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Odor and H2S Emissions from Dairy Facilities

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Introduction

Odorous and other gases are emitted from all types of livestock enterprises. Although the current focus of the public has been on the swine industry, the dairy industry is not exempt from close scrutiny on these emissions. Air quality regulations, which have exempted the livestock industry in the past, are now being applied to any and all facilities. This regulatory emphasis, along with the increasing "sensitivity" of the rural public and growing size of livestock operations, will continue to force livestock producers to pay attention to all types of air emissions.

Gas and odor generation

Studies indicate that nearly 200 different gases are emitted from decomposing manure. Some of these gases are odorous, while some are odorless. Some of these gases are toxic while others are harmless. The most common gases found in and around livestock facilities are hydrogen sulfide, ammonia and methane. Although both ammonia and hydrogen sulfide are odorous, most current research indicates that these gases are only two of several that contribute to odor emissions. Other gases emitted from decomposing organic material which contribute to odor can be classified in four groups: volatile fatty acids; indoles and phenols; ammonia and volatile amines; and volatile sulfur compounds. Concentrations of these compounds range from parts per trillion (ppt) to parts per million (ppm). Most of these gases are generated during the microbial breakdown of the manure under anaerobic conditions. This complex mixture of gases is difficult to quantify and the odor impact is difficult to predict using standard chemical analysis. This is due to the difficulty of measuring many of these gases and the synergistic and antagonistic effect these gases have the human olfactory system.

Odor and odor measurement

Odor emissions are not currently regulated by the State of Minnesota. However, odors are a primary concern to the general public and several counties are now evaluating methods to regulate odor. These regulations typically focus on land use planning and separation distances between livestock facilities and communities or neighbors. Unfortunately, there is very little scientific evidence quantifying odor emissions as they relate to the type, size or management of a livestock operation or the distance these odors will travel. Hence, regulations are based on arbitrary values which link community odor impacts to the number of animals at the facility. Several research projects throughout the world are attempting to quantify odor emissions from livestock facilities and determine the downwind impact of such facilities. To quantify these impacts, it is necessary to develop a sound method of odor measurement. Measuring individual "indicator" gases is being attempted at several research institutes. Although this method has met with some success using up to 21 different chemicals as indicators, considerably more research must be done to use such a method.

Currently, the best technology available to measure odor is with systems that calibrate the human sense of smell. Although several methods exist, olfactometry and an intensity rating system are the most common techniques. Olfactometry is a measurement system that uses several human panelists and a machine to dilute the odorous air sample with clean air. This odorous sample is diluted to the point that the panelist can no longer detect the odor. This measurement is quantified as the dilutions to threshold, the volume ratio of clean air needed to dilute a sample of odorous air to the point where human subjects cannot detect the odor.

The second most popular method of odor quantification is a measure of intensity. Intensity is also a quantification of odor using human panelists. Intensity measurements compare the relative strength of the odorous air sample to a known dilution of a single gas, typically n-butanol. The intensity of the sample is then recorded on a numeric scale (e.g., 0-10). In both quantification methods, several panelists are used and their results are averaged.

Hydrogen Sulfide Measurement

Ambient hydrogen sulfide concentrations are currently regulated by the state of Minnesota. Ambient half-hour concentrations of 30 ppb cannot be exceeded twice per five days or 50 ppb twice per year. To enforce these standards, measurements are taken at the property line of the offending facility using continuous gas sampling equipment. The Minnesota Pollution Control Agency currently uses a Jerome® meter, a hand-held, push-button instrument manufactured by Arizona Instruments, to screen facilities for the potential to exceed the ambient hydrogen sulfide standard. Over the past year, 435 individual measurements at 137 different livestock facilities have been conducted with the Jerome® meter. Fifty-eight of these measurements were made at dairy facilities with four of these measurements showing a potential to exceed the 30 ppb standard (MPCA Feedlot Air Quality Summary, March 1999).

Odor Rating System

The University of Minnesota Department of Biosystems and Agricultural Engineering has been monitoring hydrogen sulfide emissions from all types of livestock facilities over the last two years. Table 1 lists some of the preliminary results from this study. Information is presented in emissions per square meter of emitting surface. More emission data will be collected in 1999. This emission data will be used to develop an "Odor Rating System" for the state of Minnesota. This odor rating system is an attempt to quantify both the odor emission from different types of facilities and the impact of these odor emissions on the surrounding communities. This information could be used by both livestock producers and regulators to make decisions about siting facilities and employing designs and technologies to control odor.

Table 1 Odor and hydrogen sulfide emission from manure storages. (Preliminary data.)

Species	Odor source	H2S emissions µg/s/m2	Odor Emissions ou/s/m2
Dairy	Basin, crusted	2.5	1.6
Dairy	Basin, no crust	7.5	4.5
Swine Farrow	Basin, no crust	10.5	4.6
Swine Finish	Basin, no crust	14.2	8.5

Control of gas and odor emissions

Regulatory emphasis on hydrogen sulfide emissions and public pressures regarding odor emissions have resulted in significant research efforts directed at controlling these emissions. Currently, the list of proven, affordable technologies is limited to manure storage covers and biofilters. In the future, anaerobic digesters may also be considered an affordable solution. Anaerobic digestion is a treatment technology that converts the organic matter in manure to a biogas rich in methane. This biogas can be used as a fuel in a generator or burned to heat buildings or water.

Manure storage covers

Manure storage structures contribute significantly to odor emissions. Placing a cover on the manure has proven to be very effective at controlling both odor and hydrogen sulfide emissions. These covers are either non-porous or porous. Non-porous covers trap the gasses which are generated in the manure. These gases must be collected from under the cover and treated through a flare, biofilter, or some other treatment technology.

Porous covers reduce emissions by creating a boundary between the ambient air and the manure surface. Depending on the type of porous cover, microbial activity may actually destroy some of these odorous gasses. Natural crusts, straw covers, and geotextile mats are all porous covers.

Dairy manure storages often form a heavy crust. This crust significantly reduces odor and gas emissions. Unfortunately, little information has been collected on how to build and maintain a crust. One factor that may contribute to crust formation is the solids content of the manure in the storage structure. Facilities using organic bedding and limiting water wastage seem to have an easier time maintaining a crust. One of the current concerns in the industry is with new dairy facilities. Often the crust on these facilities will not form the first or second year resulting in significant odor and hydrogen sulfide emissions. Researchers hope to study this phenomenon this year in the hopes of finding a management practice which will enhance crust formation.

For those manure storages that do not form a crust, most likely on those facilities using sand bedding, a straw cover can be used. A cover constructed of straw has been shown to be quite effective at reducing odor (70-90%). This straw is blown onto the structure using a tubgrinder and a silage blower or equipment manufactured specifically for this task. Both wheat and barley straw have been used to cover manure storages and both are effective at odor control. A depth of ten to twelve inches of straw are recommended. This thickness of application requires approximately 75 large round bales of straw per acre of manure surface. Thinner layers of straw are effective at odor control but will sink quicker than a thicker layer. Straw covers will last approximately four months with the possibility of lasting for a much longer or much shorter period of time. Since it is difficult to get the straw placed evenly on the storage, some areas will be covered with thinner layers. These areas will soon be "uncovered" and require a second application of straw.

Biofiltration

Biofiltration is an odor control technology that has been used for several years to oxidize odorous compounds in an air stream through a natural, microbial process. The microbes are supported on media which is kept at temperature and moisture content suitable for optimum microbial growth. This media is often some type of organic material such as compost or wood shavings. Odorous air is routed through the biofilter and then exhausted, basically odor free, from the biofilter. Biofilters can easily be designed knowing the airflow rate of the building. Figure 1 shows the construction of a biofilter on a deep-pitted, mechanically-ventilated facility.

Biofilters are a very effective means of controlling odor from any controlled exhaust. One biofilter is currently being tested on a deep-pitted, mechanically-ventilated, heifer barn. Odor reductions from this biofilter are approximately 90%.Unfortunately, their use on dairy facilities is somewhat limited since most dairys are naturally ventilated with open air manure storages.

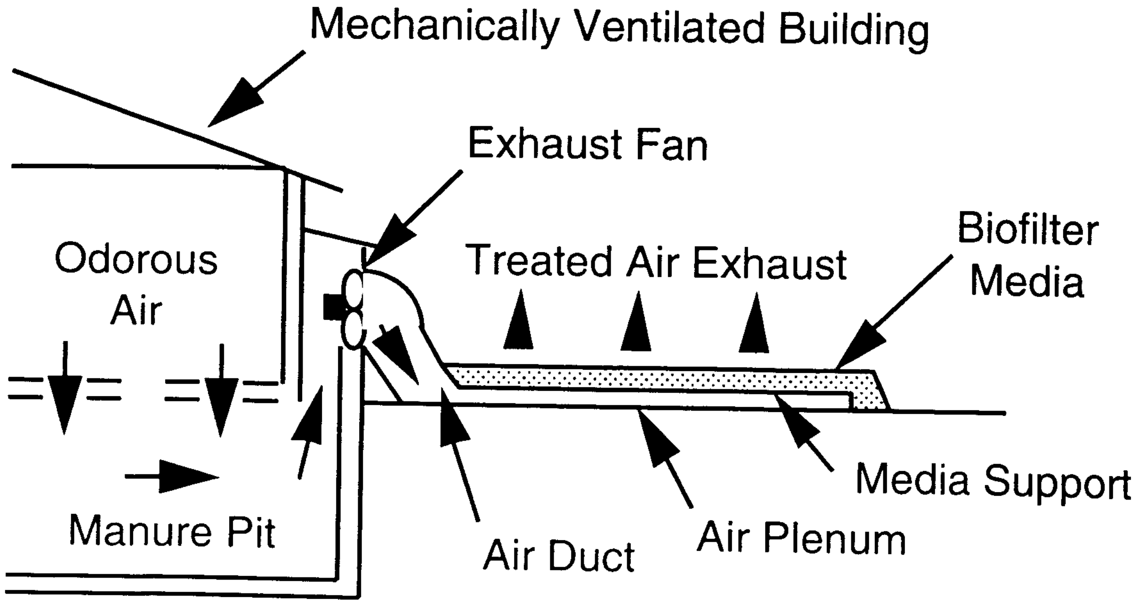

Figure 1 Biofilter construction diagram

Emission control during agitation and land application of manure

One of the worst times for hydrogen sulfide and odor emissions is during agitation of manure storage structures and land application of manure. Preliminary testing indicates the rate of odor and hydrogen sulfide emissions during this agitation is over 100 times more than during normal conditions. It is also known that most odor complaints are generated during agitation and land application. Unfortunately, there is little opportunity to control emissions during agitation. The best control is to time the agitation for days when the wind is blowing in the most beneficial direction and when the air temperature is beginning to warm. This warming of the air causes the air to rise which aids in dispersing the odor plume. Odor and gas emissions during land application of manure can be significantly reduced by injecting the manure under the soil surface, or immediately incorporating the manure after surface application. These practices also ensure that nitrogen losses in the form of ammonia emissions are limited.

Conclusions

Air emissions from dairy operations are receiving close scrutiny from local, state, and federal regulators along with the general public. Currently, odor and hydrogen sulfide are the gases of concern; however, it is also very likely that gases such as methane, ammonia and other nitrogen gases will soon be regulated. Methane emissions contribute to global warming while nitrogen emissions contribute to both global warming and acid deposition. Although Minnesota is leading the way in controlling these emissions, other states and the federal government do not lag to far behind. Therefore, it is important to understand how to design and manage facilities to minimize or control all air emissions.