Practices to Reduce Odor from Livestock Operations

Practices to control odor emissions associated with livestock production can be applied to animal housing areas, manure storage areas, and land where manure is applied. This document provides an overview of practices for each situation, highlights their advantages and disadvantages, and provides producers with sufficient information to make informed choices after evaluating production and economic aspects of their operations.

Odor Control Strategies for Livestock Housing

Odors generated in livestock housing can exit the facility and make their way to downwind neighbors. Even systems that utilize external manure storage will have some manure within the housing itself, creating odor. Additionally, there will be odors and dust particles from feed and animals themselves. Odorous compounds tend to be carried on dust particles and therefore, strategies to reduce odors from animal housing focus primarily on housekeeping measures that reduce dust emissions.

Filtration and Biofiltration

Some odors travel attached to particles. By effectively trapping particle emissions, odorous compounds can also be trapped. Mechanical filtration traps approximately 45 percent of particles between 5 and 10 μm and 80 percent of particles greater than 10 μm from animal housing areas. Mechanical filtration reduces the odor dilution threshold by 40 to 70 percent.

Biofilters trap particulates and also provide an environment for biological degradation of the trapped compounds. Biofilters have been developed to reduce odorous emissions from deep-pit, manure ventilation exhaust. Although mechanical filtration may be costly, biofiltration methods can inexpensively and effectively reduce exhaust odors. Biofiltration costs for a 700-head farrow-to-wean swine facility are estimated at $0.25 per piglet produced, amortized over a three-year life of the biofilter. Odor reductions at the facility exceeded 90 percent with similar reductions in hydrogen sulfide (90 percent) and ammonia emissions (74 percent). Similar odor and hydrogen sulfide reductions were observed using biofiltration on a dairy facility. The dust generated in a poultry facility, however, led to a poorer biofilter performance, with odor and hydrogen sulfide reductions of less than 40 percent.

Biofilters must be designed to provide suitable conditions for the growth of a mixture of aerobic bacteria within the biofilter. These bacteria will degrade the odorous compounds into less odorous end products. Oxygen concentration, temperature, residence time, and moisture content are among the parameters that must be considered when building a biofilter. Although management must be taken into consideration, it is clear that low-cost biofiltration systems ($150–200 per 1,000 cfm of air treated) can be implemented in livestock housing facilities.

Impermeable Barriers

Following the concept that odor is transmitted on dust particles, an alternative to filtering particles during air movement is to stop the movement altogether. Windbreak walls or air dams have proven effective in reducing both downwind dust particle concentrations and odor concentration. Windbreak walls have been constructed with 10-foot × 10-foot pipe frames and tarpaulins, and placed at the end of swine-finishing buildings, immediately downwind of the exhaust fans. Downwind dust and odor concentrations were reduced on demonstration facilities, in areas with the windbreak walls, due to plume deflection.
Depending on the materials used for the barriers (tarpaulins on a frame or solid wood, for example) barrier life can be from a few years to decades before replacement is needed.

**Oil Sprinkling**
Coating surfaces to control dust has involved the use of vegetable oil, either sprayed or sprinkled in animal pens. A Minnesota study reported a 40 to 70 percent reduction in odor, following a detailed protocol for oil application. Hydrogen sulfide concentrations were reduced 40 to 60 percent in the oil-sprinkled rooms. No effect on ammonia concentration was observed. The practice involves safety issues such as the slippery conditions of pens and alleys following repeated oil applications. Costs are minimal for the vegetable oil, and other costs involve a sprayer and the labor needed for the daily oil application.

**Landscaping**
Landscaping can reduce the emission of housing odors, as well as odors generated by other components of the livestock operation, beyond the property line. Landscaping acts as a permeable filter for particle emissions, slowing particulate movement and diluting concentrations of emissions. Trees and shrubs act as biofilters for odorous compounds that are attached to fine particles. By landscaping with both a treeline and a row of shrubs, particles at various heights within a plume can be adsorbed. To maximize adsorption, landscape materials with large surface areas are recommended. Trees and shrubs placed around the facility cannot impede ventilation and are often located on the property lines.

Costs associated with landscaping will vary depending on selected trees and shrubs, and on perimeter size. Estimates of a shelterbelt planted around a 3,000-head hog facility using “higher” cost trees ($25 per shrub or tree), calculated out to $0.68 per pig for one year, and amortized over 20 years at 5 percent, is just $0.09 per pig. These costs include maintenance costs. In addition to acting as a natural filtration system for odors, landscaping has the additional benefits of being aesthetically pleasing to the eye and of restricting the view of the operation. So, while documented effectiveness on emissions is scarce, the value of creating a facility that is pleasant to the eye cannot be underestimated.

**Dietary Manipulation**
An alternative to filtration of odors, as they leave housing facilities, is the reduction of the concentration of odorous emissions that can be produced upon anaerobic decomposition of the manure. Manipulation of livestock diets to alter excretion composition, and thus the odor of excretions, may be effective in housing areas. Swine studies have identified trends toward reducing odor intensity by reducing crude protein concentration. One study demonstrated reduced concentrations of odorous compounds when swine diets were formulated with crystalline amino acids, which caused a reduction in the dietary crude protein concentration. Odors should be reduced after altering the composition of manure and reducing the amount of odor precursors in it. Research to quantify reductions, after manure has been stored, are limited but some suggest as much as 20 percent odor reduction, when pigs are fed so as not to exceed their lysine and methionine requirements.

Dietary manipulation can reduce manure odors prior to excretion...
Odor Control Strategies for Manure Storage Facilities

Malodor (an odor that is undesirable) is the result of incomplete anaerobic decomposition of stored manure. During the decomposition process, malodorous intermediate compounds are produced and can accumulate if the populations of bacteria that degrade these compounds are insufficient. These accumulations result in odor nuisance. Following is a summary of practices that can be used to reduce odors from manure storage facilities.

Solids Separation

Solids separation by sedimentation, screening, filtration, or centrifugation allows for the removal of material that exceeds the screen-opening size. Often, in the case of ruminant manures, this is a fibrous material that resists decomposition during storage. By removing larger-sized material, thereby decreasing the loading rate, the life of the storage area can be extended. Decomposition of remaining stored material may benefit from removal of the poorly digestible material. Reduced odor emissions (intensity and concentration of odorants) from storage facilities are the result of improved decomposition. A 50 percent reduction in odor threshold from swine housing air samples was observed when a filter net was installed under the floor slats and daily removal of the solids collected on the net was conducted. This reduction may have been due, in large part, to the daily removal of material. Odor evaluation, following separation of dairy manure, showed no difference between separated and unseparated manure. Mechanical solids separators require a capital investment of $15,000 to $100,000. Typically, separation efficiency is much greater for ruminant manure because its particles are less uniform in size. Gravity settling (sedimentation) necessitates less capital investment but its impacts on odor reduction are undocumented.

Feedstuff selection may impact odor when manure is excreted or during manure storage. Studies with both pigs and dairy cattle demonstrated a trend of increasing odor intensity when diets contain higher concentrations of bloodmeal due to the amino acids that bloodmeal supplies in excess of animal needs when diets are formulated on a lysine basis only. Other studies have found that addition of peppermint to cattle diets improved odor of excreted manure. Fermentation characteristics of barley resulted in improved manure odor (25 percent reduction in odor intensity) compared to odor intensity from cattle fed sorghum diets.

Dietary manipulation can reduce manure odors prior to excretion as well as during manure storage, when anaerobic decomposition is taking place and odorous intermediate compounds are being formed. However, only a limited amount of research is currently available to indicate which diet regimens or ingredients cause odor reduction.

Reduced odor emissions . . . are the result of improved decomposition.
Anaerobic Digestion

Anaerobic digestion enhances a naturally occurring process by providing conditions suitable for complete decomposition of organic matter to low-odor end products. During the process, manure is contained in a closed system, preventing release of odorous emissions to the atmosphere. The use of anaerobic digestion has proven very effective in reducing manure odors both during storage and during land application. As much as a 50 percent reduction in dairy manure odor intensity was observed using a 20-day retention time of material in the digesters. Although generally thought to be a capital-intensive system, some estimates illustrate that anaerobic digestion is economically feasible for larger operations. An example of a budget shows that a positive net income per cow of $31 per year can be realized if methane is captured and used as an energy source. The following economic information, based on a 3,000-head swine finishing facility, is provided: $1.10 (20-year life) to $4 per head (10-year life) for initial construction, minus gas harvesting equipment; $40 per head capacity to install and purchase gas harvesting equipment; $3 per head capacity recaptured as income from energy produced. However, return on investment is largely related to investment costs and resale value of the energy generated. Typically, the operation must be able to utilize the energy it generates for anaerobic digestion to be affordable. This limits its use, largely, to dairy operations and some larger breeding and gestation facilities.

Additives

In a dilute manure handling system, bacterial populations are more likely to occur in quantities sufficient to provide a balanced production and utilization of intermediate degradation compounds. Addition of supplemental bacteria or enzymes may enhance the rate of processing because conditions are suitable for bacterial growth and function. Enzymatic or chemical additions are more likely to have a greater benefit on odor intensity in a dilute system than a slurry or solid system. Unpublished field reports indicate a direct relationship between lower levels of odor and the presence of anaerobic photosynthetic bacterial populations in lagoons. The anaerobic photosynthetic bacteria utilized many of the odorous compounds for bacterial growth. Reduced odor from lagoons where the pink-rose color is present, which is indicative of the populations, is likely the result of degradation and utilization of such odorous intermediates. Mode of action of many commercially available products remains unknown, but it is possible that some enzymes enhance biological decomposition of odorous compounds to less odorous end products. However, recommendations for modes of action or products that are routinely effective are not available.

Impermeable Covers

Covering a manure storage area with an impermeable cover prevents the release of odorous gases from manure storage into the atmosphere, and eliminates the effects of wind and radiation on emission rates. Odor reduction efficiencies of 70 to 85 percent have occurred, with reductions as great as 90 percent.
when surfaces are completely covered by impermeable covers. Polyethylene covers typically range in price from $1.00 to $1.40 per square foot, installed. Wind and snow-load damage present the greatest challenges with respect to implementation of the extended use of impermeable covers. Damage due to weather alters the life of the cover, impacting the capital investment required over time. Many manufacturers list a useful life of 10 years if the storage area is constructed to prevent snow accumulation on the cover, but no guarantee against wind damage is provided.

**Permeable Covers**

Permeable covers, or biocovers, act as biofilters on the top of manure storage areas. Materials often used as covers include straws, cornstalks, peat moss, foam, geotextile fabric, and Leka rock. Permeable biocovers reduce odor, in part, by reducing both the radiation onto the manure storage surface and the wind velocity over the surface of the storage area. Covers act as a barrier to these forces. At the solution/air interface, humidity is relatively high, which creates a stabilized boundary that slows the emission rate of odorous volatiles. The aerobic zone within the biocover allows the growth of aerobic microorganisms that utilize carbon, nitrogen, and sulfur for growth. By further degrading and making use of these compounds prior to exiting the biocover, odors emitted above the biocover are altered and reduced. Reports of odor reductions of 40 to 50 percent are common when various straw materials are used. An 85 percent odor reduction efficiency was noted following the use of a floating mat or corrugated materials.

Costs for biocovers vary widely depending on material used and method of application. In Minnesota, an operation employed a 1⁄8-inch thick geotextile material that cost $0.25 per square foot plus installation. Straw was added on top of the geotextile cover for additional odor control. Straws and cornstalks cost approximately $0.10 per square foot, applied; peat moss and foam cost about $0.26 per square foot, and Leka rock is approximately $2.50 per square foot for a 3-inch layer. Leka rock is a product of Norway, thereby requiring considerable shipping costs ($5 to $6/cubic foot). The cost to cover a 1.5-acre earthen storage was $6,000 while an above ground tank over 0.2 acre was $500, for the same material. Most recommendations suggest a minimum of 8-inch depth, preferably 10- to 12-inch depth of coverage on a manure storage surface. New covers (except Leka rock which may be a single application) need to be applied at least annually, as one study showed that only 50 percent of the straw cover remained four months after installation. Therefore, management and re-investment costs need to be considered. Removal of large, fibrous material during storage cleanout must also be considered before selecting this option.

**Aeration**

Because nuisance odor results from incomplete anaerobic processes, strategies to supply oxygen and maintain an aerobic environment can effectively control odor. Use of mechanical aerators on manure slurry or dilute manure storages will...
Composting is a better option for operations that handle solid manure.液态系统将需要某种干燥过程或大量造粒剂来避免在堆肥过程中产生气味。

干粪料存储
在开放式设施中，尘土和径流控制是管理牲畜设施中气味的主要手段。应允许良好的排水，并避免不必要的加水（例如，溢出的饮水机）。通常，使用开放区域进行饲养的牛肉或奶牛设施将使用垫料-床。控制这些设施中的气味的最佳方法是保持干燥的 bedding area 通过适当的维护。充足的 bedding 必须按常规添加。管理这些系统的指导方针，所需 bedding 量和吸收各种 bedding 材料的能力，可以在 MWPS-18 中获得（1993）。

Aerator on second-stage lagoon at swine facility will reduce hydrogen sulfide emissions, but may also increase ammonia emissions.

Facilities should be covered to prevent runoff due to precipitation, and if built on a compacted area, it will prevent leaching of nutrients. Odor reduction benefits are not well documented, despite conventional thought that composting can be an effective control practice for odor. Costs include construction of the site with a compacted floor and roof, and continuous maintenance of the compost, which involves equipment of appropriate size to turn (aerate) the pile. For example, a 4-foot × 6-foot × 3-foot deep pile may be turned more properly with a small skid loader whereas a considerably larger pile would be better handled with a front-end loader.

Composting is a better option for operations that handle solid manure. Liquid systems will require some type of drying process or a large amount of bulking agents to avoid odor during the composting process.

Compostig beef manure.

Aeration, by design, incorporates oxygen into the manure storage. Most commonly, mixing of the manure is used to introduce oxygen. During this process, N is volatilized to the atmosphere, primarily as ammonia. Therefore, aeration, although effective for reducing odor, can increase ammonia emission.

Composting
Composting can control odors because it maintains an aerobic environment in the manure. Disadvantages of composting include the high levels of management required to keep the process timely: minimal management leads to slow decomposition whereas intensive management can lead to quick decomposition. Another disadvantage is the need to bring in a bulking agent (newspaper, straw, wood chips) to maintain a balance of carbon to nitrogen (C:N) during the decomposition process. Loss of N to the atmosphere, primarily as ammonia, is a problem that needs to be weighed carefully when considering this option, particularly when controlling ammonia emissions is also an objective.
Strategies to Reduce Odors During Land Application

During land application of manure, producers are more likely to receive nuisance complaints. In addition to increased road traffic, manure spreading brings odors closer to nearby residents than when manure is in storage at the livestock facility. Therefore, measures to minimize odor nuisance during the time of manure application should be considered, in addition to odor control measures used during manure storage.

Injection and Incorporation

Injecting or incorporating manure shortly after surface application can best prevent odorous emissions that occur as result of land application. Estimated costs to inject manure are $.003 per gallon above the cost to haul and broadcast liquid manure. A portion of the added cost can be recaptured in the form of reduced nitrogen losses for injected manure versus broadcast application. Field tests in Iowa demonstrate odor reduction ranging from 50 to 75 percent with injection as compared to broadcast application. Based on these reports, greater benefits can be realized by incorporating manure after broadcast application.

Irrigation

Pivot irrigation systems can be a substantial source of downwind odor. Systems that spray close to the canopy can minimize dispersion of odorants by altering the dispersion plume. Nozzle selection may also contribute to improved odor control. Nozzles should be positioned to avoid application outside of property boundaries, and if possible, use low-rise, low-pressure or trickling systems to achieve maximum odor control of irrigated manure effluents. Systems that spray close to the canopy and employ appropriate nozzle position likely realize a uniform nutrient application as well. When pivot application is the most desirable means for nutrient application, careful timing of application will minimize nuisance.

Manure Additives

Manure additives have been widely debated as to their effectiveness in controlling odorous emissions. In general, there have not been any additives or classes of additives, so far identified, that routinely reduce odor during manure application. Costs are product-specific and often determined as much by application rate and frequency as by the cost per unit weight.

Timing of Application

Practices that do not involve physical changes to their existing operations should be implemented by producers. One such practice is timing of manure application. More frequent application and less time for manure storage is a more desirable practice from an odor control standpoint. However, best use of nutrients will occur when manure application coincides with the times when crops are most in need of manure nutrients. The compromise, then, is to apply manure in the
spring or fall, or both, and try to plan the applications when they will be least offensive to neighbors. Producers should avoid holidays and be aware of wind conditions so that their neighbors will be in the downwind direction as little time as possible. Notifying neighbors of manure application plans is also a very important strategy to be undertaken. Application in early evening, when air is still, is conducive to greater odor than at midday, when air is more turbulent, allowing odor to dissipate more readily.

**Conclusions**

Employing practices to control odor from livestock facilities can result in fewer nuisance concerns. Several practices are available but not all are suited for all operations. Careful consideration and selection of each practice will ensure the desired results. Regardless of the practice selected, common sense and consideration of neighbors are necessary components of a sound odor management plan.

### Resources

For a list of research reports, ISU Extension publications, and links to current news regarding air quality and animal agriculture, please visit the Air Quality and Animal Agriculture Web page at: http://www.extension.iastate.edu/airquality.


PM 1972a *Practices to Reduce Hydrogen Sulfide from Livestock Operations* is found on the Web at: http://www.extension.iastate.edu/Publications/PM1972a.pdf


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