PRACTICAL APPROACHES TO IMPROVE AIR QUALITY OF ANIMAL FEEDING OPERATIONS WITH PROPER FACILITY AND MANURE MANAGEMENT

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Introduction

The two most common sources of public complaints faced by owners and operators of animal feeding operations (AFOs) are emissions of excessive odor and dust. Depending on the animal species, housing type, and waste management method, manure may contain urine, feces, feathers, waste feed, and spent bedding material. Livestock and poultry odors are caused by noxious gases and volatile organic compounds emitted by animals and by the decomposition of manure. Dust also accompanies animal production. The dust from different types of AFOs may contain soil, poultry litter, spent bedding, and dried livestock manure.

Several practical approaches may be adopted by livestock and poultry producers to mitigate excessive odor and dust production from planned and existing animal manure and housing facilities. These approaches can also improve environmental air quality.

Siting of New Animal Facilities

When siting new animal facilities, including housing and waste storage and treatment structures, give special consideration to set-back distances, wind, and topography. An odor assessment tool also can help mitigate odor and dust problems with neighbors.

Animal feeding operations (AFOs) should maintain ample set-back distances from neighboring residents and public use areas such as parks, schools, and places of worship and from any known future commercial or residential development zones. A minimum set-back distance of 800 m is recommended (Mukhtar and Zhang, 1995).

Wind direction and topography directly influence the transport of odor and dust from an AFO to the surrounding area. Avoid locating buildings and manure storages directly upwind from neighbors. For example, if the predominant wind direction for a locality is from south to north, do not build animal facilities directly south of local residential and public-use areas.

Topographic features such as flat areas, hills, and valleys influence the transport of odor and dust from AFOs. Locate facilities on relatively flat terrains with good air movement to mix, dilute, and disperse odors. Sites with trees and shrubs will dissipate odors and screen the facilities from public view.

Avoid locating facilities on hilltops or near large water bodies, where atmospheric temperatures and wind direction can change abruptly and frequently. Air
carrying odors and dust can drain from a hilltop to the low terrain during the calm wind and stable atmospheric conditions that generally prevail from dusk to dawn.

When siting an animal facility, Harmon and Hoff (2007a) recommended minimizing the number of hours that the wind blows from AFOs (source) to the neighbors (receptor). Figure 1 shows the effect of site layout and distance on exposure angle. Exposure angle is defined as the sum of the wind angles when wind is blowing from source to a receptor for a minimum number of hours. As illustrated in Figure 1, the potential of wind carrying odors and dust from a source to a receptor is reduced when the facility is sited at smaller exposure angles and longer set-back distances.

Researchers have developed an animal facility siting tool called the Community Assessment Model (CAM) to minimize the odor exposure of a source (animal facility) to receptors (residences and public-use areas) in a community.

![Figure 1. Effect of source exposure angle and distance on odor and dust potential to downwind residences. (Source: Harmon and Hoff, 2007a).](image)

This odor-dispersion model has been used extensively since 2005 (Hoff et al., 2008) to evaluate the odor exposure from existing swine production systems to public use areas and residences in a community. The model also predicts how different odor-control technologies affect the odor exposure to receptors.

To use this odor-assessment tool, an on-site visit is conducted to assess and map community receptors and planned or existing animal-related odor sources. The mapped data is then used in CAM to predict the odor exposure from sources to receptors.

According to information provided by its developers, CAM can be used to determine the adequacy of a site for a new AFO of up to 20 animal production sources with as many as 100 receptors in a community of any size. Such tools will help in planning and locating new AFOs that may create conflicts with surrounding communities.
Best Management Practices (BMPs) to Minimize Dust and Odor from Existing Animal Facilities

Excessive odor and dust are the result of poor management of a facility and animal manure that create either highly wet (anaerobic) or dry conditions on the farm. AFOs that handle solid animal waste such as scraped manure from livestock feedlots (manure and soil scraped from unpaved surfaces) and litter (a combination of poultry excreta, waste feed, feathers, and bedding material) from poultry operations, need to be managed so that the waste accumulating in the facility is neither too wet to cause nuisance odor nor too dry to increase dust generation.

For example, Figure 2 shows the qualitative relationship between odor and dust potential in response to the moisture content of an unpaved beef feedlot surface. When the moisture content of the lot surface is between 25% and 40%, both odor and dust potential from this open lot are reduced. When the moisture content is below 25%, the potential for dust generation increases; when it is above 40%, the potential for odor emission increases.

Feedlot surfaces must be designed and managed to facilitate good drainage (Figure 3, left view) after rain events to prevent standing water or excessive moisture, which increases the likelihood of excessive odors. A poorly drained surface with thick, loose soil and manure (Figure 3, right view) will increase dust emissions when the feedlot is dry, and it will increase odors when it is wet.
Auvermann et al. (2000) and Rahman et al. (2008) recommended the following BMPs to reduce dust and odor potential from cattle feedlots:

- To promote good drainage, maintain a feedlot surface slope of 4% to 6%.
- Maintain the moisture content of the feedlot surface at between 25% and 40%.
- Scrape the feedlot surface once every 3 to 4 months to reduce excessive manure accumulation and maintain a thin (less than 5 cm deep) layer of manure.
- Properly compact the feedlot surface and subsurface layers to prevent excessive loosening of manure by cattle hoof action.
- To reduce dust emission, maintain a stocking density of 14 m$^2$ per animal to discourage excessive cattle activity and hoof action.

Mukhtar et al. (2001, 2004) suggested the following BMPs to reduce odor and dust from indoor poultry growing facilities such as broiler (meat chicken) and turkey barns where birds are raised on litter:

- Maintain the moisture content of poultry litter between 30% and 35% to reduce odors and dust.
- Operate the barn ventilation system at or above minimum recommended rate, and keep the fans and fan shutters clean and fan belts properly maintained. Dirty fans, shutters, and worn-out belts reduce air flow by more than 30%.
- Replace the water-misting system with evaporative cooling pads. If using a water-misting system, adjust it properly to avoid excessive litter wetness.
- Ensure that the correct flow of water is provided to evaporative cooling pads, and prevent water leaks on the litter.
- To reduce water spillage on the litter, replace bell-type water drinkers with more efficient nipple drinkers.
- Compost the litter before applying it to land. Properly composted litter reduces the noticeable odors during transportation and land application.
- Land application of manure and litter generates a significant number of neighbor complaints. Mukhtar et al. (2004), and Mukhtar and Zhang (1995)
recommended the following BMPs for land application of animal waste to reduce odor and dust nuisance:

- Transport litter or manure to the field in properly covered and spill-proof vehicles, and avoid public roads with heavy traffic.

- Apply manure or litter at correct amounts, based on the results of soil tests and the nutrient needs of plants. If too much manure is applied, excessive dust and odor result, and the risk of water quality impairment is increased.

- Apply manure or litter when wind is blowing away from the neighbors. Avoid land application during weekends and holidays.

- Apply manure or litter early in the morning when temperatures are lower and air flow patterns will lift odors high up into the air and disperse and dilute them. Avoid hot, still afternoons or extremely windy days, when scraped manure or litter is likely to generate dust during application.

- Do not apply litter or manure during or soon after rain or when rainfall is imminent.

- When and where possible, inject or incorporate manure or litter into the soil to reduce odors and dust and to prevent loss of nutrients in the runoff.

- To minimize odor, use low-trajectory manure spreaders, big gun nozzles, or an irrigation system for surface application.

Other methods of controlling odor and dust transport from source to receptors include installing windbreaks such as evergreen trees and walls and using biofilters to filter exhaust air from ventilated animal housing and manure structures.

Windbreaks serve two purposes. As shown in Figure 4, an entire facility can be hidden from public view to help reduce the perception of odors (Harmon and Hoff, 2007b). Windbreaks also filter dust and promote the quicker dissipation of odors by diverting the polluted air plume vertically and diluting and dispersing it in the wind.

Also, the transport of dust to downwind neighbors has been reduced by properly designed and installed windbreak walls (generally 4-m high) of wood, metal, UV-resistant tarpaulin or plastic material. The walls are installed in front of the exhaust fans of tunnel-ventilated swine or poultry buildings at a distance of four to five times the fan diameter (Bottcher et al. 2001).

![Figure 4. A windbreak around a swine barn (Source: Harmon and Hoff, 2007b).](image-url)
Studies also show that dust and odorous gases in the exhaust air from liquid manure pit fans or from ventilated livestock and swine buildings can be effectively removed (50 to 90% reduction) by filtration and treatment with biofilters (Harmon and Hoff, 2007b; Nicolai and Schmidt, 2005).

Biofilters are typically constructed from a mixture of compost and woodchips and designed to retain polluted air in the filter for 3 to 4 seconds. When properly designed and maintained, biofilters efficiently convert odorous air into carbon dioxide and water at biofilter temperatures of between 20°C and 32°C, and at moisture contents of between 40% and 60% (on a wet basis).

Dairy, poultry, and swine operations that store and/or treat freshly excreted or flushed manure either in pits inside the building or in outdoor slurry tanks and lagoons, are generally concerned with emission of nuisance odor rather than dust. To reduce odor emissions, manage waste storage pits and treatment structures properly:

- Remove manure from barn gutters and alleys as quickly as possible.
- Fill shallow pits with about 5 cm of water and recharge deep pits with water.
- Avoid overloading pits and treatment lagoons with manure.
- Do not dump dead animals in lagoons.
- Manage the lagoon sludge properly and remove it at the intervals prescribed in the lagoon maintenance plan. Excessive sludge and organic matter promote nuisance odors and reduce the dilution and treatment of waste.

Improper handling and disposal of farm mortality increases potential for odors, propagates disease, and threatens soil, water, and air quality. Quickly isolate and dispose of dead animals properly within 24 to 48 hours. Transport dead animals in covered and leak proof containers to offsite disposal facilities.

References


