Lesson 41

Emission Control Strategies for Building Sources

By Larry Jacobson, University of Minnesota; Jeff Lorimor, Iowa State University; Jose Bicudo, University of Kentucky; and David Schmidt, University of Minnesota

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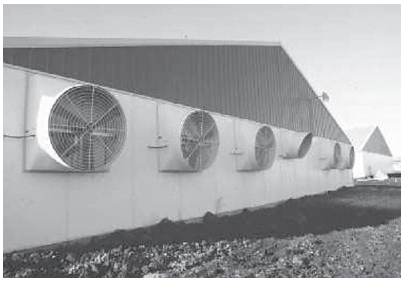

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Disclaimer

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Intended Outcomes

The participants will

- Understand odor emission potential from building sources.
- Determine the best technology for controlling odor/gases from their buildings based on
  - Effectiveness.
  - Cost.

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Activities

- Lecture with slides and video
- Show products/demonstrations
- Develop checklist of technologies for each participant

PROJECT STATEMENT

This educational program, Livestock and Poultry Environmental Stewardship, consists of lessons arranged into the following six modules:

- Introduction
- Animal Dietary Strategies
- Manure Storage and Treatment
- Land Application and Nutrient Management
- Outdoor Air Quality
- Related Issues

Note: Page numbers highlighted in green are linked to corresponding text.

Introduction

Odors and gases are emitted from the buildings that house livestock and poultry by (1) ventilation fans or (2) buoyancy or wind forces in naturally ventilated barns. Methods to reduce these odors and gas emissions are less well documented than either manure storage facilities or land application control methods. Of the three sources (buildings, storages, and land application), buildings are believed to release a relatively constant amount of the total odor and gas emissions generated. Building emissions, combined with releases from the manure storage facility, form the "baseline" emission levels from an animal production operation. The two approaches to minimizing odors from buildings are (1) minimize the odor generated and (2) treat the odor as it exits the building. This lesson will discuss both approaches. To better understand the odor risks associated with your own confinement livestock or poultry housing, an Animal Housing self-assessment tool (see Appendix A) is provided to assist you in a review. A similar tool is provided at the end of Lesson 42, Controlling Dust and Odor from Open Lot Livestock Facilities, which addresses odor and dust issues associated with open lot production systems.

Of the three sources (buildings, storages, and land application), buildings are believed to release a relatively constant amount of the total odor and gas emissions generated.

Minimizing Odor Generation

Manure removal management and housecleaning

Manure, wet feed, and other products that could produce odors in buildings should be removed regularly. This list includes dust buildup both on the inside and on the outside of buildings but especially inside animal housing facilities. Odor from floor surfaces will be reduced if the floors are kept clean and dry.

Control of odors from under-floor manure pits depends on the type and length of manure storage. Manure stored longer than five days will generate more offensive gases. Undiluted liquid manure has a large potential for odor production. Therefore, to reduce odors from shallow gutters with pull plugs, the manure should be removed at least once a week. Often, weekly cleaning is not a standard practice but may become so if odor control is the main objective.

One method of shallow gutter management to enhance odor control that is still being debated is the practice of using recharge water, which is required for weekly cleaning of pull-plug systems. Some facilities use clean recharge water, some recycle recharge water, and others do not recharge their shallow gutters. Anecdotal evidence suggests that using clean or "treated" recycled recharge water may reduce odorous emissions compared to using no recharge water. These reductions are likely to be very dependent on the quality of recharge water.

Summary. The potential for odor production can be reduced by instituting good housecleaning and management practices for the manure handling system in the animal housing. The amount of odor reduction is not well documented and is difficult to assess, but most experts think that odor reduction should be measurable and noticeable by both workers and those living near the housing facilities.

The potential for odor production can be reduced by instituting good housecleaning and management practices for the manure handling system in the animal housing.

Bedded systems

Using solid manure systems rather than liquid manure systems is generally considered to reduce odor. Although gases and dust are emitted from solid or bedded systems, most people feel that odor from bedded

systems is less objectionable than the odor from liquid systems. Using bedding/dry manure systems for animals is generally considered to be more environmentally acceptable from both water quality and outdoor air quality viewpoints.

Anecdotal evidence suggests that organic bedding such as straw, cornstalks, compost, wood chips, or newspaper may reduce odor emissions. European research supports the use of some type of bedding (especially sawdust) to reduce odor generation/levels in buildings and subsequent odor release or emission (Nicks et al. 1997). Relatively small bedding levels may be enough to have an effect on odor generation/emission. Until liquid systems were adapted, primarily for convenience, bedding had been used for livestock production for generations. Many dairy and poultry facilities still use dry or solid manure systems.

Hoop structures have recently become popular for a few swine and dairy producers, in part due to their odor control effectiveness. They feature a deep-bedded pack system using straw or other crop residues to provide animal comfort and soak up manure liquids. Bedding availability is crucial for solid manure systems except for high-rise layer houses. Hoop structure bedding requirements for finishing swine are estimated to be 200 pounds of baled cornstalks per pig marketed. MidWest Plan Service (MWPS) publications AED-41 and -44 give details on using bedded hoop structures for swine production.

Summary. Using solid manure systems rather than liquid manure systems is generally considered to produce less odor. Controlled studies to quantify odors from the two different systems are underway, but most people feel that odor from bedded systems is less objectionable than odor from liquid systems. Manure systems that use bedding for any animal species seems to reduce odor. Many modern layer facilities are high-rise units that store the manure as a solid product. Broilers and turkeys use litter systems effectively.

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Vegetable oil sprinkling

Airborne dust, a common problem inside animal housing facilities, has been linked to both human and animal health concerns. Since suspended dust particles can and often do absorb toxic and odorous gases, the reduction of the airborne dust concentrations inside buildings lowers the odor and gas emissions from these animal housing facilities. Research has shown that sprinkling various types of vegetable oil inside pig buildings reduces the indoor airborne dust levels.

Description. Detailed information on sprinkling vegetable oils in pig barns is given in the MWPS publication AED-42 (Zhang et al. 1997). Oil can be applied manually with a hand-held sprayer or automatically with a permanently installed sprinkler system. Once-a-day application is recommended. It is important to operate the oil-sprinkling equipment so the droplet size is neither too large, which results in poor distribution, nor too small (aerial mist), which may be a health hazard for the animals. Operating the spray nozzles within pressure and temperature limits of the suggested vegetable oils can control droplet size. The MWPS publication gives the recommended levels for such oils as canola, corn, flax, soybean, and sunflower.

Research data. Oil-sprinkling research (Takai et al. 1993) indicates reductions in dust levels, and in one case (Zhang et al. 1996), reduction of odorous gases like hydrogen sulfide and ammonia. Dust levels were lowered 80%, while hydrogen sulfide and ammonia concentrations were reduced 20% or 30%, respectively, in these studies.

Research has shown that sprinkling various types of vegetable oil inside pig buildings reduces the indoor airborne dust levels.

Research conducted at the University of Minnesota (Jacobson et al. 1998) showed total dust concentrations were reduced considerably by oil sprinkling (Figure 41-1). Dust levels in the oil treatment room were about 40% of the dust levels in the control room. Respirable dust levels (the fraction that reaches the human lung), however, did not follow this trend, showing similar concentrations for both the control and treatment rooms. Reasons for the inconsistent results are difficult to determine but may be related to the fact that once-a-day sprinkling may only reduce the large particulate (feed and fecal) materials and not smaller airborne particles.

Also during this same study, an average odor reduction of 50% was seen in an oil-treated pig nursery compared to an untreated control pig nursery (Figure 41-2).

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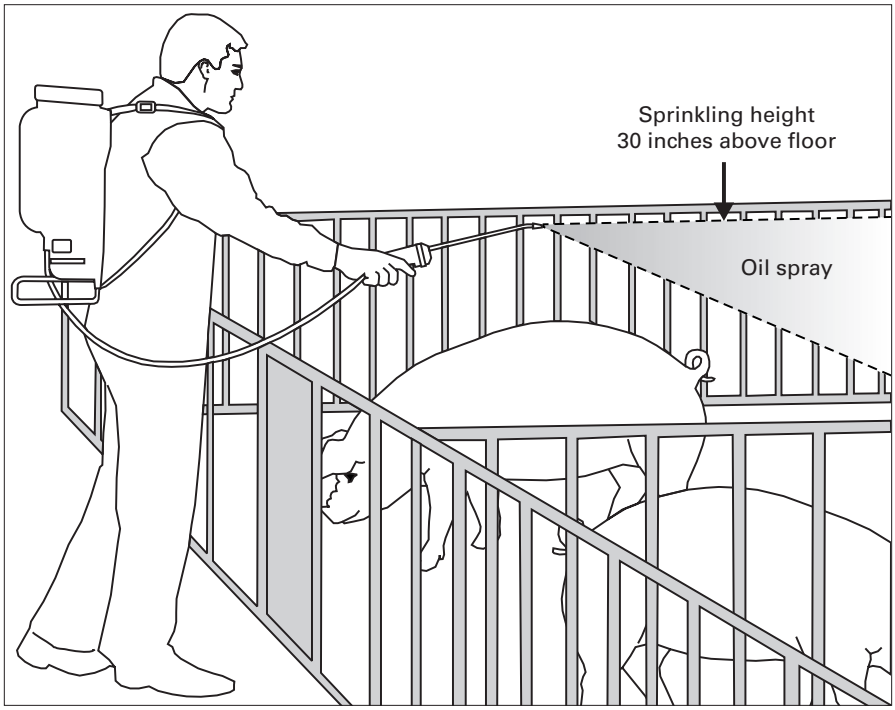

Figure 41-1. Applying oil in oil treatment room.
Source: MWPS, AED-42.

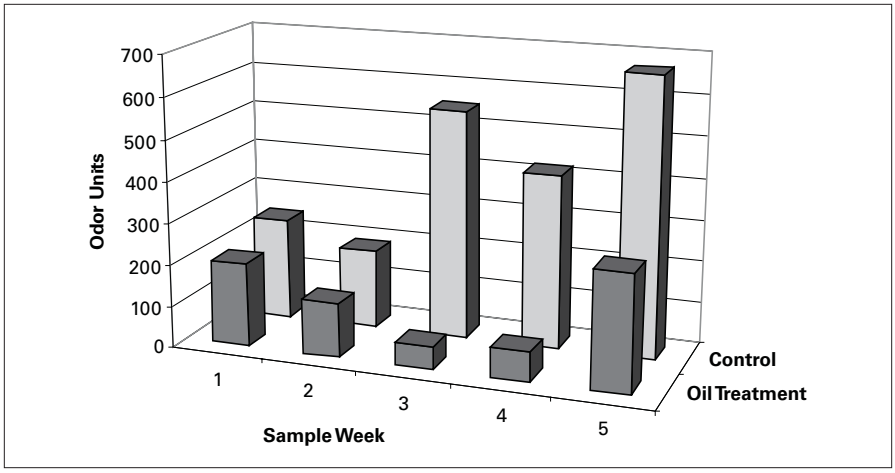

Figure 41-2. Odor levels in rooms.

Hydrogen sulfide levels were reduced about 60% in the rooms sprinkled with oil, but ammonia levels were unaffected by the oil treatment.

Oil sprinkling in the pig nursery barn did not have the same effect on individual gas concentrations. Hydrogen sulfide levels were reduced about 60% in the rooms sprinkled with oil, but ammonia levels were unaffected by the oil treatment.

Challenges. Compared to the control room, extra labor was needed to clean the oil treatment room after each group was moved out of the respective buildings. Producers may want to add a "presoak" segment to their cleaning protocol to aid the cleanup of surfaces in these facilities, which will lead to additional wash time. To be used at the farm level, an automated system is needed to deliver the oil in the building, as opposed to using hand-held sprayers. Existing presoak sprinkling systems may potentially be modified to accomplish this with the aid of timers, oil injection pumps, and solenoid valves.

Summary. As outlined in the MWPS publication AED-42, daily sprinkling of very small amounts of vegetable oil inside an animal facility reduced the odor, hydrogen sulfide, and total dust levels of the air inside the barn and in the exhaust ventilation air. Oil sprinkling was less effective in reducing ammonia concentrations or respirable dust levels inside the treated barn.

Washing walls and other wet scrubbers

Using water to scrub odorous dust, ammonia, hydrogen sulfide, and other gases from the airflow of swine building ventilation fans can be an effective method of controlling odor.

Using water to scrub odorous dust, ammonia, hydrogen sulfide, and other gases from the airflow of swine building ventilation fans can be an effective method of controlling odor. Many industrial air pollution control systems use sprays of water to scrub dust, ammonia, sulfur oxides, and nitrous oxides from various polluting air streams. In a wet scrubber, an alkali is usually added to react with acidic pollutants.

A wet scrubber design that recirculates most of the water through the system has been tested in North Carolina (Bottcher et al. 1999). This design involves a wetted pad evaporative cooling system installed in a constructed wall about 4 feet upwind of ventilation fans and downwind of the pigs in a tunnel-ventilated building (Figure 41-3).

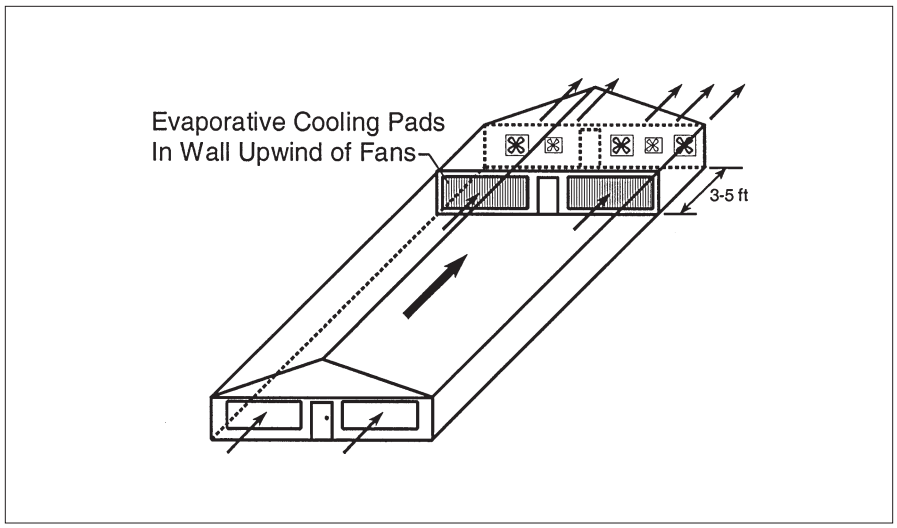

Figure 41-3. Evaporative cooling pad installed as a wet scrubber in a tunnel-ventilated swine building.
Source: Bottcher et al. 1999.

Measurements taken by Bottcher et al. (1999) show that the system reduces total dust levels over 60% at low ventilation rates but only by about 20% at a high airflow rate typical of maximum hot weather ventilation. Although the changes in odor levels across the wetted pad scrubber were not as great as desired at the high ventilation rate, the data does indicate a modest odor reduction, consistent with the dust reduction. These results agree with other observations that dust removal from swine building airflow is associated with odor reduction. The wetted pad wall also reduced ammonia levels in the ventilation airflow by 50% at low ventilation rates and by 33% at medium ventilation rates.

Summary. A wet scrubber can reduce dust and gases. Wetted pad wall installation costs are approximately $5.70 per pig space for an 880-head finishing building (Swine Odor Task Force 1998). The main operating cost is the 1-hp water pump, which will cost about $600 annually. The wetted pad wall does not impose a significant airflow restriction on the building fans. Maintaining adequate airflow is important if a healthy indoor environment is to be provided for the animals in warm weather.

Chemical additives

In some instances, chemical additives are an option for odor or gas emission control. One application where additives were shown to be effective is the addition of alum to poultry litter. Moore et al. (1995) reported on a number of products that reduced ammonia volatilization from poultry litter, including alum, which provided a 99% reduction in ammonia volatilization when 200 g/Kg (20%) was added to the litter in broiler houses. Many other additives for both liquid and solid manure are on the market. A recent laboratory study tested 35 different manure pit additives (NPPC 2001) and found that only four products reduced odor by a 75% "certainty" level. Approximately 10 products reduced H_2S by either a 95% or 75% certainty level while 12 products lowered ammonia by the same percentages. Until the mechanisms for the various products are understood so reliable performance can be predicted, the additional costs for additive products may be hard for producers to justify.

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Ozonation

Description. Ozone is a powerful oxidizing agent and a very effective natural germicide. Ozone high in the atmosphere protects the earth from solar radiation. At ground level, however, the gas can be toxic at high levels. The current OSHA permissible exposure limit for ozone is 0.1 part per millon (ppm) for an 8-hour, time-weighted average exposure (OSHA 1998).

Ozone has been used to treat drinking water on a municipal scale since 1906, when it was installed in the treatment facilities for the city of Nice, France (Singer 1990). More than 2,000 water treatment works, primarily in France and other European countries, now use ozone for disinfecting, taste, and odor control of water supplies (Tate 1991). Currently, about 100 water treatment plants in the United States and Canada use ozone (Droste 1997).

Ozone generators are sold to "freshen" the air in offices and industrial facilities. A number of commercial ozone generators are currently being sold as residential air-cleaning devices.

The molecular arrangement of ozone is three atoms of oxygen (O_3). Ozone is unstable and reacts with other gases, changing their molecular structure. At low concentrations of 0.01 to 0.05 ppm, ozone has a "fresh or

outdoor smell" associated with it. At higher concentrations, it begins to smell like an "electrical fire." The decomposition of ozone to oxygen is very fast. The half-life of ozone can reach 60 minutes in a cool, sterile environment and is near 20 minutes in typical conditions. In dusty animal houses, however, it may be much less. The most common products of the complete oxidation process are water vapor and carbon dioxide. Ozone reacts with and oxidizes most organic material. Thus, the relatively high level of indoor odors and dust in livestock buildings, the ability of ozone to oxidize pollutants, and the potential for ozone to be rapidly depleted continue to make the ozonation of indoor air an attractive but controversial technology for reducing emissions from animal facilities.

Application in animal facilities. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)(1989) determined that ozone is **not** an effective means of eliminating odors in ventilated air inside of buildings, but several ozone systems are on the market, and some are being tested on livestock farms with encouraging results.

In a 16-month experiment, Priem (1977) found that ozone (at concentrations up to 0.2 ppm) reduced ammonia levels in a swine barn by 50% under winter ventilation conditions and by 15% under summer ventilation conditions. Researchers at Michigan State University reduced odorous compounds and disease-causing bacteria by treating swine manure slurry with high concentrations of ozone (Watkins et al. 1996). In this study, ozone was bubbled directly into fresh and stored swine manure in a continuously stirred batch reactor. Ozone concentrations of 1, 2, and 3 mg/l were used. Olfactometry determinations showed a significant odor reduction in ozonated manure samples in comparison to raw and oxygenated samples. More specifically, hydrogen sulfide concentrations were reduced slightly, while sulfate concentrations concurrently increased.

Researchers at North Carolina State University are evaluating a commercial ozone air treatment system in a tunnel-ventilated swine-finishing house at safe ozone levels for odor and dust reduction (Keener et al. 1999, Bottcher et al. 2000). Ozonation decreased ammonia levels 58% and total dust 58% compared to the control building, both at high ventilation rates. The concentration of dust particles with optical diameters less than 1 mm were lower in the ozonated house than in the control house. However, an olfactometry panel did not measure significantly different levels of odor parameters in the air samples from the ozonated and the control buildings. The reason for the difference between field observation and laboratory evaluation is still being investigated. More testing is needed before the ozonation of lagoons or of the air inside swine facilities can be recommended.

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Summary. A limited number of published studies has evaluated the use of ozone for odor reduction in animal production facilities. Ozonation can potentially reduce odors in livestock facilities by killing the odor-producing microorganisms and by oxidizing the odorous metabolites. When oxidized, most compounds are reduced in odor intensity.

Diet manipulation

Nutrition may become one of the most important means of reducing emissions from livestock and poultry facilities. Research has begun to focus on the effect of diet on odor and gas emissions from animal manure, already showing that reducing the amount of protein in animal diets reduces the potential emission of ammonia from manure.

Nutrition may become one of the most important means of reducing emissions from livestock and poultry facilities.

Much of the feed animals consume is excreted. After excretion, microorganisms break down this undigested feed, along with the other partially digested material in the feces and urine. During the microbial degradation of manure, gases are given off. Research has identified at least 168 gaseous compounds resulting from the anaerobic decomposition of manure; of these compounds, 30 are responsible for the majority of manure odors (O'Neill and Phillips 1992). These odorous compounds can be placed into the general groups of carboxylic acids, alcohols, phenolics, aldehydes, mitroheterocycles, mercaptans, amines, and sulfides (Zhu et al. 1997). Many of these compounds contain nitrogen or sulfur. Much of the research on reducing odor through diet focuses on reducing nitrogen and sulfur intake. Other odor reduction research focuses on improving the digestibility and/or balance of various feed ingredients. To date, most of the work on odor control through dietary formulations has focused on the swine industry.

Sutton et al. (1998) reduced many gasous compounds through dietary (1) changes in protein and synthetic amino acids and (2) reductions in copper sulfate and ferrous sulfide. With a low-sulfur starter diet, Shurson et al. (1998) produced from 2% to 40% reductions in swine odor concentrations.

Limited research has shown decreases in ammonia emissions with increases in cellulose and other nonstarch polysaccharide sources in swine diets. In one such study, adding coconut meal, soybean hulls, or dried sugar beet pulp reduced ammonia levels from 6.4% to 35.8% (Canh et al. 1998). This research did not evaluate odor emissions; however, this type of research does indicate that gas emissions can be altered by simple dietary changes.

Other less traditional research has shown that there is also the possibility of masking manure odor through dietary changes. For instance, researchers at Clemson University showed that adding garlic powder to chicken diets resulted in a less offensive smell inside the facility. Not enough research has been conducted in this area to determine the impact of such odor-masking technology.

Dietary changes to reduce odor emissions offer little economic benefit. Typically, diet formulations that reduce odor are more costly than a traditional diet. However, if state and local regulations require the use of some odor reduction strategy, implementing dietary changes may be one of the least costly methods of odor reduction.

Summary. Diet manipulation to minimize odors is becoming an accepted concept. Odor generation may be reduced by adjusting animal diets to minimize the overfeeding of nutrients that might contribute to odors. The primary challenge with developing dietary formulations for odor control is maintaining a balance between odor control and the animal's health and performance. Dietary changes may also impact the quality of meat, egg, or milk products. The research to monitor these unintended effects takes time and is costly. This concept is discussed at length in Lesson 10, Reducing the Nutrient Excretion and Odor of Pigs Through Nutritional Means.

Odor generation may be reduced by adjusting animal diets to minimize the overfeeding of nutrients that might contribute to odors. The primary challenge with developing dietary formulations for odor control is maintaining a balance between odor control and the animal's health and performance.

Treating Odor Emissions from Buildings

Biofilters

Concept. Biofiltration is an air-cleaning technology that uses microorganisms to break down gaseous contaminants and produce non-odorous end products. It is used successfully around the world for treating a wide range of air emissions from industrial sources. Biofiltration works well

Biofiltration is an air-cleaning technology that uses microorganisms to break down gaseous contaminants and produce non-odorous end products. It is used successfully around the world for treating a wide range of air emissions… .

for treating odors because most odorous emissions are made up of compounds at low concentrations that are readily broken down by microorganisms.

The microorganisms in a biofilter break down (i.e., oxidize) airborne volatile organic compounds (VOCs) and oxidizable inorganic gases and vapors in the odorous exhaust air. The byproducts of the process are primarily water, carbon dioxide, mineral salts, some VOCs, and microbial biomass.

Description. Figure 41-4 illustrates a typical open face biofilter. Odorous air is exhausted from the building with wall or pit ventilation fans that are connected by a duct to the biofilter plenum. The plenum distributes the air evenly across the biofilter media. A supported porous screen holds the media above the plenum. The air passes through the media before it is exhausted to the atmosphere. As the air passes through the biofilter, the odorous gases contact the media and are absorbed onto the biofilm where they are degraded by aerobic microorganisms.

Biofiltration use on livestock facilities began in Germany in the late 1960s and in Sweden in 1984 (Zeisig and Munchen 1987, Noren 1985). Biofilters on pig and calf sheds had average efficiencies around 70% (Scholtens et al. 1987). Nicolai and Janni (1997) reported an average odor reduction of 78% (minimum of 29% in April and maximum of 96% in August) from a pilot-scale biofilter built to treat air exhausted from a pit fan on a farrowing barn in Minnesota. Hydrogen sulfide and ammonia concentrations were reduced an average of 86% and 50%, respectively. The pressure drop across the media (which indicates how much the filter media restricts airflow) ranged between 0.10 and 0.19 inches of water (25-47 Pa).

The average odor reduction was 82% during the first 10 months of operation. During the same period, the average hydrogen sulfide reduction was 80% and ammonia reduction was 53%.

Data from a full-sized biofilter used to treat the exhaust air from a 700-sow gestation/farrowing swine facility were reported by Nicolai and Janni (1998b, c). The average odor reduction was 82% during the first 10 months of operation. During the same period, the average hydrogen sulfide reduction was 80% and ammonia reduction was 53%. Total pressure drop across the fans reached a maximum of 0.4 inches of water, 0.2 inches of that could be attributed to the building's ventilation inlet system.

The amortized construction and operating costs over three years for this full-sized biofilter were $0.22 per piglet produced per year. Rodent control costs were $275 per year. Additional operating costs of $125 per year included sprinkling costs and costs of operating the higher power ventilating fans (Nicolai and Janni 1998b, c). In general, initial costs for a biofilter are

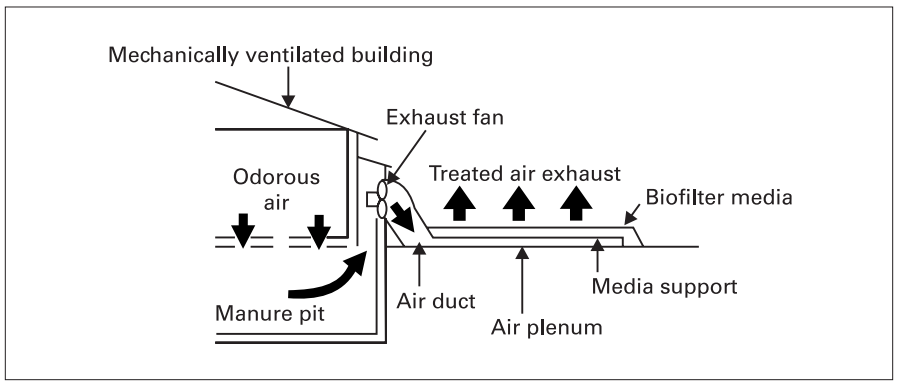

Figure 41-4. Typical open face biofilter layout.

approximately $0.10/cubic feet per minute (cfm) of ventilation air with annual operating costs of $0.02/cfm.

Design and management. Recent research has led to the following recommendations for biofilters used to treat air from swine and dairy facilities:

- Provide a residence time (amount of time the ventilation air is in contact with the media) of at least 5 seconds. This amount of time has resulted in 80% to 90% odor reductions; longer times do not increase this already high level of efficiency.
- Use a biofilter with a minimum depth of 10 inches.
- Ensure a flow rate of 20 cfm per square foot of biofilter area.
- Maintain the moisture level of the biofilter media at approximately 50% wet basis.
- Purchase fans with the capability of moving sufficient air exchange at a total static pressure (includes pressure drop of the barn's air inlets as well as the biofilter's media) of 0.4 inches of water. When designing a biofilter, consider this pressure drop and its impact on the ventilating system.
- Implement and maintain a rodent control program.
- Limit vegetative growth on the biofilter surface.

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While media selection is important, many common materials can be used for a biofilter, including dark red kidney bean straw and compost (Nicolai and Janni 1997), shredded wood and compost (50% by weight) (Nicolai and Janni 1998a, b, c), and even shredded wood and soil (50% by weight). Shredded wood is used to increase porosity, making it easier for the air to flow through the biofilter. Wood maintains biofilter porosity longer than straw. Compost and soil are a source of microorganisms and nutrients.

Continual excessive moisture can lead to increased airflow resistance (pressure drop) and limited oxygen exchange that could create anaerobic zones. Insufficient moisture leads to drying, microbe deactivation, and channeling, which reduce contaminant removal efficiency.

If present, mice and rats will burrow through the warm media in cold winter months, causing channeling and poor treatment. Rabbits, woodchucks, and badgers have also been suspected of burrowing through and nesting in biofilters.

Finally, excessive vegetative growth on the biofilter surface can reduce its efficiency by causing channeling and limiting oxygen exchange. Root systems can cause plugging, and noxious weeds need to be removed before they produce seed. Excessive vegetative growth may also detract from the site's aesthetic appearance.

Summary. Biofilters effectively reduce odor, hydrogen sulfide, and ammonia emissions from mechanically ventilated livestock buildings. While simple in appearance, they are rather complex biological systems that need to be designed and managed properly to perform well and prevent ventilation problems. Research is continuing to demonstrate their performance and to develop better design and management recommendations.

Biofilters effectively reduce odor, hydrogen sulfide, and ammonia emissions from mechanically ventilated livestock buildings. While simple in appearance, they are rather complex biological systems that need to be designed and managed properly to perform well… .

Windbreak walls

Walls erected downwind from the fans that exhaust air from tunnel-ventilated poultry buildings are being used on more than 200 farms in Taiwan to reduce dust and odor emissions onto neighboring land. These structures,

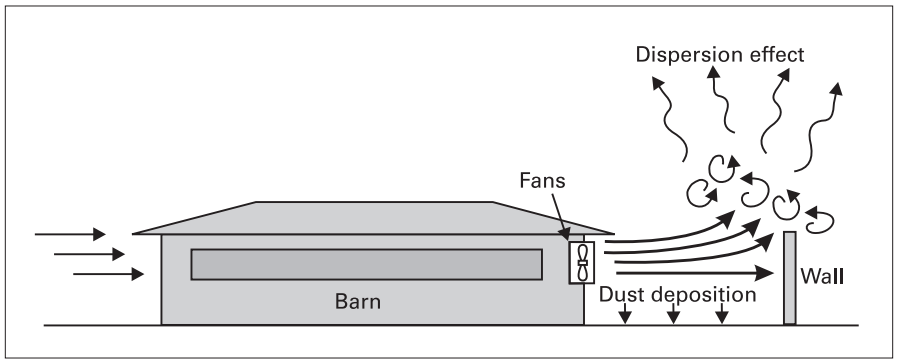

Figure 41-5. A tunnel-ventilated barn with a windbreak wall.

Windbreak walls work by reducing the forward momentum of airflow from fans, which is beneficial during low-wind conditions... .

known as windbreak walls, provide some blockage of the fan airflow in the horizontal direction. They can be built with various materials covering a wood or steel frame; plywood and tarps are common. The walls are placed 10 to 20 ft downwind of the exhaust fans of tunnel-ventilated barns (Figure 41-5).

Another variation of the windbreak wall is called a straw wall. These systems have been used in North Dakota and elsewhere. They are made with wooden structures and "chicken wire." Straw is placed inside the structures, providing a barrier to dust and other air emissions. They may also offer some filtration capability.

Windbreak walls work by reducing the forward momentum of airflow from fans, which is beneficial during low-wind conditions, because odorous dust settles out of the airflow and remains near the barn. In addition, the walls provide a sudden, large vertical dispersion of the exhausted odor plume that acts to mix fresh outside air into the odor plume at a faster rate than would naturally occur, providing additional dilution potential.

The data and observations taken by Bottcher et al. (1998) using scentometers at a full-scale windbreak wall site in North Carolina showed that

- Dust builds up on wall surfaces.
- The walls redirect airflow from the building exhaust fans upward.
- When wind speeds are low and blowing from the buildings toward the lagoon, the walls move the fan airflow upward so that it blows 10 ft or more above the lagoon surface. Without the windbreak wall in place, the fan air flows directly on top of the lagoon surface.
- Dust and odor levels are greater in the airflow from the fans than they are 10 ft downwind of the windbreak wall, because the fan airflow is deflected upward.

...tall wind barriers placed around a manure storage or lagoon...[may] reduce odor emissions... .

A model study done in Iowa predicted that tall wind barriers placed around a manure storage or lagoon would reduce odor emissions (Liu et al. 1996). Anecdotal evidence suggests a swine farm located in Minnesota benefited when a steel wall was built around an earthen storage basin. Although the operating cost of windbreak walls is relatively low, periodic cleaning of odorous dust from the walls is necessary for sustained odor control, unless rainfall is sufficient to clean the walls. Installation of windbreak walls is estimated to cost at least $1.50 per pig space (e.g., $1,500 for a building that houses 1,000 pigs).

Summary. Research to evaluate windbreak walls and barriers for dust and odor control is continuing. However, it is difficult to determine the

effectiveness of windbreak walls. As wind speed and direction shift, the airflow from building fans changes direction. As a result, it is difficult to measure odor downwind. Also, windbreak walls may not be suited for animal buildings equipped with multiple fans at non-uniform locations around the building.

Research to evaluate windbreak walls and barriers for dust and odor control is continuing.

Biomass filters

Researchers at Iowa State University have tested biomass filters as a means of removing odorous dust from swine buildings (Hoff et al. 1997a). Biomass filters use the principle that dust, if removed from the ventilation exhaust stream, will capture a large portion of the odors with it. Hoff et al. (1997b) were able to demonstrate a relationship between scrubbing dust and odors in controlled laboratory experiments and in a full-scale field trial. Using inexpensive material, a biomass filter removes odorous dust from the air stream. The biomass consists of either chopped cornstalks or corn cobs (Figure 41-6), but other materials can be used. Both odor and dust levels were significantly reduced: odor by 43% to 90% and dust by 52% to 83%. These reductions occurred with low resistance to airflow at cold weather ventilation rates.

Using inexpensive material, a biomass filter removes odorous dust from the air stream.

Summary. Biomass filters are a cross between biofilters and the windbreak walls previously described. Instead of a horizontal filter bed as shown for the biofilter design, the filter material is vertical like the windbreak wall design but connected to the building so the exhaust air is forced through the biomass filter materials. The cost of this dust and odor control technology is not as well documented as other listed control technologies, but it is probably similar to biofilters in both initial and operating costs.

Biomass filters are a cross between biofilters and ...windbreak walls... .

Figure 41-6. Biomass filter composed of sandwich panels of chopped cornstalks outside of swine nursery.

...it is generally believed that windbreaks reduce odors by dispersing and mixing the odorous air with fresh air.

Natural windbreaks

Rows of trees and other vegetation known as shelterbelts, which have historically been used for snow and wind protection in the Midwest, may have value as odor control devices for all species and systems. Similarly, natural forests and vegetation near animal facilities in other sections of the country may serve the same purpose. These shelterbelts also create a visual barrier. A properly designed and placed tree or vegetative shelterbelt could conceivably provide a very large filtration surface (Sweeten 1991) for both dust and odorous compound removal from building exhaust air and odor dispersion and dilution, particularly under stable nighttime conditions (Miner 1995, NPPC 1996). Currently, a few studies are addressing the total impact of vegetative barriers on odor reduction from animal farms, but many people already attest to their value. Shelterbelts are inexpensive, especially if the cost is figured over the life of the trees and shrubs, but it may take 3 to 10 years to grow an effective vegetative windbreak.

Summary. Although not confirmed by solid research, it is generally believed that windbreaks reduce odors by dispersing and mixing the odorous air with fresh air. Windbreaks on the downwind side of animal houses create mixing and dilution. Windbreaks on the upwind side deflect air over the houses so it picks up less odorous air. Producers should avoid placing dense windbreaks so close to naturally ventilated buildings that cooling breezes and winds exchanging the air in these buildings are eliminated or greatly reduced. A minimum distance of 100 feet, or five to ten times the tree height, from a naturally ventilated building is recommended.

Summary

A number of technologies exist for the reduction of odor and gas emissions from livestock buildings, starting with good housekeeping and including both physical and chemical treatments (see Table 41-1). Effective reduction of overall emissions will most likely include several of these control strategies rather than any single one.

Table 41-1. Summary of technologies for odor control.

Process/System		Description	Advantages	Disadvantages	Cost
Exhaust Air Treatment	Biofilters	Odorous gases are passed through a bed of compost and wood chips; bacterial and fungal activity help oxidize volatile organic compounds.	Effectively reduces odors and hydrogen sulfide emissions	May need special fans because of pressure drop. Rodent control is important.	$0.50 to $0.80/pig
Dust Reduction	Windbreak walls	Many odorous compounds are adsorbed on dust particles and conveyed on dust. A wall made of tarp or any other porous material is placed 10-15 ft from exhaust fans. The walls block some of the fan airflow in the horizontal direction. Dust and odor levels downwind of windbreaks may be lower since the plume is deflected.	May effectively reduce dust and odor emissions is necessary for sustained odor control.	Periodic cleaning of dust on walls	$1.50/pig space of bldg capacity

Table 41-1. (Continued)

Process/System		Description	Advantages	Disadvantages	Cost
Dust Reduction	Shelterbelts	Rows of trees and other vegetation are planted around a building, creating a barrier for both dust and odorous compound removal from building exhaust air. Trees can absorb odorous compounds, and they create turbulence that enhances odor dispersion upward.	May effectively reduce dust and odor emissions	It may take several years to grow an effective vegetative windbreak.	$0.20/pig space of bldg capacity or more
	Washing walls	A wetted pad evaporative cooling system is installed in a stud wall about 5 ft upwind of ventilation fans and downwind of hogs in a tunnel-ventilated building. All of the ventilation airflow passes through the wet pad before being pulled through the fans.	At medium ventilation rate, reduces about 50% of dust and 33% of ammonia	Residence time inside the pad is very small; thus odor removal may not be highly effective.	$5.70/pig space of bldg capacity installation cost
	Oil sprinkling	Vegetable oil is sprinkled daily at low levels in the animal pens.	Helps reduce airborne dust and odors	Requires more time and effort to power waste between groups of animals	$2.50/pig space of bldg capacity
Diet Manipulation	Synthetic amino-acids and low crude protein content	Products are mixed into the feed.	Lower N content in the manure, may reduce odor and ammonia emissions	Not known yet	N/A
	Feed additives (Yucca schidigera)	Product is mixed into the feed.	May reduce odor and ammonia emissions	Not known yet	$0.20/pig marketed or more
Bedding		Dry carbon source added to animal pens to promote comfort and soak up manure.	Reduced obnoxious odors, works for all species	Must harvest or buy bedding and add it throughout the year, increased volume of manure to haul	$3.00/head capacity for swine buildings
Manure Additives		Chemical or biological products are added to the manure.	May reduce odor and ammonia emissions	Usually questionable products, may not achieve desirable results under field conditions	$0.25 to $1.00/ pig or more

Assessment

A number of methods are available that reduce odor, dust, and gases emitted from animal production houses and feedlots. Use Table 41-2 below to assess your own situation and whether you could potentially use each technology.

Table 41-2. Evaluate your own livestock housing and which technologies might help you reduce emissions.

Odor Remediation Method	Would this technology work for your housing system?		COMMENTS Concerns it would or would not solve and why
	Yes	No	
Biofilter			
Biomass filter			
Windbreak wall			
Shelterbelt			
Washing wall			
Oil sprinkling			
Feeding low-protein diet			
Bedding			
Manure additive			
Other chemical treatment (ozone or other)			

APPENDIX A

Environmental Stewardship Assessment: Air Quality Issues in Animal Housing

The goal of this assessment is to help you confidentially evaluate environmental issues that relate to outdoor air quality. For each issue listed in the left column of the worksheet, read across to the right and circle the statement that best describes conditions on your farm. If any categories do not apply, leave them blank.

Potential Odor Risk	High Risk	Moderate Risk	Low Risk
Manure is handled as a . . .	Slurry or liquid	Solid with limited dry organic matter (bedding) additions	Solid with substantial dry organic matter (bedding) additions
Cleanliness of indoor confinement			
Rate (by checking appropriate response) the cleanliness of your animal housing.	Seldom cleaned	Cleaned occasionally	Cleaned frequently and thoroughly
• Cleanliness of animals.	☐	☐	☐
• Manure and feed accumulation on floors and walkways.	☐	☐	☐
• Manure buildup on the floor.	☐	☐	☐
• Feed spillage (outdoors).	☐	☐	☐
• Manure or contaminated water around outside of facility.	☐	☐	☐
• Weed growth, debris, and accumulation around facility.	☐	☐	☐
Drainage around indoor confinement			
Rate the drainage around your animal housing relative to that of other similar production facilities.	Not as clean as other facilities	At least as clean as typical facilities	As dry or drier than all other facilities
• Is manure controlled and collected?	Some manure regularly pools or accumulates in areas around the animal housing.	Some manure occasionally pools or accumulates in areas around the animal housing.	All manure is contained within housing and not allowed to collect around animal housing.
• Frequency of manure and waste feed removal?	Less than once per week	Manure is removed every two to seven days.	Manure is flushed or scraped from a facility at least once a day. OR Animals are heavily bedded to maintain dry conditions.
• Recharge water for filling shallow pits after they are emptied?	No recharge water is used after draining a pit.	Shallow pits are recharged with at least 4 inches of recycled lagoon or storage water.	Shallow pits are recharged with at least 4 inches of fresh water.
• Dust minimization in confined facilities?	Few efforts have been made to control dust.	Housing facilities use some "low-risk" dust control practices.	Three or more of the following are implemented: • Diet contains significant amounts of fat or oil (e.g., 50 lb per ton or more added fat). • Liquid feeding systems • Drop tubes on all augers • Housing sprayed with vegetable oil daily

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Glossary

Aerobic. Achieving solids reduction in manure mixtures using microorganisms that require oxygen. Thus, the breakdown of organic material tends to be odor free.

Ammonia volatilization. Loss of ammonia to the atmosphere.

Anaerobic. Transformation of manure by microorganisms that do not require oxygen.

Biomass. Organic plant materials like cornstalks, small grain straw, and other plant fibers. Total amount of living material, plants and animals, above and below ground in a particular area.

Odor plume. Airspace downwind from an odor source, which contains a detectable odor.

Ozonation. Water and odor control technology using ozone (O_3) either in the air or dissolved in water to oxidize pathogens and odorous compounds.

Plenum. Duct that transports ventilation air to or from a building.

Recharge water. Water that is placed in either gravity or pull-the-plug manure drain systems to assist in the transport of manure out of the animal building.

Residence time. Amount of time the ventilation air is in contact with the media.

Respirable dust level. Aerodynamic size fraction (< 3 microns) of dust that is small enough to reach the human lung.

Shelterbelts. Extended windbreak of living trees and shrubs established and maintained for protection of farmland or buildings.

Volatile organic compounds (VOCs). Organic molecules, usually arising from the decomposition of manure, that tend to move from liquid into the air above animal facilities.

Wet scrubber. Air treatment technology that uses wet chemicals and/or water to remove dust and gas compounds from an air stream.

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Click on road map to return to Contents.

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Livestock and Poultry Environmental Stewardship Curriculum: Lesson Organization

This curriculum consists of 27 lessons arranged into six modules. Please note that the current lesson is highlighted.

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2. Whole Farm Nutrient Planning

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10. Reducing the Nutrient Excretion and Odor of Pigs Through Nutritional Means
11. Using Dietary and Management Strategies to Reduce the Nutrient Excretion of Poultry
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