Airborne Emissions from Animal Production Systems

Type of emissions

Odor emissions from animal production systems originate from three primary sources: manure storage facilities, animal housing, and land application of manure. Table 40-1 is a partial list of livestock and poultry odor sources and characteristics that may affect airborne emissions. The list illustrates the diversity of odor sources and factors that may impact emission rates and odor characteristics.

Table 40-2 summarizes identified odor sources and animal species for justifiable complaints in a 1982 study in a United Kingdom (U.K.) county (Hardwick 1985). Almost 50% of all odor complaints were traced back to land application of manure, about 20% were from manure storage facilities, and another 25% were from animal buildings. Other sources included feed production, processing centers, and silage storage. Between the three animal species, hogs were identified as the source of slightly more than half of the complaints (54%), with cattle and poultry being the source of 20% and 24% of the complaints, respectively. Even though these findings from the U.K. are nearly 20 years old, general observations in this country seem to agree with this distribution of odor sources. However, with the increased use of manure injection for land application in certain parts of the country and longer manure storage (and larger manure storage structures), there may be a higher percentage of complaints in the future associated with manure storage facilities and animal buildings.

Most of the odorous compounds that are emitted from animal production operations are byproducts of anaerobic decomposition/transformation of livestock and poultry wastes by microorganisms. Animal wastes include manure (feces and urine), spilled feed and water, bedding materials (i.e., straw, sunflower hulls, wood shaving), wash water, and other wastes. This highly organic mixture includes carbohydrates, fats, proteins, and other nutrients that are readily degradable by microorganisms under a wide variety of suitable environments. The byproducts of microbial transformations depends, in a major part, on whether it is done aerobically (i.e., with oxygen) or anaerobically (i.e., without oxygen). Microbial transformations done under aerobic conditions generally produce fewer odorous byproducts than those done under anaerobic conditions. Moisture content and temperature affect the rate of microbial decomposition.

A large number of volatile compounds have been identified as byproducts of animal waste decomposition. Kreis (1978) developed one of the earliest lists of volatile compounds associated with decomposition of cattle, poultry, and swine wastes. He listed 32 compounds reported to have come from cattle wastes, 17 from poultry wastes, and more than 50 compounds from swine wastes (Kreis 1978). O'Neill and Phillips (1992) compiled a list of 168 different gas compounds identified in swine and poultry wastes. The compounds are often listed in groups based on their chemical structure. Some of the principal odorous compounds, individual and as groups, are ammonia, amines, hydrogen sulfide, volatile fatty acids, indoles, skatoles, phenols, mercaptans, alcohols, and carbonyls (Curtis 1983). Carbon dioxide and methane are odorless.

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Table 40-1. Livestock and poultry odor sources and characteristics.

- **Animal Barns and Lots**
  Beef
  Dairy
  Horses
  Poultry
  Broilers
  Laying hens
  Turkeys
  Sheep and goats
  Swine
  Hoop barns
- **Manure Treatment**
  Solid/Liquid separation
  Chemical
  Biological
  Aerobic (i.e., composting, lagoon, oxidation ditch, other)
  Anaerobic (i.e., digester, lagoon, other)
- **Manure Systems**
  Deep pit storage
  Shallow pit storage
  Pull-plug
  Flush
  Bedded pack
  Litter
- **Manure Storage**
  Deep pit below barn
  Earthen lined basin
  Tanks–concrete or steel
  Tanks–above or in ground
- **Land Application**
  Surface applied
  Surface applied with incorporation
  Injection
- **Other**
  Silage
  Feed processing centers
  Dead animal composting/disposal

Table 40-2. Number and source of odor complaints received during a one-year period in a United Kingdom county.

	Pig		Cattle		Poultry		Total	
Odor Source	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Buildings	224	22	65	18	163	36	452	25
Slurry storage	169	17	98	28	78	17	345	19
Slurry spreading	526	52	122	34	190	42	838	46
Animal feed production	84	8	4	1	11	3	99	5
Silage storage	10	1	68	19	8	2	86	5
Total	1,013		357		450		1,820	
Percent		56		20		24		100

Source: Hardwick 1985.

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Some of the gases (ammonia, methane, and carbon dioxide) that are emitted have implications for global warming and acid rain issues. Among these gases are ammonia and non-odorous gases such as methane and carbon dioxide. European countries have instituted strict ammonia emission limits in recent years. It has been estimated that one third of the methane produced each year comes from industrial sources, one third from natural sources, and one third from agriculture (primarily animals and manure storage units). Although animals produce more carbon dioxide than methane, methane contribution to the greenhouse effect is estimated at 15 times that of an equal amount of carbon dioxide.

Dust, pathogens, and flies are also airborne emission concerns from animal operations. Dust is another airborne emission concern that is difficult to eliminate from animal production units. It is a combination of manure solids, dander, feathers, hair, and feed. It is typically more of a problem in buildings that have solid floors and use bedding as opposed to slatted floors and liquid manure. Dust concentrations inside animal buildings and near outdoor feedlots have been measured and range from 1 up to 10 mg/m^3 (Curtis 1983). However, dust emission rates are mostly unknown from animal production sites.

Pathogens are yet another airborne emission concern for animal production operations. Although pathogens are present in buildings and manure storage units, they typically do not survive aerosolization well, but some have been transported by dust particles.

Flies are an additional concern from certain types of poultry and livestock operations. The housefly completes a cycle from egg to adult in 6 to 7 days when temperatures are 80 to 90ºF. Females can produce 600 to 800 eggs, and larvae can survive burial at depths up to 4 feet. Adults can fly up to 20 miles. These facts verify that large populations of flies can be produced relatively quickly if the correct environment (moisture and nutrients as when manure is stored) are provided. Studies have shown that flies proliferate in areas where animals do not walk. To reduce the number of flies, try to keep spoiled feed and manure from under feeders and waterers, under fences, and other areas that the animals do not reach. If not managed correctly, compost piles make excellent fly habitat.

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Emission movement or dispersion

The movement or dispersion of airborne emissions from an animal production facility (Figure 40-1) is difficult to predict and is affected by many factors including topography, prevailing winds, and building orientation. Odor plumes decrease exponentially with distance (Brembery 1994), but long distances are needed if no odors, gases, or dust are to be detected downwind from a source. Recommendations exist for separation distances of animal production facilities from residential developments and other public and private areas where people live and work. A number of models are being developed to more accurately predict setback distances from livestock and poultry operations based on animal units (Schauberger and Piringer 1997) or actual emission values (Jacobson et al. 1999).

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Figure 40-2 shows the odor dispersion from a pig production facility using one of the models (Jacobson et al. 1999). The odor plume is visually shown by approximating equal odor unit lines at several distances (330, 660, and 1,300 ft or 100, 200, and 400 meters) from the pig finishing barn and aboveground manure storage facility odor sources. The numbers above the line are predicted by the dispersion model, and the numbers below are actual field measurements that validate the model results. The OFFSET method developed by Jacobson et al. (2000) using this dispersion model would estimate a setback distance of ¼ mile (or approximately 400 m) from this production unit, using a 98% odor-annoyance-free frequency estimation level.

Prevailing winds should be considered so facilities are sited to minimize odor transport to close or sensitive neighbors. For many existing facilities, this is impossible. For those situations, odor reduction techniques may be needed to reduce the odor emission rate or disperse odors faster and more effectively before they reach a sensitive neighbor or individual. Producers are encouraged to closely evaluate siting issues to better understand the potential for odor nuisance concerns. The Community Siting assessment tool (see Appendix B) will assist a producer in identifying facilities or land application sites that present the greatest and least risk of causing odor nuisances.

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There is ample evidence that outdoor air quality (OAQ) issues have become a major concern in the siting of animal production facilities. A variety of

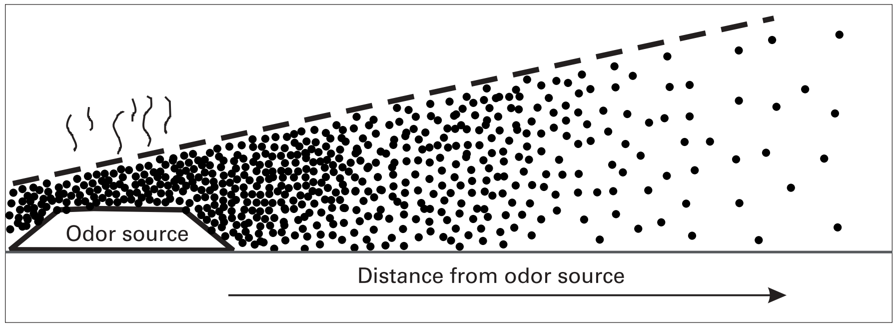

Figure 40-1. As the arrow shows, odors and gases become dispersed, mixed, and less concentrated with increasing distance.

livestock and poultry producers, from various areas of the United States, have reported difficulty in obtaining permits to construct new or expand existing livestock operations due to OAQ complaints from neighbors. Odors typically lowered property values of residential homes near livestock production facilities. Another often-mentioned concern is the reduced value of land near livestock and poultry units for outdoor recreational activities.

In a 1999 survey of states by the North Dakota Attorney General's office, 31 states reported various types of airborne emission regulations. Many of these states either exempt or choose not to enforce the regulations for agricultural operations. Most states and local units of government deal with this issue through zoning or land use ordinances. Typically, certain setback distances are required for a given size operation or for land application of manure. Also, setbacks from lakes and public waterways are common. A few states (for example, Minnesota) have an ambient gas concentration (H_2S for Minnesota) standard at the property line. Another possibility is an odor standard that only a few states (North Dakota, Colorado, Wyoming, and Missouri) have adopted that is again measured at the property line. Gas and odor standards are difficult to enforce since on-site measurements of gases and especially odor are hard to complete with a high degree of accuracy. Producers should be aware of odor- or dust-related emissions applicable to their livestock operation. The assessment tool for air quality (see Appendix C) will assist producers in identifying current regulations that may impact their livestock or poultry operation.

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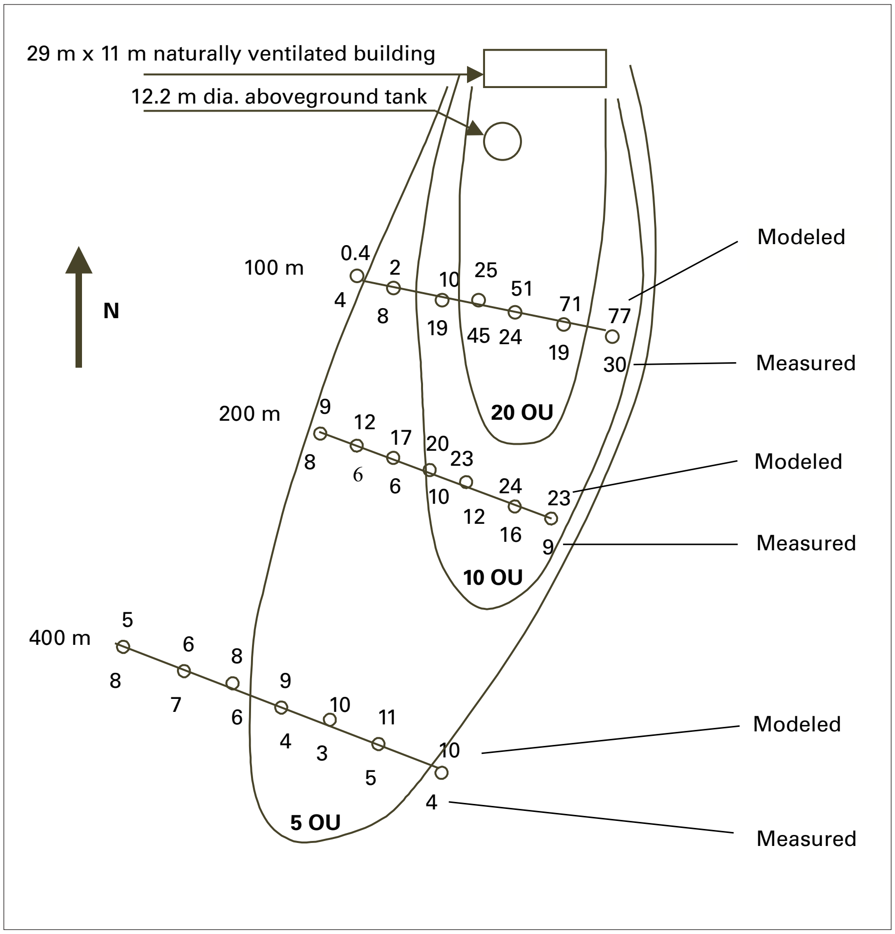

Figure 40-2. Odor plume from a pig finishing barn and aboveground manure storage tank showing comparison between odor threshold values from a dispersion model and measurements taken in the field. (Note: 1 m = 3.3 ft)