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Using Covers to Minimize Odor and Gas Emissions from Manure Storages

José R. Bicudo[1], David R. Schmidt[2], and Larry D. Jacobson[2]

Odor emissions from animal production sites are typically the leading cause of nuisance complaints. Locating facilities far from neighbors is often a solution to the odor problem, but this is not always an option for producers. Most often, reducing odor emissions from the farm is the only option available.

Most livestock and poultry odors are generated by the anaerobic decomposition of livestock wastes such as manure (feces and urine), spilled feed, bedding materials, and wash water. Increased organic loading rates due to expanding animal numbers, slug loading, concentrated waste streams, and/or inadequate amounts of dilution water increase the potential for odor emissions from waste management systems. Odor emissions from manure storages tend to occur when the liquid surface is disturbed during windy conditions or during agitation and pumping prior to land application. Spring turnover, a phenomenon seen in colder climates, also increases odor emissions from manure storages.

Covering manure storages and anaerobic lagoons is becoming popular among livestock producers and offers one of the few proven methods to control odor emissions. Although installing a cover on the manure storage may not solve all the odor problems on the farmstead, using a cover will often reduce odor enough to minimize complaints from neighbors.

Covers primarily reduce gas and odor emissions by creating a physical barrier to prevent volatile chemical compounds from leaving the liquid. These volatile chemical compounds include many of the odorous gases (e.g., hydrogen sulfide, volatile fatty acids, and ammonia). Although these gases will still be released during agitation and land application, the total emissions from the storage site are significantly reduced.

With any cover system, it is important to remember that there will be emissions during the agitation and pumping of manure, so good land application practices (incorporation and injection) should be used to decrease odor problems. Also, if the effluent from the covered storage system is used for recharging shallow pits, odorous gases will likely be released during recharge, thus resulting in high concentrations of odor, hydrogen sulfide, ammonia, etc., inside the building. These higher gas levels in production buildings can negatively affect the health of workers and animals.

Types of Covers

Covers can be either permeable (allowing gases to escape) or impermeable (not allowing gases to escape—also known as non-permeable covers). Various types of covers have been tried and are currently being used by producers (Table 1). The most popular types of covers are the permeable floating covers, such as straw or geotextile. Natural crusts often develop on dairy manure storages (and some swine manure storages) and are classified as a permeable cover. Other types of covers being used on farms include impermeable plastic covers. These can be either inflatable or negatively pressurized.

Most plastic covers have a life expectancy of about 10 years, although instances of failure within one year have been reported, as have life expectancies of four years. Geotextile covers have a reduced life expectancy (three to five years) as compared to plastic covers. Some geotextile covers are not protected against UV radiation, which causes material deterioration and thus reduced life expectancy. Warranties on materials vary depending on the type of cover. Plastic cover vendors may offer material warranties starting at 10 years, but warranties on workmanship usually do not exceed two years. Geotextile cover vendors may warranty the material for up to three years, whereas workmanship is typically guaranteed for one year. If a plastic or geotextile cover is likely to fail because of workmanship, it most often occurs within the first year.

Impermeable covers are usually tightly sealed around storage edges (often with an anchor trench on earthen basins or lagoons). Provisions for collecting and removing rainwater must be considered in areas of high precipitation and low evaporation. Runoff collected in the cover can be drained through a series of perforated collection pipes laid on the cover surface, which are in turn connected to a manually activated pumping system. Other systems collect rainfall in trenches made by folds in the cover surface and are pumped out periodically.

Impermeable cover systems require an exhaust ventilation system to avoid pressure buildup inside the cover due to the production of manure gases. Provision to collect and remove biogas can be made through the installation of perforated gas collection pipes and/or exhaust fans when installing pressurized systems. For complete odor control, the collected gas can

[1] *Biosystems and Agricultural Engineering, University of Kentucky* [2] *Biosystems and Agricultural Engineering, University of Minnesota*

Table 1. Types of covers, effectiveness, life expectancy, and capital cost.

Cover	Type	Effectiveness (%)			Life Expectancy	Capital Cost (US$/ft^2)
		Odor	H_2S	NH_3		
	Inflatable plastic, positively pressurized	95	95	95	10 years	0.75 - 1.00
	Floating plastic, negatively pressurized	95	95	95	5 - 10 years	0.35 - 0.40
	Floating plastic	95	95	95	10 years	0.50 - 1.00
	Natural crust	10 - 90*	10 - 90*	10 - 90*	2 to 4 months	0.00
	Straw	40 - 90	80 - 95	25 - 85	Up to 6 months	0.03 - 0.10
	Geotextile (non-woven, 6.35 mm thick)	15 - 75	0 - 100	25 - 50	3 - 5 years	0.15 - 0.25**

* Effectiveness of natural crusts is difficult to quantify and depends on thickness and other physical characteristics of the crust.

** Geotextile cover costs are given for orders over 500,000 square feet; lower volume orders may have higher costs.

be directed to a biofilter or to some other air treatment system before it is discharged to the atmosphere (Figure 1). Note that the design of these air treatment systems should take into account the particularly high odorous gas concentrations (H_2S concentrations have been measured in the 600 to 1000 ppm range). A University of Minnesota Extension fact sheet gives general information on biofilters. Detailed design information is available in the Midwest Plan Service publication on outdoor air quality (see first entry under "Additional Information" for ordering information).

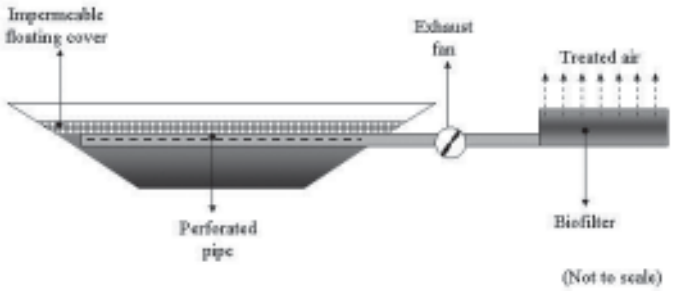

Figure 1. Schematic of a system to remove and treat biogas collected underneath impermeable covers.

Permeable or impermeable fabric covers are either fastened to the berm using anchor trenches (Figures 2 and 3) or tethered with ropes to ground anchors, metal or wood stakes/posts located around the perimeter of the storage structure (Figure 4).

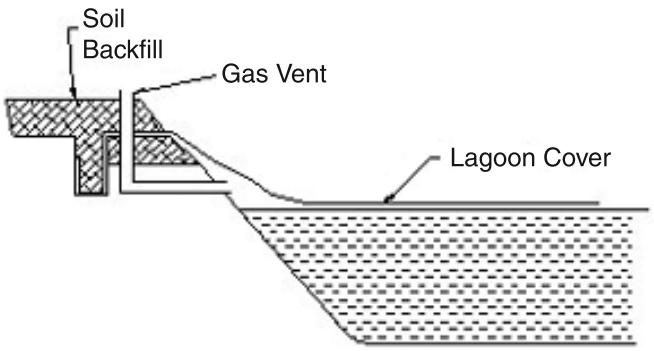

Figure 2. Fastening a cover to a berm using anchor trenches (gas vents are needed for impermeable covers only)

Figure 3. Anchor trench on impermeable plastic installation.

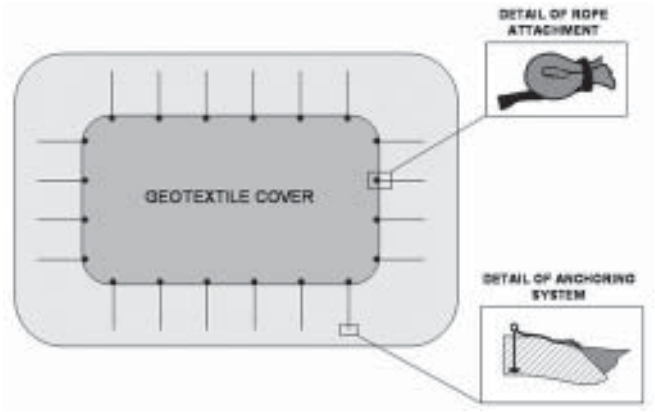

Figure 4. Geotextile cover tethered to ground anchors around the perimeter of the storage (adapted from BEI Ag Environmental Solutions).

Covers should be designed to withstand wind damage, ultraviolet radiation, and other environmental effects. In the case of permeable covers, there is no need to provide ventilation or rainwater collection devices.

Both plastic and geotextile covers should be selected in terms of important physical properties such as tensile strength and resistance to elongation and puncture. Other factors to consider in selecting this type of material are related to attachment methods, long-term maintenance, ease of repair, useful life of the material, and final disposal. Agitation and pumping from under these storage covers have also been challenging. Individual cover system manufacturers have all developed flaps or lift systems in an attempt to resolve this problem.

Artificial floating organic covers, also called biocovers, include straw, chopped cornstalks, sawdust, wood shavings, rice hulls, etc. Both barley and wheat straw can be used as organic floating covers. Usually a thick layer of straw (about 12 inches deep) is applied to manure storages using a straw chopper/blower (Figure 5). A single, large, round straw bale (6-foot diameter) can cover about 500 square feet of storage (12-inch thick layer).

Figure 5. Blowing straw to a manure storage.

Natural floating covers are those formed by the fibrous material contained in the manure. Dairy manure usually contains high amounts of such material, and it is therefore common to observe the development of a crust on the surface of manure. Stored swine manure can sometimes develop a natural crust, but its consistency is usually much different from dairy manure.

Lightweight rigid covers are available for most new circular steel and concrete storages. Heavy-gauge polyester with PVC coating material is available for the retrofit of existing aboveground storages. It is important to take into consideration increased wind loads and the weight of the cover and its supports when installing impermeable covers to both new and existing storage structures. Rainwater falling on the cover must be directed away from the structure, preferably to a well-drained vegetated area.

Effectiveness

Plastic impermeable covers are very effective in reducing odor and gas emissions and will generally last longer than other types of covers (Table 1). On the other hand, they cost more and require the installation of devices for ventilation or biogas extraction as well as rainwater collection.

Covers made of geotextile fabric can perform reasonably well if properly managed. Farm research conducted jointly by the University of Kentucky and the University of Minnesota showed variable reductions in odor, hydrogen sulfide (H_2S), and ammonia (NH_3) emissions due to geotextile covers (non-woven, 6.35 mm thick) (Table 1). Cover performance in reducing odor and H_2S deteriorated during the second year of the study. Analysis of ambient H_2S data suggested the covers were effective in reducing ambient H_2S concentrations near manure storage ponds located at two pig finishing units.

A new generation of geotextile covers has ultraviolet protection and one or more foam layers to improve flotation and performance. This type of material will likely last longer (up to 10 years), but its cost (not included in Table 1) can be twice that of first-generation geotextile covers.

Straw covers can last between two and six months, depending on the amount applied (depth of straw), evenness of application, basin size, and wind conditions during application. University of Minnesota researchers have shown that a 4-inch layer of straw alone gives 60%, 69%, and 61% reductions on odor, H_2S, and NH_3, respectively. Thicker layers of straw (8 and 12 inches) resulted in even better cover performance with reductions ranging from 70% to 90%. The effectiveness of straw covers reduces with time, likely due to the saturation and sinking of the straw. The type of straw used as cover usually does not affect reductions in gas and odor emissions; however, different types of straw may float longer than others.

Natural crust can in most cases help reduce odor and gaseous emissions from manure storages, but researchers have found it difficult to quantify these reductions. Reductions are likely similar to crusts formed using straw. At this point, we do not fully understand the physical, chemical, and biological mechanism by which the natural crust forms and dissipates.

Operation and Management

Once a cover is properly constructed and installed, there are additional technical and operational needs. Agitation and pumping of manure are essential operations where manure is to be applied to agricultural land. Custom manure applicators may charge a higher rate if conditions to agitate and pump are inconvenient or considered hazardous. Access to a covered manure structure for manure agitation and removal equipment would normally require removing a portion of the cover, often at several points around the structure or installing permanent openings (Figure 6) that can be completely sealed between pumping.

Figure 6. Opening for the access of agitation and pumping equipment in a geotextile-covered manure storage.

Cover maintenance may include removal of snow, rainwater, debris, and silt and the exclusion of animals and the repair of tears or punctures. In addition, there are concerns with the management of a geotextile cover after the winter season since it may take one or two months for the geotextile covers to float properly after thawing. This is a difficult issue to resolve if producers are interested in reasonably low-cost technology.

Safety is also a consideration during agitation and pumping of manure due to potentially high concentration of toxic gases (e.g., H_2S) under the fabric covers. Gaining access to the manure under the fabric cover through access flaps or a cover lift system must also be done with caution.

Disposing of plastic and geotextile material after it is no longer usable can be costly. One producer in southwest Minnesota has paid $1,000 for pick-up and hauling of a 2,000-square foot geotextile cover and an additional $800 in landfill fees. Note that both pick-up/hauling and landfill fees vary with location and hauling distances, and the above numbers may not be representative of service fees available in your area.

Straw covers may break up or sink due to high winds and heavy rain. If a cover starts to break up or sink, additional straw may be added in order to retain its effectiveness. Straw-covered storages can be successfully agitated and pumped using chopper-pumps.

Potential increased nutrient concentration in manure, especially where an impermeable cover is used, may mean that more land is needed for application at agronomic rates. There also may be corresponding shifts needed in cropping systems in order to accommodate changes in pumping and application frequency. These and other system changes impose additional financial and managerial requirements on the enterprise.

Additional Information

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