AIR QUALITY IN ANIMAL STRUCTURES

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ABSTRACT

Animal buildings contain a variety of airborne contaminants including specific manure gases, general odors, particulate matter or dust, and biogenic particles. The indoor concentrations of many of these contaminants may approach or exceed suggested threshold levels for housed animals and human employees. Also, since these buildings are ventilated at relatively high rates (up to 90 air changes per hour during summer conditions), they may emit sufficient quantities of specific gases, odors and dust that can impact neighbors and may exceed state or federal regulatory emission standards.

INTRODUCTION:

A wide variety of airborne pollutants are found near and inside animal housing facilities. These facilities house animals (livestock or poultry), and contain feed and water delivery systems, environment control equipment such as fans, heaters, and coolers, along with handling and storage systems for manure. The combination of animals, associated equipment and manure sources produce many of the air pollutants that exist inside the

facilities and are emitted from them. Potential airborne contaminants include gases – especially hydrogen sulfide and ammonia, odor, particulate matter (dust), and biogenic particles. Individually and combined, some of these pollutants may need to be controlled because of regulations and health and safety concerns. They may also create a nuisance for neighbors.

GASES

A total of 331 gaseous compounds have been measured in animal housing systems (1). Concentrations of these gases vary widely and depend on animal species, housing, and manure handling systems. In high concentrations, some of these gases may pose a threat to human, animal, and ecosystem health. From this extensive list, hydrogen sulfide and ammonia are the most commonly monitored and extensively studied. Many other gases are odorous and/or potential irritants, but are not typically found at high enough concentrations in animal buildings to be a concern.

Hydrogen Sulfide

Hydrogen sulfide (H_2S) is a product of the anaerobic decomposition of organic (primarily manure) material. It is a colorless gas that is heavier than air, highly soluble in water, and has the characteristic odor of rotten eggs. Liquid manure storage pits (inside buildings) or basins (near barns) are the primary sources of hydrogen sulfide in animal production.

Typically in well ventilated (indoor carbon dioxide concentrations at or under 3000 ppm) and managed animal buildings, the concentration of H_2S will be less than 1 ppm. Hydrogen sulfide was measured at 90 ppb in a well ventilated pig building and 280 ppb after the ventilation was shut off for six hours (2). Clark and McQuitty (3) investigated air quality in six Alberta commercial free-stall dairy barns. They measured H_2S in four of the six barns and concluded that the concentrations of H_2S were low (the maximum recorded value was 145 ppb), and the possibility of detecting more than trace concentration of H_2S was remote where manure was removed twice daily from free-stall dairy units with solid passageways.

Significant quantities of hydrogen sulfide can be released during agitation of stored liquid manure. Patni and Clarke (4) measured peak hydrogen sulfide concentrations near the floor of a dairy barn during agitation at 70 ppm. They also found peak hydrogen sulfide concentrations in a deep pitted swine barn were 100 ppm in the pig area and concentrations as high as 220 ppm were documented in the exhaust air from the pit fan during agitation of the manure in the pit. The Occupational Safety and Health Act (OSHA) currently limit indoor workplace exposure of H_2S to 10 ppm over an 8-hour day. A concentration of 50 ppm may cause dizziness, irritation of the respiratory tract, nausea, and headache while paralysis of the respiratory system can occur with little or no warning in concentrations exceeding 1,000 ppm (5).

Ammonia

Urine is the primary source of ammonia (NH_3) and is released during manure storage and decomposition. NH_3 gas is an irritant, colorless, lighter than air, and highly water soluble. It has a sharp pungent odor becoming detectable at levels as low as 0.7 ppm. Ammonia is a strong irritant: eye irritation can occur at levels as low as 4 ppm, and at 25 ppm respiratory irritation may develop. Very high levels of NH_3 concentrations, such as 2500 ppm may be fatal. OSHA has set a short-term (15 minute) exposure limit for NH_3 at 35 ppm.

Ammonia concentrations vary considerably depending on the animal species and the housing system. Typical NH_3 levels in well-ventilated swine buildings with liquid manure systems are 5 to 10 ppm and 10 to 20 ppm where manure and urine are deposited on solid floors (6). Meyer and Bundy (7) surveyed 200 swine-farrowing houses and determined that the average NH_3 concentration was 11.4 ppm from December to February and 6.9 ppm from March to May. Clark and McQuitty (3) studied the air quality in six Alberta commercial free-stall dairy barns and found that the NH_3 was present in all six barns and the overall mean values ranged from 7 to 20 ppm. Also, McQuitty, et al. (8) found an average ammonia concentration of 33 ppm in the exhaust air of three commercial poultry laying barns during winter conditions.

ODORS

Most of the odorous gases that make up livestock odors are by-products of anaerobic decomposition of livestock wastes by microorganisms. Livestock wastes include manure

(feces and urine), spilled feed and water, bedding materials (i.e., straw, sunflower hulls, wood shavings), 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 by-products of microbial transformations depend, in a major part, on whether the transformation is done aerobically (i.e., with oxygen) or anaerobically (i.e., without oxygen). Microbial transformations occurring under aerobic conditions generally produce fewer odorous by-products than those occurring under anaerobic conditions.

People attribute numerous health effects to bad odors, including headaches, nausea, eye, nose and throat irritation, and depression. Although odors have received considerable attention, it is generally considered a nuisance since it is difficult to assess its impact on human health. Odors are typically mixtures of several different gases and concentrations of these gases. In addition, there is a large variability in people's ability to detect odors. Smokers and elderly people tend to be less sensitive to smells, while one study demonstrated that females might be more sensitive to odors (9). Odor measurement standards that use trained human sensory panels have been developed and used in many countries to provide greater objectivity in the assessment of odor.

PARTICULATE MATTER (PM) OR DUST

Particulate matter (PM) or dust in and around animal facilities includes bits of feed, dried skin, hair or feathers, dried feces, and endotoxins (cell wall of gram-negative bacteria).

Dust comes from the animals themselves, feed storage and processing sites, floors, manure storage and handling equipment, open lots, compost sites, and other elements of animal production systems. Dust levels or concentrations are generally measured on a mass or weight basis per volume of air (mg/m^3). Takai, et al. (10) reported on a large study (some 329 different animal buildings) from four countries in Europe indicating average dust levels for cattle, pig, and poultry barns. Inhalable (a measure of the total) dust levels were 0.38 (cattle), 2.19 (pigs) and 3.60 (poultry) mg/m^3 while respirable (measure of the small particles, < 5 microns) dust concentrations were 0.07, 0.23, and 0.45 mg/m^3 for cattle, pig, and poultry respectively.

Health effects from elevated levels of particulate matter or dust are well established. Particulate matter has been linked to aggravated asthma, increased respiratory symptoms like coughing and difficult or painful breathing, chronic bronchitis, decreased lung function, and premature death (11). Human respiratory effects can begin to occur at concentrations of PM_{10} (particles 10 microns or less in diameter) from 30 to 150 $\mu g/m^3$ (12). These effects are well documented and employees should wear protective masks to reduce their exposure. Airborne dust particles can also accumulate VOCs (Volatile Organic Compounds), ammonia, and other gases on their surfaces, acting as carriers of potential irritants.

BIOGENIC PARTICLES

Organic dusts in livestock buildings may carry pathogenic bacteria, fungi, viruses, endotoxins, or other organic substances. These are called biogenic particles - a collection of airborne biological particles, which range in size from 0.02 to 100 μm in diameter. Biogenic particles can originate from feed, litter, manure, and animals, creating a potential route of transmission for infectious diseases. These particles are primarily a problem for people working in or animals housed in livestock or poultry buildings. High levels of bacteria, mold spores, and endotoxins are generated in animal operations. Over 50 million cfu's (colony forming units) of aerobically growing bacteria has been detected in one gram of dust from a swine house (13). Endotoxins in swine barns averaged 0.12 ug/m^3 in a study by Clark, et al. (14), which is ten times higher than endotoxin levels found in sawmills. Human exposure guidelines suggest endotoxin concentrations of 0.20 and 0.01 ug/m^3 for development of toxic pneumonitis and inflammation of airways respectively (15).

CONCLUSIONS:

Concentrations of airborne contaminants in animal structures vary widely and depend on animal species, housing type, and manure handling systems. Although many gases have been found in animal buildings, ammonia and hydrogen sulfide are the most commonly monitored. Reported levels of H_2S and NH_3 in barns have approached or sometimes exceeded suggested threshold values to protect worker health. Most other gases have been found at below threshold concentrations although some research suggests there are synergistic effects between these gases and dust and biogenic particles.

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