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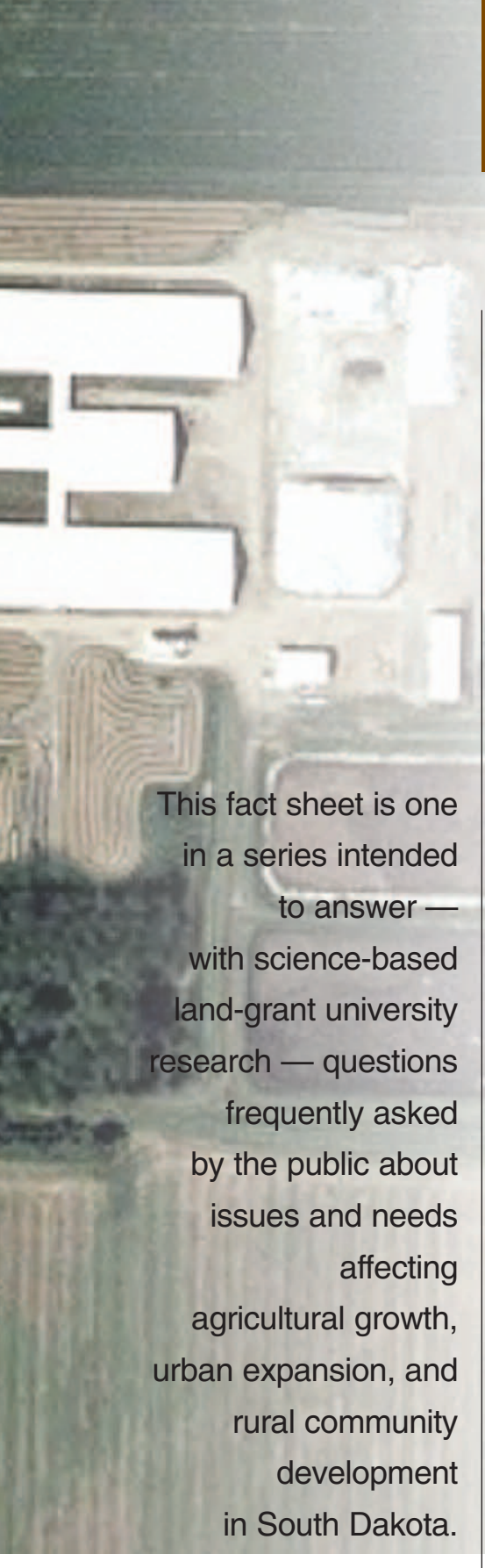

Covers for Manure Storage Units

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This fact sheet is one in a series intended to answer — with science-based land-grant university research — questions frequently asked by the public about issues and needs affecting agricultural growth, urban expansion, and rural community development in South Dakota.

Every livestock operation needs some kind of manure storage. Storage allows the nutrients in the manure to be applied to cropland at appropriate times in the growing cycle. Storage also allows the manure to be held when fields are frozen or snow covered when application might result in runoff that would pollute surface water.

Recommended storage capacity for manure is 6 months or more, depending on the moisture content of the manure and whether it is liquid or solid. Solid manure piles typically emit very little odor due to crusting of the pile surfaces. However, liquid manure storages can be a significant source of odor and hydrogen sulfide emissions.

Odor emissions from manure storage are typically the leading cause of nuisance complaints. Liquid manure storage tends to give off odor and gas emissions when the surface is disturbed during windy conditions or during agitation and pumping prior to land application. Spring turnover, a phenomenon that occurs when the storage warms, also increases odor and gas emissions.

Covers over the lagoons significantly reduce both odor and hydrogen sulfide emissions. Covers create a physical barrier at the liquid-air-interface, which helps retain more volatile chemical compounds in the liquid phase and minimizes emissions to the atmosphere. However, there is limited design information, and it has been difficult to evaluate performance of covers in field conditions.

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

Type of cover	*Material*	*Effectiveness (%) Odor*	*H_2S*	*NH_3*	*Life expectancy*	*Capital cost (US/yd^2)*	*Reference*
Impermeable	Concrete lid	95	N/A	N/A	10-15 years	N/A	1
	Wood lid	95	N/A	95	10-15 years	N/A	1,2,3
	Inflatable plastic	95	95	95	10 years	7-15	1,4
	Floating plastic (HDPE)	60-78	90	N/A	10 years	3-5	5
Permeable	Straw	40-90	80-94	25-85	Up to 6 months	0.25-1	1,5,6,7,8,9
	Geotextile	40-65	30-90	0	3-5 years	1.25-1.6	9
	Geotextile + straw	50-80	60-98	8-85	N/A	1.5-2.6	9
	Leca®	90	N/A	65-95	10 years	15.45	3,7
	Macrolite®	60	64-84	N/A	10 years	15.45	5

References

1 Mannebeck, 1985
2 DeBode, 1991
3 Sommer et al., 1993
4 Zhang and Gaakeer, 1996
5 Clanton et al., 1999
6 Anonymous, 1993
7 Bundy et al., 1997
8 Jacobson, 1998
9 Clanton et al., 2001

How covers work

When a cover is placed directly over the manure surface, the following processes take place:

1. Resistance to the transfer of gases is increased because of the physical barrier between the liquid and the air.
2. Gas concentrations build up under the cover.
3. The rate at which a gas diffuses out of the manure is reduced (because the concentration gradient has decreased).
4. Hydrogen sulfide, ammonia, and other volatile odorous compounds may be kept in solution, increasing the emissions of these gases when the cover is removed for land application of manure.

Most widely used covers float on the surface of the manure and are made of straw, geotextile, or a combination of both. Other types of covers on farms include impermeable plastic covers; rigid covers made with concrete, wood, and PVC material; and air-filled clay balls like Leca® and Macrolite®. Inflatable plastic covers have also been popular in Canada.

Covers are usually classified as impermeable or permeable. Impermeable covers do not allow any gases coming off the manure to be emitted to the atmosphere, while permeable covers permit transmission of some gases. Table 1 describes the effectiveness and cost of various types of covers.

Impermeable covers

Because impermeable covers trap and hold gases coming off the manure, a vent must be provided to prevent build-up of excessive pressure in the headspace and to ward off a possible explosion (Fig 1). Odorous gases under covers are extremely corrosive or toxic. Flat, low-profile covers should be specified whenever possible to minimize headspace. Minimal headspace reduces air exchange volumes, reducing the need for odor control equipment.

Figure 1. Rigid cover (concrete, wood, PVC, etc.) or hoop structure placed on a manure storage tank and venting gases to the atmosphere.

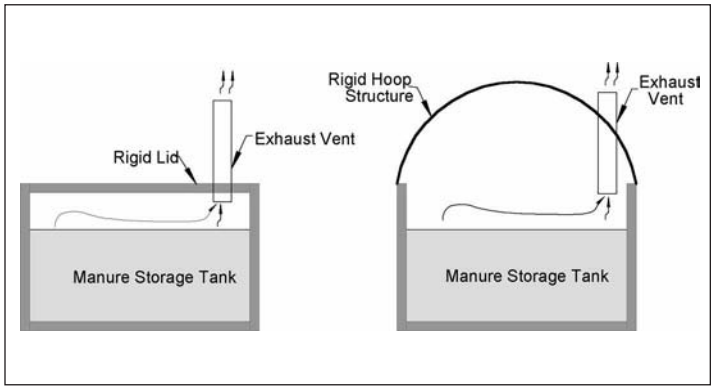
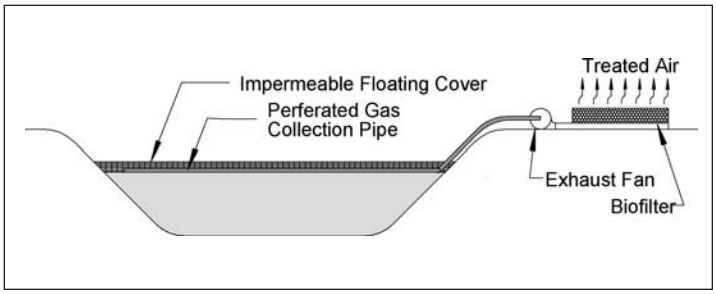


Figure 2. System to remove and treat biogas from manure storage using an impermeable cover and biofilter.



Impermeable covers need to be designed for easy access for operation or maintenance, have a minimum number of joints, and seals at all joints. The corrosive action of sulfides and sulfuric acid must be considered when selecting cover materials and concrete coatings. Overhangs, ledges, or lips on the underside of covers where condensate may collect should be avoided.

Odorous gases in a covered storage tank must be vented to the atmosphere to avoid pressure build-up inside the cover from the production of manure gases. Collecting and removing biogas can be done through installing perforated gas collection pipes and/or exhaust fans. Methods to reduce odor include the burning or flaring of these gases or some form of gas treatment as biofiltration or ozonation before discharge to the atmosphere (Fig 2). The design of these air treatment systems should take into account the highly odorous gas H_2S concentration (600 to 1000 ppm).

Extension Fact Sheet 925-C gives general and specific design and operating information on biofilters.

Flexible membrane covers

Flexible membrane covers are constructed of high density polyethylene. They have effectively controlled odor from industrial and municipal sites. The membranes are 20 mil minimum thickness and must be UV stabilized. Membrane covers, either permeable or impermeable, when used on an earthen basin manure storage system, are typically anchored to the manure storage perimeter with an anchor trench (Fig 3). The cover floats on the surface of the manure and partially inflates with manure gases.

If the cover is impermeable the gases must be vented to the atmosphere. This is accomplished by a variety of techniques; often, a perimeter tile is placed under the cover near the top of the berm of the manure storage and then vented through the cover. The gases are either flared or treated using some other gas treatment system. Access to the manure is typically through a large flap that can be folded back. The flap must be large enough to allow for pumping and agitation equipment.

Typical life of the covers is anticipated to be 10-15 years with an installation cost of approximately $3-5 per square yard. This includes the venting system and is a function of the size of the area covered.

Inflatable dome system

With inflatable cover systems (Fig 4), a tarp is fastened to the tank perimeter as tightly as possible and supported by a center column with radiating straps. Air is delivered through a low-pressure blower, and the cover is maintained at a constant operating pressure (usually about 1 in H2O, or 250 Pa). Zhang and Baakeer (1996) observed that at an operating pressure of 0.4 in H2O (100 Pa), air leakage was 125 cfm. This leakage is approximately equivalent to the airflow rate of a bathroom exhaust fan.

For agitation and pumping, the structure is deflated, allowing the tarp to lie over the radiating supports. Access doors are then opened to introduce pumping equipment.

Figure 3. Fastening a cover to a berm using anchor trenches.

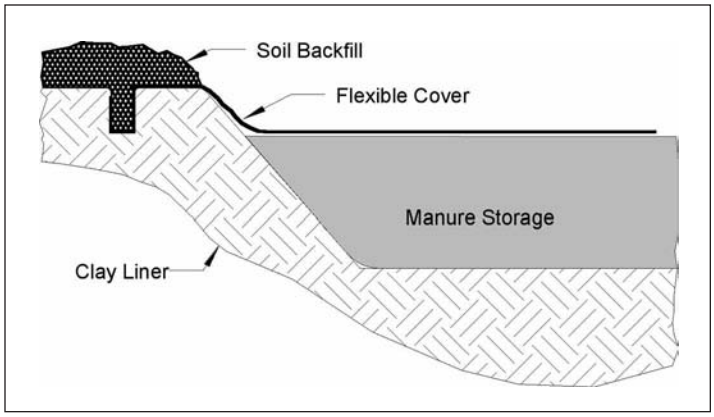


Figure 4. Inflatable dome cover and control system.

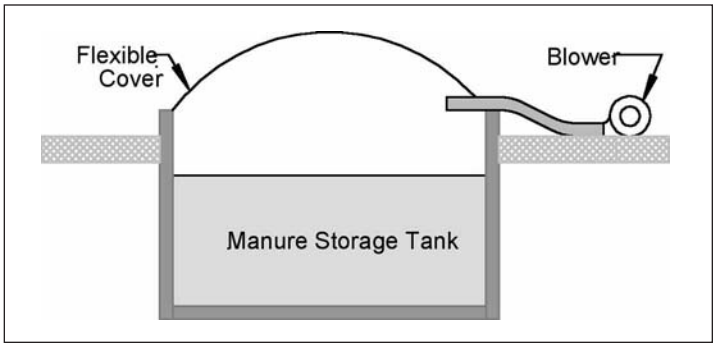
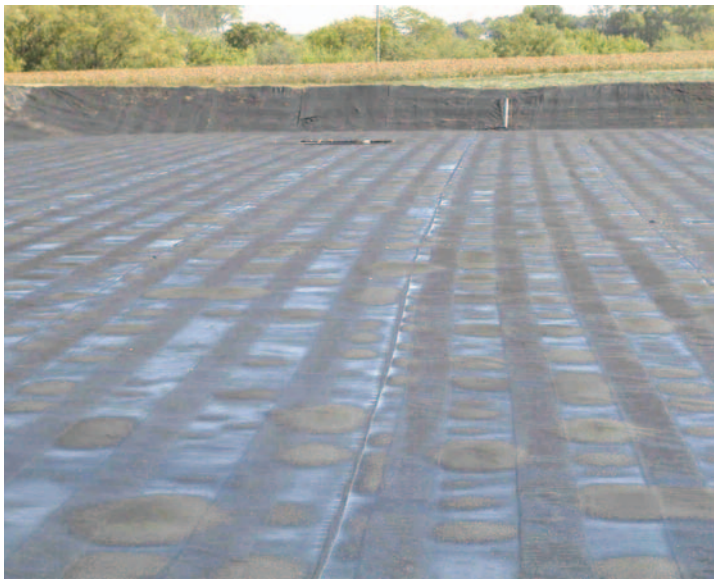


Figure 5. Geotextile floating permeable cover with closed-cell flotation.



Permeable covers

Permeable covers, such as straw, geotextile, or floating clay balls, are also effective alternatives for reducing odor from livestock manure facilities. Effectiveness of odor and gaseous emissions control is lower than with impermeable covers (see Table 1).

A biofilm may develop at the interface of cover and liquid. Some of the odorous compounds that escape to the atmosphere are broken down within the aerobic layer that is established.

Straw

Both barley and wheat straw can be used as organic floating covers; there is no significant difference between them. The straw is applied to manure storage tanks using a straw chopper/blower. The degree of odor control is not affected by the type of straw but rather the ability of the straw to float on the surface. Thus, odor reduction will vary from 90% for a thick, newly applied cover to 40% or less depending on straw thickness and uniformity. OFFSET modeling uses 50% reduction over the average life of a straw cover. Sometimes oil is added to the straw at the time of application to increase the time the straw floats.

Straw covers usually last between 2 and 6 months depending on the amount applied (depth of straw), uniformity of application, basin size, and wind conditions during application. If the cover starts to break up or sink, additional straw must be added to retain effectiveness. Successful agitation and pumping of straw-covered storages can be accomplished by appropriate equipment (chopper pumps).

University of Minnesota researchers (Clanton, 2001) have shown that a 4-inch layer of straw alone gives 60%, 69%, and 61% reductions of odor, H_2S, and NH_3, respectively. Thicker layers of straw (8 to 12 inches) resulted in even better odor and gas reductions (70% to 90%), with the exception of ammonia reduction with a 8-in layer (about 60%). The effectiveness of straw covers apparently decreases with time.

A 12-inch depth of straw is typically recommended, since this depth has been shown to float longer than lesser depths. The amount of straw needed depends on the area of the manure storage and desired depth of the straw layer. A single large round straw bale (6 ft diameter) can cover about 500 ft^2 of storage (12-inch layer).

Table 2. Cover design considerations.

1. Odor and H2S reduction needed:	a. If more than 90% reduction is needed, then an impermeable cover is needed. b. For 60-90% reduction geotextile or straw covers can be used.
2. Type of storage:	a. Geotextile, straw, and HDPE covers can not be easily installed on earthen basins. b. Inflatable plastic domes can not be easily installed on earthen basins. c. Concrete lids will not work with steel tanks or earthen basin. d. Straw covers will not work well on anaerobic lagoons because of the large size.
3. Size of storage:	a. Straw covers on manure storages or anaerobic lagoons over 2 acres are impractical. Wave action on these large areas will disturb the straw cover. These large surface areas have been covered by both geotextile and HDPE fabric.
4. Manure management:	a. Geotextile and HDPE fabrics are not recommended for manure storages where frequent pumping or rigorous agitation is needed. b. Covers installed on manure storages or lagoons where manure is recycled back into the barns for flushing or pit recharge is not recommended. High concentrations of dissolved gases in the manure will be released when this manure is brought back in the barn. c. Considerations should be made for evaporation and rainfall. Impermeable covers do not permit rainfall to enter storage but also restrict evaporation. Permeable covers allow rainfall to enter but may restrict evaporation.
5. Life expectancy for the solution:	a. Straw is considered an effective short term solution to an odor problem. b. HDPE has a life expectancy of 10-15 years. c. Geotextile fabrics are expected to last 3-5 years.
6. Cost:	a. Costs should include both capital investment and long term maintenance.

Geotextile

Other floating permeable covers, such as geotextile materials (non-woven fabric composed of thermally bonded, continuous polypropylene filaments), may provide a better solution than straw alone for certain types of storage basins.

Geotextile materials are self-floating and provide a physical barrier to mass transfer of gases from the liquid to the air. There is also some possibility that the geotextile helps maintain an aerobic layer of microorganisms on the manure surface, but more research is needed to verify this process. This layer would reduce the odorous gases to carbon dioxide and water.

Geotextile materials have higher initial cost than straw covers but all costs, such as installation and maintenance, must be included in the final evaluation of a cover.

One concern with geotextile or geotextile-straw covers is the ability to agitate the manure storage. This applies only in manure storage basins and tanks and not to lagoons, which are typically not agitated.

Most types of agitation equipment pump manure over the surface to help with the stirring. This is not possible with the geotextile covers. To achieve any agitation, the cover is partially removed—typically from one corner of the basin—or the cover is lifted by a cable and winch system and the agitation/pumping equipment is positioned under the cover. Neither of these options allows for vigorous agitation.

Procedures and equipment to agitate under the cover through an access is being developed.

Long-term floatation of geotextile covers was a concern when the product was first introduced. In two field situations with this early product there has been some partial sinking of the geotextile in the spring after surface ice thawed. However, in both situations, the covers came back to the surface as the system warmed.

Adding a layer of closed-cell foam between two types of geotextile materials has doubled the life of the covers and prevented sinking (Fig 5). The top geotextile layer has the ability to protect against ultra-violet radiation. Microbial buildup on the cover between the layers may increase odor reduction; more research is needed.

Management of manure covers

After a cover is installed properly, there are additional technical and operational needs. Parts of the cover may need to be removed to permit agitation and pumping when the manure is removed for land application. A permanent opening may be installed that can be sealed between pumping intervals.

Safety should **always** be considered during agitation and pumping of manure. There may be a high concentration of hydrogen sulfide or other gases under the fabric cover. Opening the flaps or lifting part of the cover must be done with caution.

Cover maintenance includes the repair of tears or punctures and removal of debris and silt accumulation on the cover surface. Geotextile covers without an additional float system may sink after the winter season and may take 1 or 2 months to float again on the manure surface. Disposing of plastic and geotextile covers after they are no longer usable may be difficult and costly depending on local hauling and landfill fees.

Straw covers may break up or sink due to high winds and heavy rain. If a straw cover starts to break up or sink, additional straw may be added to reestablish the cover's original effectiveness. Agitation and pumping of straw covered manure storages can be successful.

Manure nutrient concentration may increase after an impermeable cover is installed. More land is needed to achieve the same agronomic application rate if the manure concentration is increased.

Additional Resources

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