Liquid Manure Odor Control Techniques

The odor potential of land applied manure is directly related to the degree of odor generated by the manure storage system. All manure storages are not equal in their odor potential. Anaerobic processes are excellent odor control processes if allowed to proceed to completion. Anaerobic lagoons (Figure 44-1) have substantially lower odor potential due to a lower volatile organic compound (VOC) emission rate (a primary source of odor) as compared to other storage facilities. Spray irrigation of effluent from a purple lagoon or oversized anaerobic lagoon can be accomplished with less odor than spray irrigation from an earthen basin, below barn pit, or undersized lagoon, which each have very high odor potentials. Manure storage systems that allow anaerobic processes to proceed to completion can be coupled with pivot application of effluents with modest odor risk.

The odor potential of anaerobic lagoons is affected by time, temperature, and other factors related to the biological processes. Thus, management of the facility is a critical factor in defining odor emission from the storage or potential odor emissions during land application. For example, spray irrigation from an anaerobic lagoon in July will have much less odor than spray irrigation from the same lagoon in March.

Some anaerobic lagoon design considerations for minimizing odors are as follows:

- Design anaerobic lagoons with a large permanent pool since it (often 50% of lagoon volume or more) ensures a stable bacteria population for processing odorous compounds and satisfactory dilution of new manure additions. Designing lagoons for light loading rates significantly helps minimize odors.
- Consider time of application. June through fall application of anaerobic lagoon effluent has the least odor. Active biological processes during warm periods better stabilize odors. Winter and spring applications produce the greatest odors due to limited biological activity to stabilize odors during this period.

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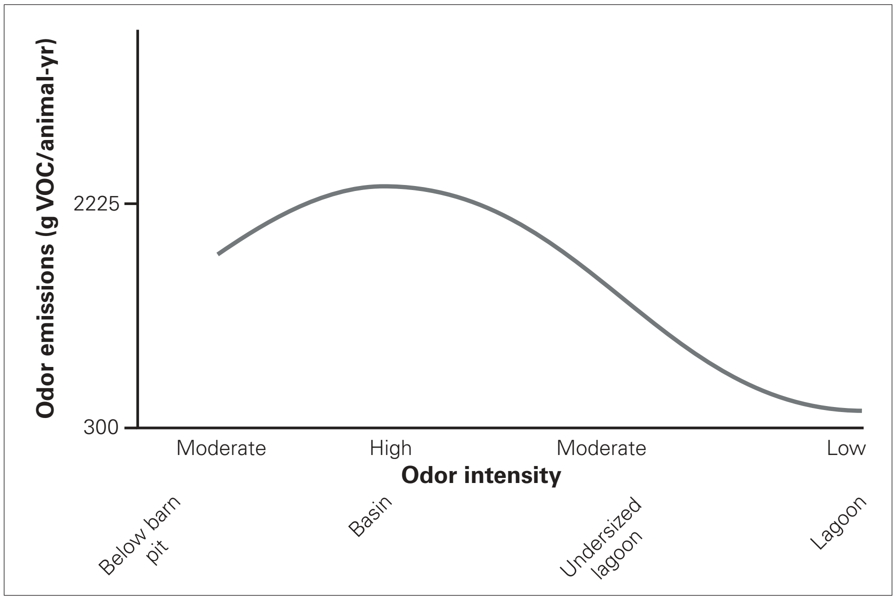

Figure 44-1. Relative odor emissions from different manure storage systems.

- Maintain a permanent pool in the lagoon. Clearly mark the top of the permanent pool to avoid over pumping and regularly record the lagoon level.
- Test electrical conductivity and ammonia levels yearly. Salt and ammonia buildup indicates conditions that can be toxic to anaerobic bacteria. Electrical conductivity and ammonium concentration should also be checked yearly. A conductivity reading greater than 10,000 μmho/cm and 670 mg of ammonium/liter (150 lbs of ammonia/acre-inch) indicate a poorly functioning and potentially odorous lagoon.
- To limit salt buildup, pump liquids yearly.
- Add dilution water liberally. When evaporation or low rainfall limits the need for pumping, pump out part of the permanent pool and refill it with fresh water to dilute salts and ammonium. Also liberally use dilution water for barn cleaning, pit recharging, and other housing maintenance activities.
- Establish purple sulfur bacteria population or purple lagoon. Effluent from a purple lagoon can be used to seed a non-purple lagoon. Salt and ammonium concentrations must be acceptable for purple sulfur bacteria to thrive.
- Stop lagoon feeding for two weeks before pumping effluent (allows bacteria to process odorous compounds).

Several methods of reducing odor from liquid manure land applications include incorporating the manure into the soil either during or shortly after it is spread, placing the liquid manure on the soil surface but below the crop canopy, or treating the manure in the storage unit before it is spread on land.

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Injection and incorporation

Manure injection into the soil is the most effective way to reduce odor during the land application of untreated liquid manure (Figure 44-2). Table 44-1 shows odor dilution thresholds for various land application methods. One can see that the injection and the unmanured (control) methods have essentially the same odor units. The other common option is to simply

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Figure 44-2. Injection of liquid manure into the soil.

Figure 44-3. Surface application of liquid manure on cropland.

Table 44-1. Odor thresholds for various land application methods.

Application Method	Odor Detection Threshold[a]
Broadcast	2818
Plow	200
Harrow	131
Inject	32
Unmanured	50

[a]Ratio of fresh air to odorous air (fresh: odorous) to dilute the odor to where it is just detectable.

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spread liquid manure on the surface (Figure 44-3) and immediately incorporate (plow or harrow methods in Table 44-1) into the soil. This method also reduces the odors considerably compared to the broadcast method. However, incorporation after spreading on the surface does not result in as great a reduction of odors as direct injection since some manure remains on the soil surface. Another study (Berglund and Hall 1987) found the odor intensity (measure of odor's strength) from surface application at 400 meters (1,300 ft) downwind was perceived to be equal to that from injection at only 50 meters (165 ft). A more recent study at Iowa State University showed odor reductions from 20% to 90% by immediate incorporation of manure into the soil. This study looked at five different types of incorporation or injection devices, with all resulting in significant odor and hydrogen sulfide reductions compared to broadcast manure left on the surface (Hanna et al. 1999).

The types of injectors used today include narrow tines, sweeps, disk injectors and covers, and conventional chisel plows. Besides their ability to achieve complete manure coverage for odor control, it is also important that these injectors leave crop residue on the surface to minimize erosion and limit energy (tractor horsepower) requirements. Sweeps require more horsepower than simple tines for a given depth, but the sweeps more than compensate for this by permitting complete coverage while operating at a shallower depth. The disk covers, when set properly, require the least horsepower while still providing complete coverage, but they may also cover more crop residue. When the manure is placed on top of the soil surface and a conventional chisel plow is used for incorporation, complete coverage cannot be achieved. Thus a high level of odor control may be at the expense of higher energy requirements and the potential for greater erosion. The additional cost of manure incorporation or injection for odor control is offset somewhat by the savings in manure nitrogen. An Iowa study suggests that injecting the manure from a storage system increases costs $0.49 per year per breeding sow and $0.17 per finish hog while injecting the manure from a lagoon system increases costs $1.39 per year per breeding sow and $0.68 per finish hog (Fleming et al. 1998). However, these cost increases did not consider reduced nitrogen losses with the injection system. An Iowa survey of commercial manure applicators showed an average difference of 1/10 of a cent per gallon more for injection versus broadcast (see <http://www.ae.iastate.edu/manurdir99.htm>).

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Drop hoses

Another method of application, used in northern European countries, is to simply place liquid manure on the surface through a series of drop hoses much like a sprayer hose or boom (Figure 44-4). This technique has been used to spread manure slurry (liquid manure from under barn pits) on tilled cropland and on growing crops (especially small grains), producing minimum odor and minimum potential runoff and/or erosion. The system has been used with manure tanks but could be adapted to drag hose technology on pastures or some crops such as forages. Adoption of this technology may be limited in the United States because of the prevalence of row crops and the difficulty of matching tanker tire size with rows and wheel spacing.

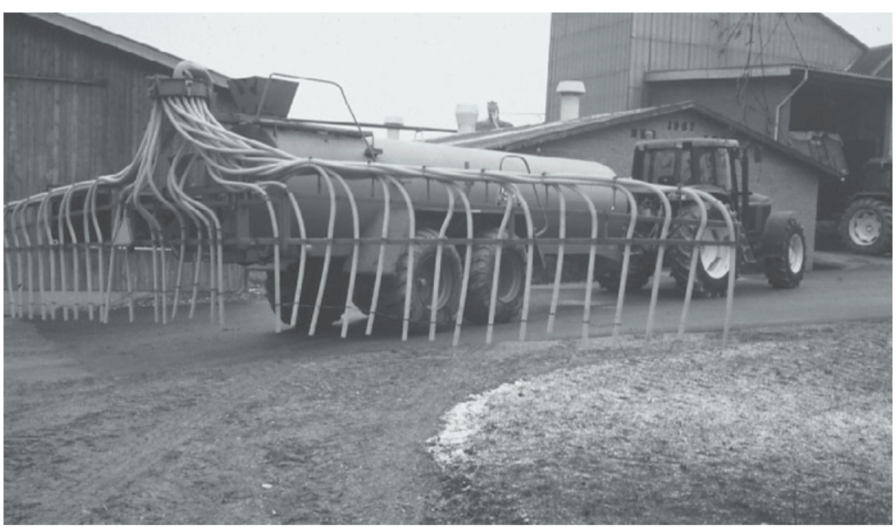

Figure 44-4. Drop hose liquid manure applicator.

Agitation or mixing of the manure before and during pumping contributes to odor and gas emissions... .

Figure 44-5. Agitation and pumping equipment for the deep pit manure storage under a pig-finishing barn.

Pretreated manure

Treated liquid manure may be less offensive than raw or untreated manure, although this depends on the degree of treatment. Liquid manure can be treated either aerobically or anaerobically (anaerobic digestion) to significantly reduce odors. Research indicates odor reductions of 80% or more during anaerobic treatment of manure (Pain et al. 1990). In such cases, manure can be surface applied or even irrigated with very little odor emissions. The same can be said for solid manure that is applied frequently (hauled daily), dried, or composted since it will generate less odor during land application.

Treating manure in pits

Agitation or mixing of the manure before and during pumping (Figure 44-5) contributes to odor and gas emission during manure application. This mixing is necessary to suspend the solids that have built up in the bottom of the storage and to distribute the nutrients evenly throughout the manure. Odor and gas emissions during agitation and pumping are difficult to control. The best method for reducing the impact of these odor emissions is to agitate during times when the outside air is heating (sunny clear mornings), causing the odorous air to rise and disperse.

Other techniques to reduce these emissions, such as the addition of chemical additives to the manure, are also being evaluated. Research has shown reductions in hydrogen sulfide emissions of over 90% with additions of calcium hydroxide, ferric chloride, ferrous chloride, ferrous sulfate, hydrogen peroxide, potassium permanganate, or sodium chlorite (Clanton et al. 1999). Although these reductions in emissions do not guarantee reductions in odor emissions, odor reductions are likely.

Surface application by irrigation

Applying liquid manure with irrigation (both surface and spray) systems (Figure 44-6) remains a popular and efficient method to distribute manure nutrients onto cropland in some sections of the United States. As mentioned previously, it can produce considerable odors if not managed properly and/or the liquid manure is untreated or has a high nutrient content. Characteristics of irrigation systems that reduce odor include using nozzles and pressures that

Figure 44-6. Spreading liquid manure with a traveling gun irrigation system.

produce large droplet sizes, installing drop nozzles on center pivot systems, and adding dilution water to the liquid manure before applying.

Droplet size is of importance because of the much higher surface area per unit volume associated with smaller droplets as well as the potential for greater drift of smaller droplets. In general, larger droplets are better for odor control. Droplet size is determined by a combination of nozzle size and pressure. To overcome their tendency to drift, droplets generally must be greater than 150 microns in size, depending on wind speed. Traveling guns must operate at high pressures, but the nozzle size is large, resulting in primarily large droplets.

Fresh water dilution can also be used to reduce manure odors and nitrogen loss during irrigation applications. One Midwestern state (Iowa) requires a 15:1 dilution with fresh water if untreated slurry manure is to be irrigated. Burton (1997) reported that 3:1 fresh water additions to manure slurry reduced ammonia losses from 20% to 90%. Lagoon liquid is often mixed into irrigation water in states that commonly use irrigation for crop production. The lagoon effluent is then spread in a very dilute and greatly odor reduced manner.

Center pivot irrigation systems are unique because they are permanently established on a specific parcel of land. They are appropriate only for lagoon effluents. If producers select pivot applications, they need to consider the odor risk associated with this method and identify practices that minimize this risk. The following list provides some design and management considerations to keep in mind when selecting a pivot irrigation system:

- Center pivots have wide latitude for nozzle size and pressure combinations. Use low-pressure drop nozzles to maximize droplet size and minimize droplet suspension time.
- Dilute effluent with fresh water (2 parts fresh water to 1 part effluent or greater dilution. Corn is most sensitive to salt and to ammonia prior to the 6-8 leaf stage. Greater dilution may be necessary during this stage of growth). Mixing fresh water and effluent requires a back flow protection system to prevent manure from contaminating a fresh water well.

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- Select pivot application sites that (1) maximize the setback distance between the pivot and receptors and (2) do not place a pivot downwind of neighbors based upon prevailing winds during the time of the year that manure application is most likely.
- Install a weather station that (1) constantly monitors wind direction and speed and (2) automatically shuts the system down if the wind blows toward the neighboring residences.
- Monitor the wind speed. Shut down the pivot when the wind speed is likely to remain less than 5 mph for an extended period. Low wind speeds produce more stable air and less dilution of odorous air. Odor plumes extend much further during stable atmospheric conditions such as low wind speeds.
- Irrigate during morning and afternoon hours only (odors disperse more quickly when the temperature is rising).
- Maintain records about the timing of applications and associated weather conditions. This practice will provide documentation of your operating procedures that may be helpful if neighbors complain.