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ODOR MANAGEMENT INFORMATION FOR LIVESTOCK OPERATIONS

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Introduction

Odor and other air-borne emissions have always been associated with livestock production operations. As these operations become larger and more concentrated, the management of odor and dust emissions to reduce their negative impacts on livestock producers and adjacent land users becomes an important issue. This paper provides basic concepts about the production, measurement, and dispersion of livestock-operation odors.

Sources of Odors

More than 160 organic and inorganic compounds have been identified as potential contributors to odors emitted by livestock operations. Some of the most odorous compounds in manure include ammonia, amines, hydrogen sulfide, volatile organic acids, indoles, skatoles, phenols, mercaptans, alcohols and carbonyls. These odorous compounds vary with species, diets, types of production systems, manure handling systems and practices, and other factors.

While manure is typically the source of most odors, other sources include livestock, feeds, and dust. Dust particles can be odorous themselves, or they can serve as transporters of odorous gases adsorbed on the particles.

Manure odors are emitted from three principal sources:

1. buildings or lots where livestock are located and manure is collected, handled, and sometimes stored;
2. manure treatment and storage facilities outside the buildings or lots where animals are located; and
3. land areas where manure has been applied. The greatest odor problems often are associated with the land application of manure when injection or incorporation is not used and consequently where there is no soil cover over the manure.

Impacts of Odors on People

People are affected by obnoxious odors in two ways: physiologically (health effects documented by research and with established standards for exposure) and non-physiologically (effects with no research-documented exposure effects and/or safe exposure standards).

Five noxious gases (carbon dioxide, ammonia, hydrogen sulfide, methane, and carbon monoxide) are commonly found in livestock buildings and manure storage areas. When present at concentrations exceeding safe exposure levels, health risks and even death of livestock and workers can occur. Accumulation of these gases is prevented by good livestock and manure management practices and adequate ventilation.

Most odorous mixtures emitted from livestock operations are not known to have physiological effects on people. However, some people are affected by exposure and experience symptoms including mood changes, discomfort, and nausea.

Threshold Odor Level

Threshold odor level refers to the minimum concentration of an odor that an average person can detect and is known as one odor unit (ou). Threshold odor levels are determined by individuals who are trained in using established odor measurement procedures to recognize and describe odors.

How Odor Problems Are Defined

Four factors are commonly used to define the severity of an odor impact event: offensiveness, intensity, frequency, and duration. Offensiveness refers to how objectionable or obnoxious the odor is; intensity refers to concentration of the odor. Frequency refers to how often the odor problem occurs; duration is the length of time the event persists.

How Odors Are Measured

Two methods used to measure odor: instruments, which measure concentrations of specific gases, and olofactometry measurements, which rely on individuals to detect and describe the odor. While instruments can measure specific gases, typically there is no known relationship between the concentration of the individual gases in an odorous mixture and the odor of the mixture as perceived by people.

Instruments for measuring specific gases include patches, indicator tubes, long-term diffusion tubes, Jerome meters, MDA single-point monitors, ammonia analyzers, electronic sensors, gas chromatographs, and mass spectrometers. Olfactometry methods provide a good indication of how people perceive odorous mixtures but are relatively expensive since they require trained people to detect and describe the odors.

Descriptive Olfactometry Characteristics for Odors

Five descriptive characteristics are used to describe odors: concentration, intensity, persistence, hedonic tone, and character.

Concentration refers to the amount of odor and is reported in dimensionless odor units. An odor unit (ou) is defined as the volume of diluted (non-odorous) mixture divided by the volume of the odorous air sample at the threshold level. One threshold odor unit is the lowest concentration that trained olfactometry panelists can detect.

Intensity refers to the strength of an odor sample and is determined by using a five-step scale procedure with n-butanol as the reference standard odor. Persistence indicates how easily odorous air can be diluted to the threshold detection level. Hedonic tone describes the unpleasantness or pleasantness of an odor and is often rated using a -10 to +10 scale. Zero is neutral, being neither pleasant nor unpleasant. Character descriptors, such as earthy, are used to define the character of the odor.

Odor Measurement Techniques

A <u>scentometer</u> is a hand-held device used to measure odors. It consists of a box with two nasal ports connected to separate chambers of activated charcoal that have several air inlets of varying size. Trained individuals use the instrument to determine the volume of non-odorous air required to dilute it to threshold odor level. Although low cost and portability are advantages, this technique requires trained panelists. The method generally is not known for high accuracy and consistency.

A <u>field sniffer</u> is a person trained to measure odor intensity in the field. A sniffer calibrates his nose using a standard odor intensity scale for n-butanol. In the field, the sniffer wears a charcoal filter mask to breathe non-odorous air. Periodically the sniffer removes the mask, sniffs the odorous air, and records the odor intensity. This technique requires a panel of trained people to provide consistent results.

The <u>dynamic, triangular, forced-choice olfactometer</u> is the technique most commonly used to measure threshold odor levels under controlled laboratory conditions. Trained panelists are exposed to three streams of air. One stream is a mixture of non-odorous air and a small volume of odorous air; the other two streams are non-odorous air. Initially, the odorous air is added at concentrations below the threshold level. In steps, the amount of odorous air is doubled until the panelists determine that air stream to be different from the others; this point is the threshold level.

A panel of eight trained people is normally required to analyze each odor sample. While forced-choice olfactometry is the most accurate odor measurement technique, it is also the most expensive.

Odor Movement and Dispersion

When odors mix with fresh air, this odor dilution process is called dispersion. Complex dispersion models are used by industry and regulatory agencies to describe the movement of odors away from their sources. These models generate and characterize the odor plumes dispersing from the source and are used to describe odor impacts on neighboring land uses and residents. During the past decade, research has attempted to relate these dispersion models to odor movement on livestock operations.

A graphic depiction of odor dispersion from a livestock building is shown in Figure 1. As the odors are carried downwind, transport occurs downwind and mixing and diffusion processes combine fresh air with the odorous air, which dilutes the odorous air in lateral and vertical directions.

The two-dimensional distribution of the odorous air near the land surface is called an odor plume. The outermost limit of the plume represents the threshold odor level, the location where an average person would say the odor first becomes detectable when moving toward the odor source. Odor levels within the plume are greatest at the odor source and decrease both in lateral and downwind directions from the source.

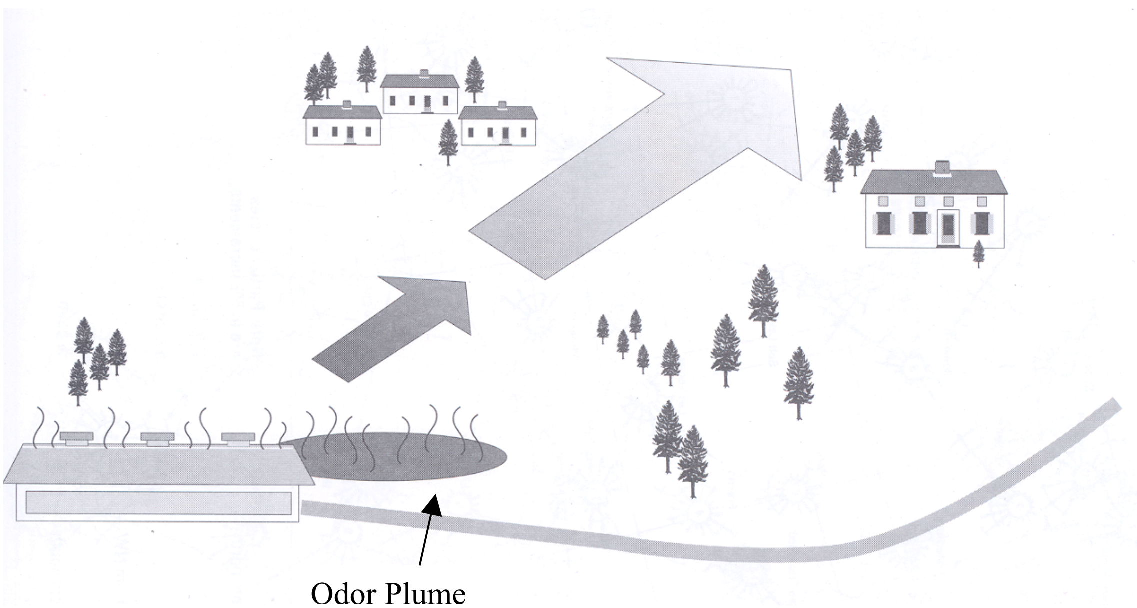

Figure 1. Odor plume and dispersion for a livestock building emitting odor (1).

The length and width of an odor plume is determined by three factors: 1) the rate at which odors are emitted from their source, 2) weather conditions, and 3) topography and vegetation near the odor source. Plumes become larger as emission rates increase.

Wind speed and air stability affect how quickly the odors are diluted. Increasing wind speed enhances the mixing process and reduces the size of the plume. Air stability is determined by the air temperature profile near the land surface. When air temperature decreases with elevation, the air becomes unstable. The warm air near the ground rises vertically since it is less dense than the cool air above it. When the air temperature at the land surface increases with elevation, the surface air is defined as stable since it is denser and will not rise.

Unstable air conditions enhance mixing and result in smaller odor plumes. Stable air conditions produce larger plumes.

The presence of tall vegetation and rolling topography also enhances mixing and reduces the size of the plume.

Approaches for Minimizing Odor Impacts

Two general approaches can be used to control the size of an odor plume for a livestock operation and the associated impacts on neighboring residents and adjacent land uses. They are:

1) utilization of livestock production and manure management practices that reduce odor emission rates, and
2) an adequate separation distance between the livestock operation and neighboring rural residents that encourages adequate odor dispersion and minimizes odor impacts.

Many effective and cost-acceptable management practices and technologies are available to livestock producers to control odor emissions and impacts of livestock operations.

Examples include but are not limited to manipulating diets to reduce odor generation from fresh manure, covers for manure storage facilities, and practices that enhance odor dispersion. The effectiveness and cost of odor reduction practices vary and are somewhat dependent on site-specific conditions.

Traditionally, decisions regarding separation distances for odor control are based on past experiences. Some South Dakota counties have adopted separation distances for new and expanding operations are based on number of livestock, characteristics of the proposed operation, and type and proximity of adjacent land uses. While this approach maintains local control by allowing the county to establish the level of odor control, it is not perhaps as satisfactory as would be desirable.

A new approach with potential for predicting acceptable separation distances is use of odor dispersion models.

Recently, researchers at the University of Minnesota developed an odor dispersion model called OFFSET (Odor From Feedlots Separation Estimation Tool). OFFSET utilizes emission rates from livestock facilities, average long-term climatic conditions for Minnesota, and type of odor control practices in use to estimate the separation distance needed to provide a specified odor annoyance-free requirement. Annoyance-free odor is defined as the level of odor that an average person might detect if attention is draw to the odor.

For example, a 98% odor annoyance-free requirement means an average person standing downwind at the calculated separation distance would detect an odor level equal or greater than the annoyance-free odor 2% of the time (14 hours per month) between mid April and mid October.

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