Extension
University of Missouri

Gases and Odors From Swine Wastes

Charles D. Fulhage
Department of Agricultural Engineering

Raising hogs in confinement has caused concern for air quality inside and outside of buildings.

Complaints and lawsuits by neighbors and urban dwellers have turned attention toward odors and methods of controlling them. Other concerns for air quality concern those who work in the buildings, and the hogs themselves.

High levels of noxious gases in confinement buildings have caused persons to experience irritation in breathing. Dead hogs also have been reported when noxious gas levels became critically high.

Origin of gases and odors

To understand how gases and odors are produced, first learn the basic chemical and biochemical transformations involved in the anaerobic (without oxygen) treatment process.

Gases and odors in a confinement facility result from bacterial action on biodegradable parts of swine waste. Gases produced in greatest volume are methane, carbon dioxide, ammonia and hydrogen sulfide.

A complicated group of volatile organic substances also contribute to the odor complex in swine buildings. This group contains amines, mercaptans, alcohols, carbonyls and sulfides in trace amounts.

Methane, the gas produced in greatest volume during the anaerobic stabilization process, results from organic acids being degraded. This gas usually escapes to the atmosphere and is a potential air pollutant.

Carbon dioxide, the second most abundant gas in the anaerobic process, is also produced as organic acids are degraded. Because it is odorless, the pollution potential of this gas is often overlooked.

Ammonia is released as amino acids in protein are broken down by bacteria. This gas is easily recognized because of its pungent odor.

Hydrogen sulfide is also a part of the odor. Anaerobic reduction of sulfur-containing compounds such as certain amino acids result in formation of hydrogen sulfide. This gas has a very offensive odor.

The volatile organic substances mentioned above are often responsible for offensive odors associated with swine facilities. Because the human nose is extremely sensitive to compounds such as amines and mercaptans, these gases are of primary concern, even though they are present in trace amounts.

Properties and physiological effects of noxious gases

Table 1 summarizes some pertinent properties and physiological effects of gases associated with hogs.

Table 1
Properties and physiological effects of noxious gases (Adapted from Taiganides and White, 1968)

Carbon Dioxide (CO_2) Asphyxiant

Density[1]: 1.98 grams per liter
Specific gravity[2]: 1.53
Odor: None
Color: None
Maximum allowable concentrations[5]: 5,000 ppm
20,000 ppm concentration[6]; Physiological effects[8]: Safe
30,000 ppm concentration[6]; Physiological effects[8]: Increased breathing
40,000 ppm concentration[6]; Physiological effects[8]: Drowsiness, headaches
60,000 ppm concentration[6]; Exposure period[7]: 30 min.; Physiological effects[8]: Heavy, asphyxiating breathing
300,000 ppm concentration[6]; Exposure period[7]: 30 min.; Physiological effects[8]: Could be fatal

Ammonia (NH_3) Irritant

Density[1]: 0.77 grams per liter
Specific gravity[2]: 0.58
Odor: Sharp, pungent
Color: None
Explosive range[3]: Minimum: 16; Maximum: — Odor threshold[4]: 5 ppm
Maximum allowable concentrations[5]: 50 ppm
400 ppm concentration[6]; Physiological effects[8]: Throat irritant
700 ppm concentration[6]; Physiological effects[8]: Eye irritant
1,700 ppm concentration[6]; Physiological effects[8]: Coughing and frothing
3,000 ppm concentration[6]; Exposure period[7]: 30 min.; Physiological effects[8]: Asphyxiating
5,000 ppm concentration[6]; Exposure period[7]: 40 min.; Physiological effects[8]: Could be fatal

Hydrogen sulfide (H_2S) Poison

Density[1]: 1.54 grams per liter
Specific gravity[2]: 1.19
Odor: Rotten egg smell, nauseating
Color: None
Explosive range[3]: Minimum: 4; Maximum: 46
Odor threshold[4]: 0.7 ppm
Maximum allowable concentrations[5]: 10 ppm
100 ppm concentration[6]; Exposure period[7]: Several hours; Physiological effects[8]: Irritation of eyes and nose
200 ppm concentration[6]; Exposure period[7]: 60 min.; Physiological effects[8]: Headaches, dizziness
500 ppm concentration[6]; Exposure period[7]: 30 min.; Physiological effects[8]: Nausea, excitement, insomnia
1,000 ppm concentration[6]; Physiological effects[8]: Unconsciousness, death

Methane (CH_4) Asphyxiant

Density[1]: 0.72 grams per liter
Specific gravity[2]: 0.58
Odor: None
Color: None
Explosive range[3]: Minimum: 5; Maximum: 15
Maximum allowable concentrations[5]: 1,000 ppm
500,000 ppm concentration[6]; Physiological effects[8]: Headache, nontoxic

Carbon monoxide (CO) Poison

Density[1]: 1.25 grams per liter
Specific gravity[2]: 0.97
Odor: None
Color: None

Maximum allowable concentrations[5]: 50 ppm
500 ppm concentration[6]; Exposure period[7]: 60 min.; Physiological effects[8]: None
1,000 ppm concentration[6]; Exposure period[7]: 60 min.; Physiological effects[8]: Unpleasant, but not dangerous
2,000 ppm concentration[6]; Exposure period[7]: 60 min.; Physiological effects[8]: Dangerous
4,000 ppm concentration[6]; Exposure period[7]: 60+ min.; Physiological effects[8]: Fatal

[1] Density: Density of the gases in grams per liter at 32 degrees Fahrenheit. Density of air is 1.29 grams per liter.
[2] Specific gravity: The ratio of the weight of pure gas to that of atmospheric air. If the number is less than 1, the gas is lighter than air; if greater than 1, it is heavier than air.
[3] Explosive range: The range within which a mixture of gas and atmospheric air can explode with a spark (percent by volume).
[4] Odor threshold: The lowest concentration at which the odor is detected. This figure can only be approximate.
[5] Maximum allowable concentration: The concentration set by health agencies as the maximum allowed in an atmosphere where men work over an 8- to 10-hour period. Possibly the levels should be lower for animals since they must be in the environment continuously.
[6] Concentrations: In parts of pure gas per million parts of atmospheric air. To change to percent by volume, divide by 10,000.
[7] Exposure period: The time during which the effects of the noxious gas are felt by an adult human or a 150-pound pig.
[8] Physiological effects: Those found to occur in adult humans. Similar effect would be felt by a 150-pound pig. Lighter pigs would be affected sooner at lower rates.

Methane is colorless, odorless and lighter than air. It is given off in considerable quantity from anaerobic action. However, it is formed by a highly specialized group of bacteria, and conditions normally found in confinement facilities are not conducive to producing significant amounts of methane. The more important danger of methane is perhaps its explosive characteristic at concentrations of 5 to 15 percent. While this gas is normally considered nontoxic, it has an asphyxiating effect.

Carbon dioxide is colorless, odorless and heavier than air. It normally makes up 30 to 60 percent of the gas resulting from anaerobic stabilization of manure. Carbon dioxide is not highly toxic. However, its greater danger is asphyxiation due to depletion of oxygen supply in the air. Concentrations of carbon dioxide greater than 4 percent are cause for concern for both humans and livestock.

Ammonia, a colorless gas, usually makes up a very small percentage (less than 5 percent) of the gases produced during decomposition of animal manure. However, it is easily recognized by its pungent odor. Ammonia concentrations greater than 0.01 percent in a confinement building are likely to cause considerable discomfort to both humans and animals. Ammonia is highly soluble in water, therefore its presence usually is less noticeable where liquid manure systems are used rather than solid floors.

Hydrogen sulfide is colorless, heavier than air, and has the characteristic "rotten egg" smell. Although given off in relatively small quantities during anaerobic decomposition, hydrogen sulfide is the most toxic of manure gases. Concentrations of this gas greater than 0.001 percent cause considerable discomfort to humans and livestock. Levels greater than 0.05 percent are likely to be lethal.

Many other gaseous compounds, some causing very strong odors, are released during anaerobic decomposition. However, they are produced only in trace amounts and have not been thoroughly studied. Compounds such as sulfides, amines and mercaptans are known to be an important part of the odor complex.

Potentially lethal situations

Under normal conditions, there is little likelihood of noxious gas levels rising to critical concentrations in a well-designed confinement facility. However, there are circumstances in which gas levels can become critically high, even in a properly designed confinement facility.

Ventilation breakdown is most often the cause of critically high gas levels in confinement facilities. If fresh air in a confinement facility is not replenished due to power failure, carbon dioxide levels can reach lethal proportions in eight to 10 hours. Death under these circumstances is usually hastened by rising temperature and humidity in the confinement facility.

Agitating manure that has been stored in a pit for several months can release dangerous quantities of noxious gases, even if the ventilation system is operating properly. The dangers during agitation are release of the highly toxic gas hydrogen sulfide and release of carbon dioxide in quantities sufficient to deplete the oxygen supply.

Entering a manure storage pit can be potentially lethal for humans. Carbon dioxide and hydrogen sulfide are heavier than air and tend to collect at the manure surface. In pits equipped with a cover or manhole opening only, methane can accumulate, creating potentially explosive conditions. Persons should never enter a manure storage pit unless it has been ventilated to get rid of dangerous gases.

Controlling gases and odors

The following guidelines may aid in preventing excess gas and odor build-up in confinement buildings:

- Remove manure from the building regularly. If manure is removed from a building before it begins to decompose, only small amounts of gases and odors are released.
- Buildings equipped with pits should have venting portals between the manure level in the pit and the slats above the pit.
- Maintain water level in manure pits to collect soluble gases.
- Keep the ventilation system in top operating condition.
- Provide for auxiliary power supply to operate the ventilation system in case of power failure.
- Use extreme care when agitating a manure pit or starting the rotor of an oxidation ditch in which manure has collected for several days.

The surest way to prevent gas and odor build-up in confinement buildings is to remove manure daily. Gas and odor control is a primary advantage of modern flushing systems that can remove manure as often as every hour.

References

- Day, D. L., E. L. Hansen, and Scott Anderson (1965). *Gases and Odors in Confinement Swine Buildings.* ASAE Trans. 8:118-121.
- Merkel, J. A., T. E. Hazen, and J. R. Miner (1969). *Identification of Gases in a Confinement Swine Building Atmosphere.* ASAE Trans. 12:310-313.
- Miner, J. R., and T. E. Hazen (1969). *Ammonia and Amines: Components of Swine-Building Odor.* ASAE Trans. 12:772-774.
- Muehling, A. J. (1969). *Swine Housing and Waste Management.* Department of Agricultural Engineering, College of Agriculture, University of Illinois at Champaign-Urbana.
