Water Quality & Waste Management

Safety in Swine Production Systems

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Published by: North Carolina Cooperative Extension Service

Publication Number: PIH-104

Last Electronic Revision: March 1996 (JWM)

Introduction

The swine industry has increasingly moved toward specialization and mechanization for high density rearing of livestock. One aspect of this specialization can be seen in housing systems that assist managers in raising animals with less labor in a more controlled environment, one that incorporates mechanized ventilation, supplemental heating, liquid or slurry manure handling, and automated dry-feed handling. These systems introduce new management factors related to both people and livestock. It is significant that animal health and performance advantages of housing sys- tems when compared to pasture or dirt lot systems are retlected in lower mortality, better feed conversion, and increased growth rates.

However, manure accumulations within enclosed buildings generate gases which can be both toxic and asphyxiating when improperly managed. Another problem is unvented heaters in poorly ventilated buildings that lack enough oxygen for complete fuel combustion. This situation can increase carbon monoxide levels. Dust resulting from automated feeding systems, animal hair and dander, and dried manure on floors and animals can irritate respiratory systems. The severity of these problems is seasonal in that the atmosphere within enclosed buildings is often much better during the summer than the winter because ventilation rates are not reduced for heat energy conservation.

The potential danger of stored manure gases must be respected. Livestock have died as a result of ventilation failures or stored manure agitation. Human fatalities have occurred from entering a manure collection or storage pit without insuring adequate ventilation or without being equipped with proper breathing apparatus. In addition, manure storage pits or tanks and lagoons, like any water impoundment, should be respected for the drowning potential.

Toxic and Asphyxiating Gases

When manure and urine are stored and undergo anaerobic digestion, dangerous gases are produced. The ones of primary concern are: hydrogen sulfide, ammonia, carbon dioxide, and methane. But more than 40 diflerent gases are produced; and some, such as volatile acids, amines, and mercaptans are highly odorous in very small quantities. In addition, carbon monoxide can rise to toxic levels when heating units malfunction or inadequate oxygen is present.

Hydrogen Sulfide (H2S). Hydrogen sulfide is the most toxic gas associated with the decomposition of swine manure. It is believed to have been responsible for most of the deaths of livestock and humans that have occurred around liquid manure storage pits. It is colorless, heavier than air, and highly soluble in water; it has the characteristic odor of rotten eggs. However, the odor of hydrogen suNide can be deceiving. It is first detected, by most people, at concentrations below one part per million (ppm) by volume. (One ppm is the equivalent of one volume of gas mixed in one million volumes of air.) Above 6 ppm, the odor will only increase slightty even though the concentration of hydrogen sulfide increases significantly. The gas at 150 ppm can have a deadening effect on the sense of smell making detection extremely difficuK.

A common level of hydrogen sulfide gas in environmentally controlled swine units is around 5 ppm. But during the first stages of stored manure agitation and pumping liquid manure, hydrogen sulfide can reach dangerous concentrations. Levels of 200 to 300 ppm have been reported to exist within a few minutes after agitation begins, and levels can go as high as 1,500 ppm. The effects hydrogen suitide can have on humans and swine, at dfflerent levels, are shown in Table 1.

The National Institute ot Occupational Safety and Health (NIOSH) maximum recommended safe concentration of hydrogen sulfide for workers in a building during an eight-hour work period five days per week is 10 ppm. Human evacuation is recommended when levels exceed 50 ppm.

Even if a person does not lose consciousness after inhaling heavy doses of hydrogen sulfide, medical attention still should be sought since fluids can accumulate in the lungs following exposure.

Ammonia (NHa). During storage and decomposition, significant amounts of ammonia are released from manure and urine. Sources of ammonia include urine and feces on the top of slats or solid floors and in the pit. Ammonia gas is an irrnant which is colorless, lighter than air, and highly water soluble. It has a sharp pungent odor that becomes detectable at levels as low as 5 ppm.

Typical ammonia levels in well-ventilated environmentally regulated buildings are 10-20 ppm with liquid manure systems and 50 ppm where manure and urine are deposited on solid floors. Levels can exceed 50 ppm with lower winter ventilation rates and reach 100-200 ppm in poorly vennilated buildings. The effects of exposure to ammonia gas are presented in Table 2. The NIOSH maximum recommended safe ammonia concentration for workers in a building for an eight-hour work period is 25 ppm.

Calbon Dloxide (CO2>. The earth's atmosphere normally contains 300 ppm of carbon dioxide. At considerably higher concentrations, it can asphyxiate people by reducing the amount of oxygen present.

Manure decomposnion and the nommal breathing process of animals can increase the level ot carbon dioxide in confined spaces. Typical concentrations inside ventilated buildings range trom 1,000 ppm during well-ventilated periods to 10,000 ppm during winter. The effects of excessive concentrations ot carbon dioxide are presented in Table 3. The NIOSH maximum recommended safe carbon dioxide concentration for workers is 5,000 ppm.

Methane (CH4). Methane is produced during natural decomposnion of manure and is nontoxic. It is rarely a problem in swine buildings. However, high concentrations can cause headaches and even asphyxiation. The major safety concern about methane is that it is highly tiammable and can be explosive at levels ranging from 50,000 to 150,000 ppm (5 to 15 percent). Because methane is lighter than air, it tends to rise and accumulate near the higher stagnant parts of enciosed buildings and tightly closed manure storage pits. This colorless, odorbss gas is only slightly soluble in water. Bun if a unit is well-ventilated, concentrations should be well below the minimum explosive point.

The NIOSH maximum recommended safe methane concentration for workers during an eight-hour period is 1,000 ppm. Its effects on humans and swine are presented in Table 4.

Carbon monoxide (CO). When fuels burn incompletely, as all fuels do to some extent, carbon monoxide is produced. This is 8 gas which is most notorious for killing people who operate their car engines inside closed garages.

Inside a building, carbon monoxide can build up in poorly ventilated areas where heating units malfunction, where there are unvented heaters, or where there are gas catalytic heaters. Winter is the most dangerous period because buildings are usually closed and ventilation rates are lowest. A victim can be unaware of the presence of carbon monoxide because it is colorless and odorless. The NIOSH maximum recommended safe working carbon monoxide concentration for adults during an eight-hour period is 50 ppm. Pregnant female workers should be aware that an unborn fetus is more susceptible to carbon monoxide than adults. Carbon monoxide has the same density as air and is insoluble in water. Table 5 presents the effects of carbon monoxide exposure.

Table 1. Effects of hydrogen sulfide exposure on humans and swine.

Exposure level	Effects or symptom
On humans	
10 ppm	Eye irritation
20 ppm for more than 20 min.	Irritation to the eyes, nose, and throat
50 to 100 ppm	Vomiting, nausea, diarrhea
200 ppm for 1 hr.	Dizziness, nervous system depression,increased susceptibility to pneumonia
500 ppm tor 30 min.	Nausea, excitement, unconsciousness
600 ppm and above	Rapid death
On swine	
20 ppm, exposed continually	Fear of light, loss of appetite, nervousness
200 ppm	Possible pulmonary edema (water in the lungs) with breathing difficulties and possible loss of consciousness and death

Table 2. Effects of ammonia gas exposure on humans and swine.

Exposure level	Effects or symptom
On humans	
6 to 20 ppm and above	Eye irritant, respiratory problems
100 ppm tor 1	Irration to mucous surfaces

hr.	
400 ppm for 1 hr.	Irritation to eyes, nose, and throat
700 ppm	Immediate irritation to eyes, nose, and throat
5,000 ppm	Respiratory spasms, rapid suffocation
10,000 ppm and above	Death
On swine	
50 ppm	Reductions in performance and health. Long-term exposure increases the possibility of pneumonia and other respiratory diseases.
100 ppm	Sneezing, salivation, and loss of appetite thereby reducing animal performance.
300 ppm and above	Immediate irritation of nose and mouth. Prolonged exposure causes extremely shallow and irregular beathing followed by convulsions.

Table 3. Effects of excess carbon dioxide exposure on humans and swine.	
Exposure level	**Effects or symptom**
On humans	
60,000 ppm for 30 minutes	Heavy tereathing, drowsiness, and headaches
100,000 ppm (10%) and above	Narcotic effect, dizziness, unconsciousness
250,000 ppm (25%) and above	Death
On swine	
40,000 ppm	Increased rate of breatzmg
90,000 ppm	Discomfort
200,000 ppm (20%)	Cannot be tolerated by market hogs for more than one hour

Dust and Particulate Matter

High levels of dust particles resulting from automated dry-feed handling systems, dander and hair from animals, and dried manure particles from animals on slotted and solid floors can occur inside swine units. Manure gases can cling to these dust particles in such a way that inhaling these gas-laden particles is like taking a breath of smog. Particulate maner also includes viral, bactetial, and fungal agents from the building environment and carries them into a person's respiratory system.

Another potential problem is inhalation of animal feed dust containing antibiotics. These inhaled particles could cause a person to become sensitive to certain antibiotics. It is