CHAPTER 9

Odor Control From Poultry Facilities

John P. Chastain

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 poultry farm also affect 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 poultry 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 poultry 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. Poultry odor sources can be classified into the following two categories: buildings and facilities, and land application sites.

BUILDINGS AND FACILITIES

Sources of odors in and around poultry buildings include:

- wet litter from leaky waterers,
- poultry bedding that is overloaded with manure (that is too little bedding relative to the amount of manure produced by the birds),
- wet manure below caged layer houses due to water leaks or inadequate drying by ventilation,
- spoiled or moldy feed,
- dust from feeders and animals,
- exhaust ventilation air,
- uncovered manure piles,
- poorly managed stacking sheds,
- poorly managed or located covered manure piles, and
- improper disposal of dead animals.

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

- Provide adequate bedding for each flock of birds.
- Remove manure from the building as often as possible.
- 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).
- Cover litter stockpiles completely with a tarp weighed down with rocks, limbs, or old tires as soon as a house is cleaned out.
- Avoid excess moisture in stacking sheds since excess moisture increases the amount of odor generated due to anaerobic decomposition.
- Make sure ventilation fans are cleaned regularly and that airflow rates are aqequate for the season and stage of growth.
- Avoid orienting buildings so that ventilation fans blow exhaust air towards neighbors or adjacent road ways.
- In high-rise layer houses, the airflow should be equiped with lower level, or basement, exhaust fans that pull air in through well designed inlets, past the birds, and out past the manure storage area to promote manure drying and to improve indoor air quality.
- Manure in high-rise buildings must be dry enough to maintain a conical pile to control odor and flies (less than 45% moisture).

Ventilation System

A well-designed ventilation system is required in all types of poultry buildings. The purposes of any poultry 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 poultry 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 animal 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 poultry 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 mechanical ventilation is the most common type of system used in modern poultry 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 publication is recommended for detailed information on mechanical ventilation design: Mechanical Ventilating Systems for Livestock Housing (MWPS-32, Midwest Plan Service, Iowa State University).

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 poultry buildings to control inside temperature to some extent. However, the air temperature of heated spaces, such as during brooding, can be controlled better with mechanical ventilation. Details on natural ventilation system design are provided in the following publication: Natural Ventilating Systems for Livestock Housing (MWPS-33, Midwest Plan Service, Iowa State University).

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. As a result, natural ventilation is a less popular alternative for poultry facilities.

The publications listed above on natural or mechanical ventilation can be obtained from the Department of Agricultural and Biological Engineering at Clemson University (864-656-3167).

Dust Control

Dust particles can carry gases and odors. In fact, a large portion of the odor associated with exhaust air from mechanically ventilated poultry 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 poultry facilities as well as the animals. 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 poultry buildings are described below.

- Clean interior building surfaces regularly. Modern poultry production facilities are designed around an "all-in, all-out" style of management. That is, all of the birds are moved to different facilities or are marketed at the same time. The time between animal groups is used to clean and disinfect the interior of the building. Strict adherence to this practice helps to reduce dust levels.
- Reduce dust from feed. Addition of oil to dry rations significantly reduces the amount of dust in a building. Proper and timely maintenance of feeders, augers, and other feed handling equipment is required for proper dust control.
- Manage the relative humidity (RH) in poultry houses. If the air in a broiler or turkey house is too dry (low RH), then the amount of dust in the exhaust ventilation air will be excessive. This will lead to excess odor and results in poor indoor air quality for the animals and the people who work in the facility. High moisture levels in the indoor air (high RH) can lead to excessive ammonia production from the litter, and in some cases will promote anaerobic conditions in the manure. If anerobic conditions persist, then foul odors will be generated from the manure. A high ammonia level inside a building can be a hazard to birds and people.

LAND APPLICATION

The most significant complaint about odor from poultry manure by the public is during and after surface spreading to the land. Spreading manure on top of the soil without incorporation can cause high odors. Some methods to reduce odor or the impact of odor are listed below.

- Incorporate manure into soil as soon as possible.
- 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 poultry 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 poultry 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 poultry 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 simple Gaussian Plume model was written to predict the level of odor downwind from animal production facilities. 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 strengths 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 a flat, open field with crop stubble, or a site surrounded by a forest barrier. Model results indicate that the use of forest barriers and odor source control are the most important factors in limiting odor dispersion. A detailed presentation of the model and applications for siting animal facilities is given by Chastain and Wolak (2000).

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 the odor dispersion model. Sensitivity analysis of an odor dispersion model is sufficient to demonstrate the influence of input parameters on the length of an odor plume. However, the input parameters are not well defined. Input variables such as the dispersion coefficients, roughness heights, and in particular the source strength of the odor are at best order-of-magnitude estimates. Even the assumption of Gaussian flow is not always true in the environment. Therefore, policy makers, regulators, and designers of livestock facilities must use caution in the interpretation of model results.

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 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) as indicated in Table 9.2. Such a high odor source would be associated with situations such as poorly designed and maintained high-rise later facilities with slurry manure in the basement or surface spreading of very wet, putrid poultry litter. Proper facility design and limitation of 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.

Table 9.2. 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

The model results shown in Table 9.3 indicates that an increase in wind speed to 4 mph, which is more typical of nighttime situations in South Carolina can help to reduce the length of the odor plume.

Table 9.3. 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

Effect of Locating Livestock Facilities Within a Forest Opening. It is a general recommendation that new poultry 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 9.4. The tables show that dense trees can have a great effect on dispersion.

Table 9.4. 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 are 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 clean-out of a poultry litter and spreading the litter on pasture which does not allow incorporation. *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 9.5.

Table 9.5. 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 a large impact on people who are 1,000 ft away.

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. <u>Buildings and waste storages should be located so that prevailing winds do not carry odors in the direction of the farm residence or neighbors</u>

Topography

<u>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.</u>

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). 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 poultry 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.

Treatment of broiler litter with alum was originally developed to reduce the amount of soluble phosphorous in poultry litter. However, it was also observed that using alum reduced the pH of the litter to below 6.5, and as a result, reductions in ammonia emissions from the litter have been observed.

Many odor reducing additives are under development. Some of them appear to reduce odor. However, any poultry 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 hear it from 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 poultry 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 poultry 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.

References

Chastain, J.P., and F.J. Wolak. 2000. Application of a Gaussian Plume Model of Odor Dispersion to Select a Site for Livestock Facilities. Proceedings of the Odors and VOC Emissions 2000 Conference, sponsored by the Water Environment Federation, April 16-19, Cincinnati, OH., 14 pages, published on CD-ROM.

Van Kleeck, R.J. and N.R. Bulley. 1985. An assessment of separation distance as a tool for reducing farm/neighbor conflict. *in* Agricultural Waste Utilization and Management, Proceedings of the Fifth International Symposium on Agricultural Wastes, Dec. 16-17. pp 446-453, ASAE , 2950 Niles Rd., St. Joseph, MI 49085-9659 USA.

du Toit, A.J. 1989. Practical odour nuisance gauging: two case studies of objective odour qualification in agriculture and industry. Water Science Technology 21:1077-1087.