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UNL's Livestock Environmental Issues Committee
Includes representation from UNL, Nebraska Department of Environmental Quality, Natural Resources Conservation Service, Natural Resources Districts, Center for Rural Affairs, Nebraska Cattlemen, USDA Ag Research Services, and Nebraska Pork Producers Association.

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Pivot Irrigation of Livestock Manure

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The selection of an appropriate land application method for manure can have an impact on several environmental issues. Individual methods should be evaluated based upon impact on:

- Air quality
- Water quality
- Soil conservation and quality
- Pathogen transmission

The following discussion will review these considerations as they relate to application of manure or lagoon effluent through a center pivot system. A generalized comparison of the relative strengths and weaknesses of alternative application methods is attached in Table 1.

Air Quality

It is important to recognize that various types of manure storage are not equal in their odor potential. Anaerobic processes are excellent odor control processes if allowed to proceed to completion as illustrated in Figure 1. Many municipal waste treatment systems use anaerobic processes for controlling odors. Note that the lagoon has substantially lower odor intensity and 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 minimal odor while spray irrigation from an earthen basin, below barn pit or undersized lagoon has a very high odor potential. Lower odor storage systems illustrated in Figure 1 provide an environment that allows anaerobic processes to proceed to completion.

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

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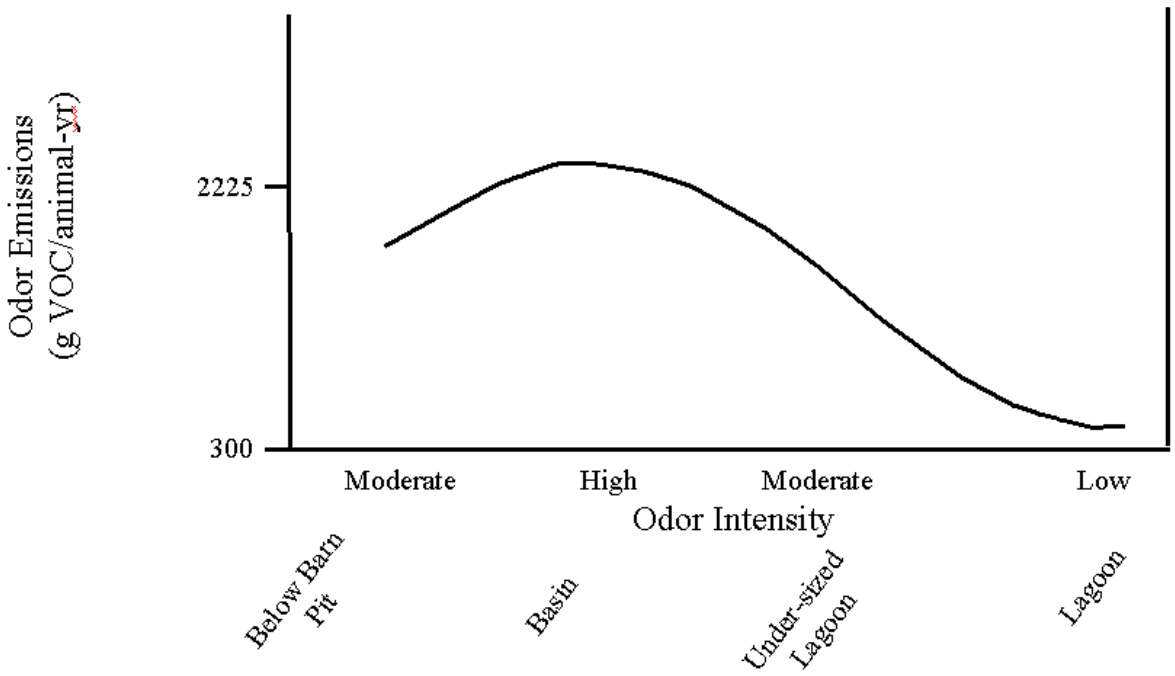
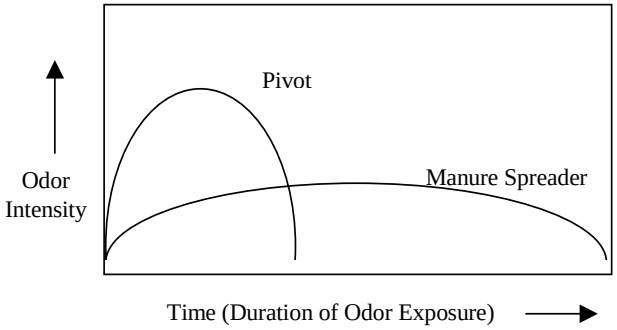


Source: J. R. Minor. 1995. Nature and Control of Odors from Pork Production Facilities. Bioresource Engineering Department. Oregon State University.

Effectiveness of anaerobic processes (anaerobic lagoons) to control odor is also affected by management factors that affect 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. Design and management recommendations for the reducing odor associated with the manure storage will be discussed later. Minimizing manure storage odor is the first step in reducing odor associated with pivot application.

Figure 2. Odor Intensity vs. Duration of Odor Exposure for Two Manure Application Systems



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From strictly an air quality perspective, there is little question that spray irrigation systems offer large potential for odor release during a short time period. These systems deliver a lot of product to the field in a short time and provide substantial opportunity for volatilizing odorous compounds during application of the manure or effluent (more intense but shorter period of time for odor exposure). In contrast, surface application of a slurry with a tanker or wet feedlot manure with a spreader will release significant odors. However, because of this equipment's inability to deliver product at the same rate, we have less intense odor over a longer period of time (see Figure 2). Is time of odor exposure or intensity of odor exposure most critical? The answer often depends on relative location of neighbors and the ability of the producer to time application based upon wind direction.

Water Quality.

When water quality issues are considered, the pivot has the least potential environmental impact if properly operated. Key advantages of a pivot from a water quality perspective are the following:

- Uniformity of nutrient application. A well-managed pivot has few equals in uniformity of distribution of manure nutrients. Uniform application of nutrients provides better opportunity for crop uptake of nutrients and less opportunity for nutrient leaching or runoff.

- Timing to limit runoff. If manure or lagoon effluent is applied to assist in meeting crop water needs, application is generally at a time of soil moisture deficit and high crop uptake resulting is a very low runoff potential. Most other application methods are confined to applications outside the crop-growing season thus increasing their potential for runoff.

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- Timing to meet crop nutrient needs. Application of nutrients (both manure and commercial nutrients) in close proximity to the time of crop nutrient uptake is ideal for minimizing leaching and runoff of nutrients. Pivot application during the growing season limits nutrient losses.

The biggest water quality disadvantage associated with pivot irrigation is the potential for over application of nutrients. Lagoon effluent applied based upon crop water needs (often 12 inches or more per growing season), will be substantially above crop nutrient needs. Two to five inches of lagoon effluent is often sufficient to meet all crop nutrient needs. To avoid over application through pivots, a nutrient analysis must be completed for the effluent being applied and application rates adjusted to not exceed crop nutrient requirements.

Water quality problems can also be associated with pivot application on wet, frozen or snow covered fields. Timing of pivot application, similar to any other method of application, influences the risk to water quality. Finally, application of manure through a pivot provides the potential for contaminating a fresh water source. Appropriate check valves must be used for irrigation systems plumbed to a manure source and a fresh waster supply, simultaneously (required by Nebraska law).

Soil Quality

Other application methods can have a negative impact on soil quality from soil compaction and loss of surface residue leading to greater erosion potential. Pivot irrigation has little negative impact on soil quality. Application of high solids manure can have a positive impact on soil quality including increased organic matter content and reduced runoff

potential. However, the low solids content of most irrigated manures is likely to result in only modest or no benefits to soil organic content or runoff reduction.

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Pathogen Transmissions to Animals and Humans:

The risk to grazing animals for E. coli O157 transmission following effluent irrigation of forages appears to be modest according to Dr. Dale Hancock, Epidemiologist, College of Veterinary Medicine, Washington State University. He further judges the risk for salmonella transmission to be greater, but not well defined. Grazing animals are likely to have experienced exposures to these same pathogens through other pathways and from other sources. Although the risk of transmission to grazing animals is low, that risk can be minimized by following effluent application with a fresh water irrigation, rainfall, or extending pasture rest time of up to one month.

Effluent application to harvested forages and grains poses a greater risk. Pathogens can live for extended periods of time in grains and hays. Significant increases in some pathogen populations are possible during storage of hay and grains. However, the biological process associated with silage and high moisture corn storage appears to be inhibitory to pathogens. For any animal feed that is to be harvested, manure or effluent should not be applied within one month of harvesting.

Putting manure on crops to be harvested for human food is an area of active discussion and controversy. The question is one of "How much risk?" not one of a presence or absence of risk. Although composting of manure is destructive to pathogens, complete composting of all parts of a manure pile is difficult to insure and thus risk is likely to result even from composted manure. At this time, manure or effluent application on human food products should probably be avoided until this controversial issue is better understood.

Minimizing Pivot Application Odors

Manure storage design considerations for minimizing production of odor and release by the pivot include:

- *Design anaerobic lagoon with a large permanent pool.* A large permanent pool (often 50% of lagoon volume or more) insures a stable bacteria population for processing odorous compounds and satisfactory dilution of new manure additions. For most of Nebraska, a permanent pool that is loaded at rates of 2 lbs. volatile solids per 1000 ft^3 per day or less has modest odor.

- *Unacceptable manure sources.* Earthen basins, formed storages, and undersized lagoons might not be acceptable for pivot irrigation or only when an application site is remotely located from neighbors.

Manure storage management considerations for minimizing odor production by the storage and release by a pivot include:

- *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 will produce the greatest odors due to limited biological activity to stabilize odors during this period.

- *Maintenance of permanent pool in the lagoon.* Clearly mark top of permanent pool to avoid over pumping. Regularly record lagoon level.

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- *Annually, test electrical conductivity and ammonia levels*.. Buildup of salts and ammonia are indicators of conditions that can be toxic to anaerobic bacteria. Electrical conductivity and ammonium concentration should be checked annually. A conductivity reading greater than 10,000 µmho/cm and 670 mg of ammonium/liter (150 lbs. of ammonia/acre-inch) are an indication of a poorly functioning and potentially odorous lagoon.

- *Annually pump* liquids to limit buildup of salts,

- *Fresh water addition*. When evaporation or low rainfall limits the need for pumping, pump out part of permanent pool and refill with fresh water to dilute salts and ammonium. Don't be conservative in the use of 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* prior to pumping effluent (allows bacteria to process odorous compounds).

Design considerations specific to the pivot can reduce odor production including:

- *Low pressure drop nozzles* (if solids plugging can be minimized).

- *Dilution of effluent with fresh water* (2 parts fresh water to 1 part effluent or greater dilution. Corn is most sensitive to salt and ammonia prior to 6-8 leaf stage. Greater dilutions will be necessary during this stage of growth). Mixing of fresh water and effluent will require a back flow protection system to prevent manure from contaminating a fresh water well.

- *Select pivot application sites* that 1) maximize setback distance between pivot and receptors and 2) do not place neighbors downwind of a pivot based upon prevailing winds during the time of the year manure application is most likely. Prevailing wind information can be found for 28 Nebraska sites for all months of the year at http://manure.unl.edu/wind/wind.html.

- Install a weather station that constantly monitors wind direction and speed.

Management practices specific to the pivot can reduce odor production including:

- *Irrigate during morning and early afternoon hours* (odors disperse more quickly when temperature is rising).

- *Monitor wind direction* and shut down the pivot when wind direction impacts neighbor.

- *Monitor wind speed*. Shut down pivot when wind speed is likely to remain less than 5 mph for an extended period. Low wind speeds produce more stable air and less

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dilution of odorous air. Odor plumes extend much further during stable atmospheric conditions such as low wind speeds.

! *Maintain records* as to timing of application and associated weather conditions. This is intended to provide documentation of your operating practices that may be helpful if neighbors complain.

Summary:
No single application method has a distinct advantage over other methods when soil, air, and water quality issues are all considered. The producer who is a good environmental steward needs to consider these issues relative to a specific site. Some sites due to proximity of neighbors may need to select an application method than minimizes odor. Water or soil quality may be higher priority issues at some sites where pivot irrigation may be a preferred option from an environmental perspective. To minimize the impact on the environment, individual site characteristics must be balanced against air, water, and soil quality considerations.

There are site specific situations when the pivot is clearly the preferred environmental option. There are other situations where pivots can pose a significant nuisance. Establishment of a “Good Stewardship ” set of practices for minimizing environmental risk of land application activities is critical for any application method including pivot application of manure. Successful implementation of such practices may need to be tied to a producer educational effort that addresses technology and management choices that impact air, water, and soil quality considerations.

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