CHAPTER 9

Air Quality and Odor Control From Swine 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 swine 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 swine 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. Swine odor sources can be classified into the following three categories: buildings and facilities, manure storages, and land application sites. The methods to control odor from lagoons and storages are covered in chapter 4 (Management of Lagoons and Storage Structures for Swine Manure). Odor control strategies for buildings, facilities, and land application sites are summarized in this chapter.

BUILDINGS AND FACILITIES

Sources of odors in and around swine buildings include:

- wet, manure covered floors and walls,
- manure in improperly cleaned recharge-pits,
- dirty, manure covered hogs,
- spoiled or moldy feed,
- dust from feeders and hogs, and
- improper disposal of dead pigs.

The solution for most of these sources of odor is good, "common sense" management.

- Wash down the pens on a regular basis.
- Collect and remove manure from the building as often as possible.
- Wash the floors daily or use slotted floors to keep animals clean.
- Repair all leaky waterers or pipes.
- Clean feeding equipment regularly.
- Remove spoiled feed regularly.
- Remove dead animals and dispose of them promptly (see chapter 7).

The amount of odor generated from flush and pit-recharge buildings is greatly influenced by how often and well manure is removed from the building. Flush facilities should be well cleaned at least 2 times each day. However, flushing 4 to 12 times per day is not uncommon for automated systems.

Manure should be emptied from a recharge pit every 5 to 7 days. A portion of the solids remain in the pit after it is emptied and can be a cause of elevated odor levels. To eliminate this problem implement the following procedure each time the pit is emptied.

1. After empting the pit, use the recycle pump to flush out the remaining solids. This is done by allowing the recycle pump to run with the drain plug open until solids no longer are removed with the flow. In order to flush solids from a pit in this manner the pipe used to refill the pit must be located on the end of the barn that is opposite the drain.
2. After all solids are flushed from the pit, replace the drain plug and fill the pit with recycle water immediately.

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

Ventilation System

Mechanical and natural ventilation are used in all types of swine buildings. Mechanical ventilation is commonly used in farrowing and nursery buildings where temperature control and heating energy costs are important. Natural ventilation can be used for farrowing and nursery buildings, but is more common for gestation, breeding, and finishing facilities.

The purposes of any swine 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, (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 swine 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, at minimum airflow conditions. Carbon dioxide and ammonia are the two most important gases to

measure. Carbon dioxide concentrations are set 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 swine 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 swine 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 the most common type of system used in modern swine facilities. It takes three basic components: properly sized fans, properly sized and distributed fresh air inlets, and controls. The fans and inlets must be designed to provide at least three stages of ventilation. A minimum, continous ventilation rate for winter, a mild weather rate for temperature control during the fall and spring, and a maximum rate to control the temperature rise of the building in summer. The following publications are recommended for detailed information on mechanical ventilation design:

> Swine Facilities and Equipment (AEnL 557, Cooperative Extension Service, Clemson University),
> Mechanical Ventilating Systems for Livestock Housing (MWPS-32, Midwest Plan Service, Iowa State University), and
> Heating, Cooling, and Tempering Air for Livestock Housing (MWPS-34, Midwest Plan Service, Iowa State University).

These publications can be obtained from the Department of Agricultural and Biological Engineering at Clemson University (864-656-3167).

The advantages of mechanical ventilation are: (1) the airflow rate and distribution can be controlled precisely during all weather conditions, (2) heating energy needs can be reduced, in farrowing and nursery rooms by using a controller that turns the heater off when the second stage of fans is activated by the thermostats, and (3) 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. Thermostatically controlled side wall curtains are used in some swine buildings to control inside temperature to some extent. However, the air temperature of heated spaces, such as farrowing or nursery rooms, can be controlled better with mechanical ventilation. Gestation, breeding, and finishing barns are good candidates for natural ventilation. Details on natural ventilation system design are provided in the following publications:

> Swine Facilities and Equipment (AEnL 557, Cooperative Extension Service, Clemson University), and
> Natural Ventilating Systems for Livestock Housing (MWPS-33, Midwest Plan Service, Iowa State University).

These publications can be obtained from the Department of Agricultural and Biological Engineering at Clemson University (864-656-3167).

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.

Floor Design and Pit Ventilation

The design of the floor can have a large impact on the odor generated from a swine building. Research in both the United States and Europe has indicated that solid concrete floors with scrapers or small flush gutters tend to increase the production of odor. Wet, manure covered surfaces emit more ammonia and other odorous compounds than slotted floors. The reason for this is that slotted floors in well ventilated facilities can be kept drier since liquids drain through to a manure pit or gutter. Many swine producers are aware of this and as a result most new swine facilities utilize either fully slatted or partially slatted floors.

Slotted floors can be used with the following types of manure collection systems: slats over a flush gutter, slats over hair-pin gutters, slats over pit-recharge gutters, or slats over a manure storage pit.

For all types of slotted floors the best strategy for maximum odor control is to exhaust a portion of the ventilation air through the pit or gutter. Pit annexes can be used to exhaust the minimum

continous and the mild weather ventilation air through the slots in the floor. Such “pit ventilation” will insure that fresh air is available at animal level, and will keep the slats dry. The result is a better environment for the pigs and the people who work in the building. The following publications provide additional information on pit ventilation of swine buildings:

Swine Housing Handbook (MWPS-8), and
Mechanical Ventilating Systems for Livestock Housing (MWPS-32, Midwest Plan Service, Iowa State University).

These publications can be obtained from the Department of Agricultural and Biological Engineering at Clemson University (864-656-3167).

The value of a well ventilated facility using pit ventilation is best demonstrated by data taken from a barn that had a poor ventilation system and was retrofitted to provide pit ventilation for the minimum ventilation rate. In this case, manure is stored in a concrete tank below the slotted floor for approximately eight months. The following table provides gas measurement data for the old and new ventilation systems during cold weather and at the minimum ventilation rate. The data shown in the table indicate that the air quality in the barn was greatly improved once the pit ventilation system was installed.

Table 9.2. Effect of improving the ventilation rate in a barn with a slotted floor or a manure storage pit.

Gas	Target Value	Old System	New Pit Ventilation System
Carbon Dioxide	3,000 ppm	5,000 ppm	2,500 ppm
Ammonia	15 ppm	25 ppm	15 ppm

On-farm data indicates that the ammonia concentration in swine finishing buildings is not a function of ventilation type, that is mechanical vs. natural. The most important factors are ventilation rate, and the quality of the waste removal system. The naturally ventilated building had lower ammonia due to higher ventilation rates as indicated by lower carbon dioxide concentrations. The pit ventilated barn was actually under ventilated during winter.

Table 9.3. Air quality measurements in swine finishing buildings with cold weather minimum ventilation rates (Both buildings strore 12 months of manure below the slotted floor).

Building Type	Carbon Dioxide	Ammonia
Pit Ventilated, 1,000 head	4,350 ppm	22 ppm
Naturally Ventilated, 1,000 head	3,050 ppm	19 ppm

Dust Control

Dust particles can carry gases and odors. In fact, a large portion of the odor associated with exhaust air from mechanically ventilated swine buildings are dust particles that have absorbed odors from within the building. Therefore, dust control in the buildings can reduce the amount of odor carried outside by the fans. High dust concentrations can also be a health risk for workers in

swine facilities as well as the pigs. Control of dust improves the working conditions for the producer and helps significantly in odor reduction.

Dust is generated from feed, manure, and the animals themselves. Factors determining the amount of dust includes cleanliness of the buildings, animal activity, temperature, relative humidity, ventilation rate, stocking density, and feeding method.

Management practices that can greatly reduce the amount of dust in swine buildings are described below.

- Clean interior building surfaces regularly. Modern swine production facilities are designed around an "all-in, all-out" style of management. That is, all of the animals of a particular age or reproductive stage are housed in the same room, and are moved to different facilities or are marketed at the same time. The time between animal groups is used to pressure wash, and disinfect all of the interior surfaces. Strict adherence to this practice helps to reduce dust levels.

- Reduce dust from feed. Addition of oil to dry swine rations significantly reduces the amount of dust in a building. Gestation rations are often mixed with water which also greatly reduces dust. Proper and timely maintenance of feeders, augers, and other feed handling equipment is required for proper dust control.

- Spray pigs with oil or water. Recent research in Canada indicates that frequent light oil sprays of pigs, and the pen surfaces can greatly reduce dust. The research indicated that the odor inside the oil sprayed rooms was much less than the untreated rooms. The amount of respiratory effort required by the workers in the swine facility was also reduced.

LAND APPLICATION

The most significant complaint about odor from swine 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.

PLANNING FOR MINIMAL ODORS

The importance of odor control will vary depending on the population density of the proposed building site. If the farmstead is located in an isolated area the impact of odors on the farm residence will be the primary concern. The factors that should be considered when selecting a site for livestock buildings and manure storages are: direction of prevailing winds, distance to neighbors and the farm residence, topography, and presence of natural windbreaks. When planning new facilities it is desirable to avoid as many potential problems as possible. The following are some items to consider when selecting a location for a new hog facility.

Separation Distance and Neighbors

The ideal separation distance between a livestock facility and the nearest neighbor to avoid an odor nuisance has not been determined, and is somewhat subjective. Always try to locate new facilities where odor problems can be avoided or minimized. South Carolina regulations have separation distances for lagoons, storages, and facilities. Be sure you study the state requirements and obtain the requirements of local government early in the planning process and before any land is purchased.

Odor dispersion
A windows based computer program was developed to be used as an educational tool and decision aid for planning swine facilities. The major focus is on control and dispersion of odor, with a secondary emphasis on nutrient management. The program was assigned the name PigE2 which is an acronym for swine production environmental evaluator.

PigE2 is designed to offer the user information in four topic areas: (1) odor control strategies, (2) odor dispersion mapping, (3) animal, manure, and nutrient inventories, and (4) regulations. The program utilizes point and click control with limited numerical input to present data tables, text, and color coded odor plume maps. A detailed discussion of the program development and features is given by Wolak et al. (1996). The topics included in the odor control section of the program are: methods to reduce odor from buildings, benefits of covering manure storages, design and management of anaerobic lagoons to minimize odor, land application methods to reduce odor emissions, site selection factors to minimize odor complaints, and use of trees and fencing as odor dispersion aids and screens.

The odor mapping section of the program allows the user to perform odor dispersion calculations using a simple Gaussian Plume model to predict the level of odor downwind from the odor source. The user can input the following variables: wind speed, direction, atmospheric stability categories, one of five odor source strengths, and one of two terrain roughness classes. The odor source strength are classified as: very low (100 OU m^3/s), low (250 OU m^3/s), moderate (500 OU m^3/s), high (1,000 OU m^3/s), and extreme (10,000 OU m^3/s). The terrain classes represent a facility surrounded by flat, open field with crop stubble, or surrounded by a forest barrier. The output of the model is a color coded map of the odor plume. The map indicates the distance downwind from the source that the odor level is slight (1 OU), mild (2-4 OU), or strong (5

≥OU). Model results indicate that the use of forest barriers and odor source control are the most important factors in limiting odor dispersion.

The following discussion and conclusions is based on a review of relevant literature (some of which is listed at the end) and a sensitivity analysis using a Gaussian Plume model of odor dispersion.

Worst Case Odor Dispersion Very few livestock facilities will ever generate odor that will travel beyond 1/2 of a mile (2,640 ft.). Odors can only travel 1/2 mile during the evening hours (under stable atmospheric conditions), with calm winds (2 mph or less), and if the odor source strength is extremely high (10,000 odor units m^3/s). Such a high odor source would be associated with situations such as: old style solid concrete feeding floors that have not been cleaned for a long period of time (hogs would be manure covered also), or agitation of an uncovered swine slurry pit. Proper facility design and limitation of agitation and land application of strong smelling waste to the morning and early afternoon hours can generally get the odor source strength out of the "extreme" category. *Therefore, this worst case scenario is fairly easy to avoid.* The following tables show the effects of odor source strength and an increase in wind speed to 4 mph which is more typical of nighttime situations in South Carolina.

Table 9.4. Estimates of plume lengths under stable atmospheric conditions (nighttime) and a wind speed of 2 mph or less (open terrain).

	Odor Source Strength		
Odor Level	High	Medium	Low
Downwind	---- Distance Downwind (ft) ----		
Slight (just detectable by 1/2 of the population)	1,875	1,250	800
Mild (Detectable by most everyone)	1,250	800	500
Strong	750	500	250

Effect of Locating Livestock Facilities Within a Forest Opening It is a general recommendation that new swine and other livestock facilities be located in areas that allow a forest buffer to aid in odor dispersion. The effect of dense trees on odor dispersion is indicated in Table 9.6. The tables show that dense trees can have a great effect on dispersion.

Table 9.5. Estimates of plume lengths under stable atmospheric conditions (nighttime) and a wind speed of 4 mph (open terrain).

	Odor Source Strength		
Odor Level	High	Medium	Low
Downwind	---- Distance Downwind (ft) ----		
Slight (just detectable by 1/2 of the population)	1,250	800	500
Mild (Detectable by most everyone)	800	500	300
Strong	500	250	200

Table 9.6. Effect of a forest barrier on estimates of plume lengths under stable atmospheric conditions (nighttime) and a wind speed of 2 mph or less.

	Odor Source Strength		
Odor Level	High	Medium	Low
Downwind	---- Distance Downwind (ft) ----		
Slight (just detectable by 1/2 of the population)	750	500	375
Mild (Detectable by most everyone)	500	375	250
Strong	250	250	125

Odor Dispersion During the Day It is also important to have an understanding of how odor dispersion occurs during the day. Our recommendations will be to manage odor sources well, but when farm operations result in short-term but possibly intense odors then these activities must be done during the day. An example of such as operation is agitation of lagoon solids or slurries prior to removal. *It should be noted that the typical daytime wind speed in South Carolina is about 6 mph. In addition, neutral atmospheric conditions are the worst case for daytime dispersion. Such conditions would be typical of a fall day.* Model results for daytime conditions are shown in Table 9.7.

Table 9.7. Estimates of plume lengths under neutral atmospheric conditions (daytime) and a wind speed of 6 mph (open terrain).

	Odor Source Strength		
Odor Level	Extreme *	High	Medium
Downwind	---- Distance Downwind (ft) ----		
Slight (just detectable by 1/2 of the population)	940	300	250
Mild (Detectable by most everyone)	630	125	****
Strong	375	****	****

* The extreme source strength is 10 times stronger than high.
**** = too small to distinguish.

These results indicate that short-term extreme odors during the day will not have an impact on people who are 1,000 ft away. Typical odor levels associated with the operation of well managed facilities will be insignificant.

Wind Direction
In South Carolina, the prevailing wind direction is highly variable depending on proximity to the coastal region, hills, forests, or mountains. Coastal sea breezes can affect local wind patterns many miles inland. Local conditions need to be observed. Buildings and waste storages should be located so that prevailing winds do not carry odors in the direction of the farm residence or neighbors

Topography

Air drainage is a factor to consider when constructing a new facility in hilly areas. During calm summer evenings the air near the ground begins to cool and drifts down-slope since cool air is heavier than warm air. If a livestock building or waste storage is located uphill from a town or cluster of houses the cool air will flow past the livestock facility, may pick up unpleasant odors, and may create a nuisance around dwellings in its path. This pattern of cold air drainage will be repeated at regular intervals throughout the year. It is important to avoid placing an odor generator in the path of an air drainage stream. As a result, it is best to choose a site that is not up-slope from close neighbors.

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.

Chemical or Biological Additives

Scientists are working hard to develop chemical or biological additives which will eliminate or reduce odors associated with swine 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 pit 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 swine 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 appearence 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, donating a hog to church or civic groups for annual events, and 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 to a 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 pork, 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.

References

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