that can remove some odor as it passes through the cover. Figure 1 provides a diagram indicating how this process works. Permeable covers, such as those made with blown straw or cornstalks will last for two to six months depending on the manure slurry thickness and the weather. The thicker the slurry, the longer the straw will float on the slurry surface. Rainfall on these covers causes the cover to sink faster as well. While short-lived, straw covers are cheap and effective while they are in place. Research has shown that a four-inch straw cover can provide a 40 percent reduction in odor release while a 12-inch straw cover will provide a 90 percent decrease in odor release from swine manure storages. Straw covers might be used as a short-term solution to an excessive odor release from an earthen manure storage in a summertime situation for example. It is important to remember that after the cover sinks, the cover material will have to be dealt with when agitating and pumping the manure storage. Geotextile materials floated on the liquid in manure storage can be expected to last from three to five years. Research has indicated that the effectiveness of geotextile covers may decrease over time. Sometimes geotextiles will be combined with a layer of close-celled foam or have straw applied above them to increase their effectiveness. Lightweight clay balls have been proven to provide a very effective permeable cover for swine manure storages. A light expanded clay aggregate (LECA), produced in Denmark, has been shown to make an excellent manure cover material in both research and field trials. The lifespan of this material can be expected to match that of impermeable covers. The LECA material has been in use in Iowa on swine manure storages for more than eight years with no problems reported.

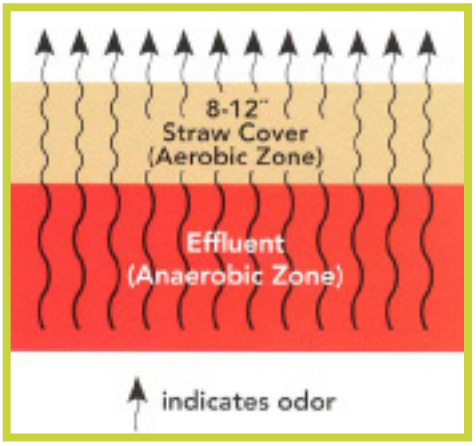

Figure 1. Cross section of a covered manure storage system with permeable (straw) cover.

Odor Transport Control Methods

Timing

The manure handling function that typically generates the greatest odor is agitation of manure and or tanker loading prior to land application. While little can be done to prevent the release of odor during manure agitation and loading, downwind transport can be minimized by conducting these activities on days that have significant convective atmospheric mixing. By agitating manure on sunny mornings as the atmosphere warms, odor will be transported upward by convective mixing to a greater extent than downwind. For more information on how to minimize odors during land application of manure please see the PIG fact sheet titled Swine Manure Land Application Practices to Minimize Odors.

Shelterbelts

Plantings of vegetation or windbreak walls downwind of the storage can be used to disrupt airflow across open manure storage structures. This can reduce odor in two ways. First, if the vegetation or wall reduces the volume of air passing across the surface of the manure storage the amount of odor released will be reduced. Secondly, if the vegetation or wall is of sufficient size and design to force the air to move vertically, it can assist in dispersing the odor and reduce the amount of it transported downwind to a receptor. Vegetated shelterbelts have the added advantage of providing surface area on the leaves that can filter odor carrying dust particles out of the air. A well-selected and placed vegetated shelterbelt may also provide a visual barrier that is more attractive to the public than a manure storage structure. Vegetated shelterbelts have the disadvantage of taking much longer to establish than constructing a windbreak wall.

Summary

The best method of odor control will depend on the situation at any given farm. For most swine operations with open manure storage however, the use of a manure storage cover currently presents the most practical approach to odor control. Vegetated shelterbelts provide a practical approach to reduce the amount of odor transported downwind to a known receptor location when the facility location, layout and predominate wind direction are favorable for their installation. Timing manure agitation and load-out from manure storage to occur on sunny days with good convective atmospheric heating is a practice that everyone should use when possible. Finally, anaerobic digesters provide excellent odor control. Anaerobic digesters may be a beneficial option for facilities that require a very high level of odor control and can sustain the capital and maintenance cost associated with these systems.

Suggested Options for Controlling Odor from Manure Storage

- Covering manure storage provides very effective odor control
- Installation of a shelterbelt downwind of your farm
- Agitate and load manure in the morning on sunny days
- Anaerobic digesters provide excellent odor control

Additional Resources

For additional information please see the following publications:

LPES Lesson 43 Emission Control Strategies for Manure Storage Facilities. http://www.extension.org/pages/Livestock_and_Poultry_Environmental_Stewardship_Curriculum

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Nicolai, R. and S. Pohl. 2004. Covers for Manure Storage Units. FS 925-D, South Dakota State University. Html version: http://agbiopubs.sdstate.edu/articles/FS925-D.pdf

Bicudo, J. R., D. R. Schmidt and L. D. Jacobson. 2004. Using covers to minimize odor and gas emissions from manure storages. AEN-84, UK Cooperative Extension Service, University of Kentucky, Lexington, KY. Available at: http://www.ca.uky.edu/agc/pubs/aen/aen84/aen84.pdf

Shah, S., P. Westerman and G. Grabow. 2007. Additives for improving hog farm air quality. AG-686W. North Carolina Cooperative Extension Service. NC State University, Raleigh, NC. Available at: http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/AG-686w.pdf

To learn more about odor mitigation practices, visit the Checkoff-funded Air Management Practices Assessment Tool at: http://www.extension.iastate.edu/airquality/practices/homepage.html