CHAPTER 9

Air Quality and Odor Control From Dairy Production Facilities

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For an odor to be detected downwind, odorous compounds must be: (a) formed, (b) released to the atmosphere, and (c) transported to the receptor site. These three steps provide the basis for most odor control. If any one of the steps is inhibited, the odor will diminish. Many of the same compounds that cause odor on a hog farm also effect the indoor air quality in the buildings. As a result, many practices that help control odor also improve air quality.

The odor that is detected from a dairy operation is a complex mixture of gases. Most often the odor is a result of the uncontrolled anaerobic decomposition of manure. However, feed spoilage can also contribute to the odor. The odor that our noses detect can be a combination of 60 to 150 different compounds. Some of the most important types of odor causing compounds are volatile fatty acids, mercaptans, esters, carbonyls, aldehydes, alcohols, ammonia, and amines. The odor strength of these compounds do not combine in an additive manner. That is, sometimes mixing several of these compounds can result in reduced odor by dilution of the strongest smelling compounds. In other instances the mixture is worse than any of the individual compounds. Ammonia can create strong odors near the manure storage or building, but is not a significant component of odor downwind from a dairy facility. Ammonia is highly volatile and moves upward in the atmosphere quickly where it is diluted.

If all of this sounds confusing to you then welcome to the crowd. In order to develop a management plan for odor control the sources of odor must be fully understood. Dairy odor sources can be classified into the following three categories: buildings and facilities, manure storages, and land application sites.

BUILDINGS AND FACILITIES

Building Maintenance

Sources of odors in and around dairy buildings include: wet, manure covered floors and walls, dirty, manure covered animals, spoiled or moldy feed, and improper disposal of dead animals. The solution for most of these sources of odor is good, “common sense” management.

- Clean alley floors 2 to 3 times per day and manage freestalls well to keep animals clean.
- Keep floors, walls, and drains clean in the milking center (parlor room and milk room).
- Repair all leaky waterers or pipes.
- Remove spoiled feed regularly.
- Remove dead animals and dispose of them promptly (see chapter 7).

The amount of odor generated from a freestall barn or milking center is greatly influenced by how often and well manure or wasted milk is removed from the building. Manures should be removed from freestall barn alleys at least 2 times each day. Freestalls should be checked for adequate bedding at least once each day. Clean all walls and floors of the milking center after each milking.

If the buildings are kept neat and tidy, the other items that must be considered for odor control in dairy buildings are: (1) the ventilation system, (2) floor design, and (3) dust control.

Ventilation System

The purposes of any dairy facility ventilation system are to: (1) maintain an adequate supply of fresh air for the animals, (2) remove excess moisture during cold weather, (3) remove combustion gases from heaters in the milking center, (4) provide adequate temperature control during mild weather, and (5) limit the temperature rise during hot weather. The major carriers of odors are: gases from manure, dust, and water vapor. A well designed and managed ventilation system will control the levels of all three and is an important factor in controlling odors from dairy buildings.

A practical and objective way of evaluating the effectiveness of a ventilation system for odor control and indoor air quality is to take gas measurements during cold weather. That is, take measurements during minimum airflow conditions. Carbon dioxide and ammonia are the two most important gases to measure. Carbon dioxide concentrations are controlled by the ventilation rate and the number of animals in the building. Ammonia concentrations are influenced by both the ventilation system and the waste system. If the concentration of these gases are at or below recommended levels then other gases are typically within recommended levels. Recommended concentrations of some of the most important gases in dairy buildings are shown in Table 9-1.

The required summer ventilation rate is at least 10 times greater than the minimum continuous rate. Therefore, gas concentrations within the building are often minimal during the summer in a properly designed facility.

Table 9.1. Recommended gas concentrations for air quality and odor control in dairy buildings.

Gas	Odor	Recommended Maximum Concentration
Carbon Dioxide	None	3,000 ppm
Ammonia	Sharp, pungent	15 ppm
Hydrogen Sulfide	Rotten egg smell	3 ppm
Carbon Monoxide	None	50 ppm

Mechanical Ventilation

Exhaust ventilation is common in milking centers. It is beginning to be used more often for summer ventilation in tunnel ventilated barns. It takes three basic components: properly sized fans, properly sized and distributed fresh air inlets, and controls. The following publications are recommended for detailed information on mechanical ventilation design:

Mechanical Ventilating Systems for Livestock Housing (MWPS-32, Midwest Plan Service, Iowa State University),
Tunnel Ventilation for Freestall Barns (C.A. Gooch and M.B. Timmons, ttp://www.ansci.cornell.edu/prodairy/), and
Environmental Control for Today's Milking Center (C.A. Gooch, ttp://www.ansci.cornell.edu/prodairy/).

The advantages of mechanical ventilation are: (1) the airflow rate and distribution can be controlled precisely during all weather conditions, and (2) maximum airflow rates can be assured during periods of minimal summer wind.

The disadvantages of mechanical ventilation are: (1) energy cost to operate the fans, (2) maintenance costs of fans, inlets, and controls, (3) requirement of a standby generator for use during power outages, and (4) replacement costs. Many of the disadvantages of mechanical ventilation can be overcome by: (1) purchasing high-quality energy efficient fans, (2) selection of durable inlet designs, and (3) using wall curtains that are designed to drop open in the event of a power failure.

Natural Ventilation

Natural ventilation uses local wind and thermal bouyancy, often called the stack effect, to move air through the structure. Fans are not used. Instead the quantity of airflow is determined by the size and placement of openings, roof slope, and orientation of the building with respect to prevailing wind direction. Details on natural ventilation system design and operation are provided in the following publications:

Natural Ventilating Systems for Livestock Housing (MWPS-33, Midwest Plan Service, Iowa State University), and
Design and Management of Natural Ventilation Systems (J.P. Chastain, ttp://www.clemson.edu/agbioeng/chastain.htm).

The advantages of a natural ventilation system are: (1) reduced operating costs as compared to mechanical systems, (2) minimal concern of loss of ventilation due to power failure, and (3) reduced lighting costs during the day due to increased levels of natural light.

The disadvantages of natural ventilation are: (1) poor control of temperature for small animals during cold weather, (2) reduced control of air distribution within the building, and (3) lack of effectiveness during summer conditions with minimal wind.

Farm Visibility and Screens

Unfortunately many people "smell" with their eyes. Providing a natural or artificial barrier between facilities and the public eye can reduce the localized environmental impact of your livestock operation, especially when it comes to odors. Consider planting several rows of fast growing trees or shrubs, building a soil berm or even a high windbreak fence between barns and manure storages and a public road. Natural and artificial barriers can also help to filter and disperse odors coming from facilities and manure storages. Another public perception is that if an operation looks bad it also smells bad. Keep facilities well maintained. Grass should be mowed regularly and equipment stored (especially manure spreaders, slurry tanks, and pumps). Locating livestock facilities and waste storages away from the public view and maintaining a "tidy" farmstead will draw less attention to your site and improve the image of the entire operation.

ODOR CONTROL FOR MANURE STORAGES

Slurry manure storages are not designed to provide manure treatment. However, slurry manure in a storage will decompose anaerobically and has the potential to release strong odors.

Covers

Covering a manure storage tank or earthen basin can reduce odors from storages to negligible levels. The amount of ammonia released from covered and uncovered manure storages was measured by researchers in Europe (see Table below). Ammonia is only one of 150 compounds that can cause odor, but it is easy to measure. A reduction in ammonia release can be used to indicate a reduction in odor release from a manure storage.

Dairy cow manure will form a crust if minimal water is added to a storage. Such a crust serves as a biological cover and has been shown to reduce odor emissions from dairy storages by 75%. Many different types of materials have been used to cover dairy manure storages. Some of the tested cover materials include barley straw, vegetable oil, vegetable and barley straw mixtures, polystyrene floatation panels with barley straw, peat moss, concrete, floating tarps, air supported hypalon covers, floating foam pellets, floating permeable mats, and geotextile fabrics.

Table 9.2. Reduction in Odor Emissions Using Covers

Type of Cover	Reduction in Ammonia Emissions
Sealed lid	95%
Floating straw	50 - 80%
Floating pellets	70%
Natural crust (dairy manure typically)	75%
Uncovered	0%

The most cost effective cover has yet to be determined, but geotextile covers appear to be cost-effective. Smaller storage structures, or structures with a smaller exposed surface area, are obviously less expensive to cover than an earthen basin with a surface area of an acre or more.

Anaerobic Digestion

A covered earthen basin or tank can be designed and operated as an anaerobic digester. An anaerobic digester uses the same anaerobic bacteria to treat manure as a lagoon but at a higher rate. Loading rates for anaerobic digesters are typically in the range of 10 to 25 lb volatile solids per 1,000 ft^3 per day. Therefore, the treatment volume for an anaerobic digester is one fifth to half the size of a lagoon. A recent study by the authors indicated that a covered earthen basin or covered lagoon digester is the most practical type for use in South Carolina.

A covered lagoon digester can be described as an earthen basin that is sized at a much higher loading rate (10 to 25 lb VS/1000 ft^3 -day). The higher loading rate results in a much smaller treatment volume and has a much greater potential for the generation of foul odors. A cover and biogas collection system solves the odor problem and yields another product - biogas. Biogas contains 550 to 595 Btu of energy per cubic ft. The energy is from methane that is a byproduct of anaerobic decomposition. Biogas is 60 to 70% methane. The remainder is mostly carbon dioxide (28 to 29%) and small but significant amounts of hydrogen sulfide and other odorous compounds. Biogas must be burned to eliminate its odor. If desired, the biogas can be used as a fluctuating, but significant source of energy.

The ideal temperature for anaerobic digestion is 95°. The temperature in an unheated covered lagoon digester will vary with the average outside temperature. During the winter months anaerobic digestion is slow. However, the warm climate in South Carolina results in only about 45 days per year when biogas production is greatly reduced.

Very little of the nitrogen is lost during anaerobic digestion since the cover greatly reduces the volatilization of ammonia. During the digestion process, a large portion of the organic nitrogen is broken down and is converted to ammonium nitrogen (NH_4^+-N). Therefore, the nitrogen in the digester effluent is more plant available than in fresh manure. Well stabilized solids that are removed from a digester also have a lower odor than lagoon solids or untreated slurries. As a result, odor is less of a concern during land application.

Aeration

Low-rate aeration can be accomplished with a 2 to 7.5 hp motor per storage since the amount of air needed to control the population of anaerobes is much lower than the amount of air needed to treat the wastewater aerobically. Use of low-rate aeration will favor the growth of facultative microbes (microbes that can live with or without air) and can provide some reduction in strength as well as control odor (the anaerobes produce the foul smelling compounds).

LAND APPLICATION

The most significant complaint about odor from dairy manure by the public is during and after surface spreading to the land. Spreading manure on top of the soil either by tankers or irrigation can cause high odors. Some methods to reduce odor or the impact of odor are listed below.

- Use low trajectory irrigation guns with large droplet size.
- Inject slurry manure or sludge into the soil if possible.
- Incorporate slurry manure or sludge into soil.
- Apply manure in the morning on sunny days.
- Apply manure on days when the wind is blowing away from neighbors.
- Apply manure on weekdays when neighbors have a higher probability of being away from home.
- Always contact close neighbors prior to spreading to avoid spoiling their outdoor activities.

CHEMICAL OR BIOLOGICAL ADDITIVES

Scientists are working hard to develop chemical or biological additives which will eliminate or reduce odors associated with dairy wastes. There are four general types of chemical compounds: (1) masking agents that override the offensive odors, (2) counteractants that are chemically designed to block the sensing of odors, (3) odor absorption chemicals that react with compounds in manure to reduce odor emission, and (4) biological compounds such as enzymatic or bacterial products that alter the decomposition so that odorous compounds are not generated. Some of these compounds are added directly to the manure while others are added to the feed. Many of these commercial products marketed for the control of odors have generally been disappointing. Masking agents, bacterial agents, and enzymatic digestive aids have been shown to be ineffective. Feed additives have been found to influence the odor of fresh feces and urine, but an odor panel was unable to detect any significant change in decomposing manure.

Many odor reducing additives are under development. Some of them appear to reduce odor. However, any dairy producer who uses an additive should understand that most of these additives are still being developed and that every site is an experiment. Time and on-farm experimentation will determine which products are effective.

SUMMARY: BE A GOOD NEIGHBOR

Run a clean, neat operation. Consider planting trees and shrubs to enhance the appearance of your operation. Keep neighbors and the public educated and informed about any plans for expansion. It is much better for to you tell them what your plans are rather than others who may not know all the facts. Get to know your neighbors and develop good relationships by: hosting a barbeque at the farm or being involved in community activities.

Attend public meetings and inquire about alternative systems. If the public knows that you are concerned about the environment and are open to ideas they may be more tolerant if temporary odor problems arise. Also, always take some action on any complaint you receive. Check with neighbors before spreading manure on cropland to be sure that you do not ruin any of their family or community events. Neighbors and people in your community are consumers of dairy products, and keeping customers happy is important in any business. Finally, as urban and rural populations share more of the same land area, it is critical that producers create a good public impression by following recommendations which reduce odor and protect water quality.