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# Overview of Odor Control for Manure Storage Facilities

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Odors are unpleasant smells caused by gases and many odorous volatile organic compounds (VOCs). On farms, natural degradation of animal manure and other organic matter sources generate many of these unpleasant smells.

Manure storage facilities can therefore be significant sources of odors. As a result, many animal producers are considering odor control practices for their operations. Various best management practices and best available technologies have been developed over the past two decades to reduce the odor emissions from manure storage facilities. This fact sheet reviews the advantages, disadvantages, and application scenarios for many of these odor control practices and technologies.

## Covers

This practice reduces odors from manure by covering the storage structure. Two basic types of covers are available—**permeable and impermeable**. Covers are made from many different materials with the basic objective to reduce odors and gas emissions. Research by Dr. Clanton et al. at the University of Minnesota indicates that permeable covers are more suitable for odor reduction than impermeable covers.

**Permeable** covers restrict air, water, and gas movement into and out of the manure storage structure. Floating permeable covers can be formed naturally or artificially. Natural covers usually are formed by the fibrous material in the manure and are dependent upon animal diet and bedding material. Dairy cattle manure with organic bedding and high fiber diets will typically form a natural, permeable crust/cover.

Artificial permeable covers can be formed by adding sufficient organic materials such as straw, chopped cornstalks, or other materials to form a mat or cover on the surface of the storage structure. Dr. Clanton's research showed that straw blown onto the surface at 4-inch, 8-inch, and 12-inch depths has been shown to reduce odors by 60%, 80%, and 85%, respectively. A 12-inch cover will require about 100 bales of straw per acre of surface. This type of permeable cover is expected to last six to eight months, at which time the organic mater begins to degrade and lose effectiveness. For this reason, organic covers are most effective when applied just prior to the warmest, most odor producing months. These types of covers are difficult to apply on structures greater than 2 acres in size. Other permeable covers are made from artificial materials such as geotextile. These floating fabrics are not recommended for storages that are pumped frequently or require rigorous agitation. Other artificial materials, such as air-filled clay balls, have also been used as permeable covers. Lesson 43 of the Livestock and Poultry Environmental Stewardship (LPES) indicates that different clay balls with various thicknesses have varying levels of odor and gas emission control, such as 56-90% odor reduction, 64-84% $H_2S$ reduction, and 65-95% $NH_3$ reduction.

**Impermeable** covers do not allow any odors, gas, or water to move into or out of the manure storage structure. Concrete and glass-lined above-ground storage structures can be covered with ridgid impermeable concrete and steel covers. Although expensive, they can last 10 to 15 years, depending on the material used.

HDPE (High Density Polyethylene) fabric is a common impermeable cover associated with manure storages. Earthen type storages are less easily covered and frequently have floating impermeable covers that require treatment and removal of trapped gas. Plastic covers can be inflated over or float on the manure surface. The cost of inflated plastic covers is about $100 per linear foot of diameter and the life expectancy is about 10 years. Dr. Funk's research at the University of Illinois has shown that floating plastic covers (see figure 1) are easier to maintain than inflatable covers.

The odor and gas emission reduction efficiencies of an impermeable roof, or a concrete or plastic cover can be as high as 80% for odor and 80% to 95% for ammonia according to the LEPS lesson 43.

When selecting a cover, consider the size and type of manure storage system, type of manure treatment system, frequency of pumping, cost, durability, maintenance, and ease of cover operation and management.

## Manure Treatment

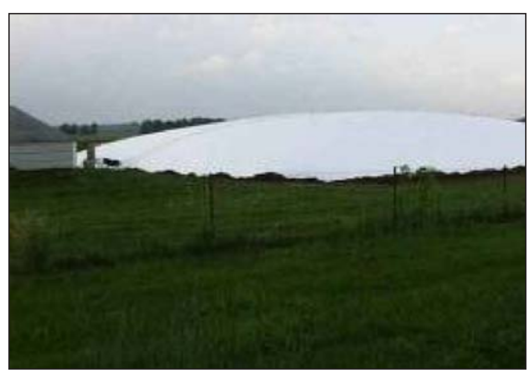
**An aerobic or aeration treatment** that adds air to the manure is an effective way to reduce odors because animal manure can be decomposed into odorless substances with the presence of oxygen. This type of treatment can be achieved by mechanical surface aerators for lagoons (figure 2), compressed air aerators, liquid pumps, and aerobic vessel reactors. Mechanical surface aerators are used widely. Complete aeration treatment can eliminate odor. However, significant energy consumption of the aeration treatments limits their wide applications. Aeration rates are determined by the biochemical oxygen demand (BOD) of the manure waste and the specific need for odor control. To save energy and reduce odor, most aerobic systems use liquid-solid separation prior to aeration of the liquid fraction. Furthermore, partial aeration of manure lagoons has proven to be a feasible means to manage odor emissions from manure lagoons. Minimum aeration requirements for acceptable odor control depend on farm size, manure characteristics, and odor control needs.

Aeration has the potential to promote ammonia and other gas emissions if the process is not well controlled. The gas release potential and high energy costs are limiting wide applications of the aerobic treatment technologies.

**Anaerobic treatment** takes place in the absence of oxygen in ***anaerobic lagoons*** (figure 3) and anaerobic digesters. Anaerobic treatment lagoons when properly sized, designed, and managed can significantly reduce odors but will never be as effective as aerobic treatment. These types of systems do not work well when temperatures are below 50°F because of low biological activity. These lagoons may be a significant source of odor in the spring as temperatures increase and biological activities resume. For more detailed design criteria for anaerobic lagoons, please refer to MWPS18, Livestock Waste Facilities Handbook.

***Anaerobic digesters*** supply more optimized and controlled conditions for decomposition of organic matters in comparison with anaerobic lagoons. The goals of anaerobic digesters are odor control and methane generation. Common types of anaerobic digesters are the plug-flow, sequencing batch, complete mixing, and contact reactors. If an anaerobic digester is designed, operated, and maintained properly, a relatively complete anaerobic decomposition process is expected and very little odor is produced. Anaerobic digesters can reduce manure odors by 70%-80%

(a)



(b)

Figure 1. A floating plastic lagoon cover (a) and an inflatable cover (b) (source: Funk et al. 2004a, 2004b).

Figure 2. Aeration of a manure lagoon
(Source: LPES Lesson 43).

Figure 3. An anaerobic manure lagoon.

compared to untreated manure. However, the cost of an anaerobic digester, the energy input to the digesters in a cold climate, and high failure rates are currently limiting wide adoption of this technology. Proper design, construction, and management of the anaerobic digester are critical to the success of this system. Research for development of low cost and effective digesters is on-going. Anaerobic digester technology could be one of the few promising technologies for animal producers to manage manure while generating biogases for energy.

**Liquid-solid separation** is the removal of the solid organic fraction of manure either by gravity settling or using mechanical equipment such as a screen, centrifuge, or screw press. Because centrifuge separators are relatively expensive, screw press separators and inclined screens are commonly used for animal manure.

Removing volatile organic compounds (VOCs) from manure reduces the organic solid loading rate on anaerobic lagoon or manure storage ponds and thus can reduce odor emissions. The odor removal effectiveness depends on the separation efficiency, i.e. the percentage of solids that can be removed. The solid removal efficiencies can range from 10% to 60% with common values of 10 to 30%. Settling basin can achieve up to 50% solids removal.

For mechanical separations, a stationary screen can achieve a 5% total solid removal; a centrifuge 30%-35%; and a screw press 20%-40%. Separated liquid manure can be treated in an anaerobic lagoon and solids need to be treated by composting or other drying methods. The liquid-solid separation is therefore an important step in manure treatment but the odor control effectiveness of the different steps has not been clearly quantified.

**Composting** is a biological process in which microorganisms convert organic materials such as manure, sludge, and leaves into a soil-like material called compost under aerobic conditions (in the presence of oxygen.) Composting is most applicable for solid or semi-solid manure and can reduce manure volume, stabilize manure nutrients, kill pathogens and weed seeds, and produce a homogeneous non-odorous product. Composting manure can be a value-added process that converts animal manure into useful and economically competitive products. If

(a)

(b)

Figure 4. Composting facilities: (a) a composting facility with controlled environment and (b) an outdoor composting site.

operating conditions are managed properly, carbon dioxide and water vapor will be the primary gases emitted from the composting process. If the carbon and nitrogen ratio is too low, the excess nitrogen will be emitted as ammonia and other forms of nitrogen gas. For example, poultry manure is high in nitrogen and therefore composting of poultry manure cannot be sufficiently and economically amended with carbon to avoid ammonia emission. The ammonia should be recovered to conserve the valuable nitrogen nutrient and prevent air pollution. For more information about the composting process, please refer to NRAES 54, On Farm Composting Handbook, and OSU Extension Bulletin 792—The Composting Process.

**Manure additives** are typically chemicals, microorganisms, enzymes, disinfectants, and adsorbents or absorbents added directly to the manure to control odor. Manure additives have various odor control effectiveness. A National Pork Producer Council study conducted by Purdue University under laboratory conditions showed that only four manure pit additives reduced odor and the majority did not. The performance of many of these additives needs to be scientifically tested under field conditions before they are widely applied.

## Landscaping

Odor perception is subjective, and is affected by visual cues. Landscaping with trees and shrubs can form a visual barrier between neighbors and the potential odor sources and may also provide a large filtration surface for odorous compounds and dust. This also slows wind speed across the manure surface and thereby reduces odor and gas emission.

## Summary

Covers on manure storages can significantly reduce odors. Permeable organic covers are effective, but not durable. Synthetic covers are durable and relatively expensive, but not suitable for storages with frequent agitation and emptying needs. Aerobic treatment is a good odor control, but consumes a significant amount of energy. Liquid and solid separation is usually used to reduce solid content of manure storages and thus reduce odor. Anaerobic lagoons and digesters are good odor controls. However, anaerobic digesters usually require high energy inputs and high technical expertise in design, operation, and maintenance. Manure additives vary greatly in their effectiveness and caution is advised in selecting a manure additive for odor control. Landscaping around manure storages definitely helps in reducing the perception of odor by neighbors. Selection of the appropriate technology for odor control should be based on the level of control needed, and the specific manure storage situation including the size and type of manure storage, the frequency of pumping, existing manure treatment systems, the cost and lifetime of the technology, the maintenance required, and the ease of operation.

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