Chapter 6.2 Animal Health Effects

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The preponderance of scientific studies on the effects of air contaminants and emissions on animal health has been conducted in and around swine facilities. Air contaminants can be divided into gases, particulates, bioaerosols, and toxic microbial by-products. Excess ammonia has been associated with lowered average number of pigs weaned, arthritis, porcine stress syndrome, muscle lesions, abscesses, and liver ascarid scars. Particulates (dust) have been related to reduced growth in growing pigs and turbinate pathology. Bioaerosols have been associated with lowered feed efficiency, decreased growth, and increased morbidity and mortality due to respiratory disease and abscesses. There are few scientific studies regarding the health effects and productivity problems of air contaminants on cattle and other livestock. Ammonia and hydrogen sulfide are the two most important inorganic gases affecting the respiratory system of cattle raised in confinement facilities. These gases affect the mucociliary transport and alveolar macrophage functions of the respiratory system lessening its protective responses.

6.2.1 Ammonia - Livestock Health Effects

At concentrations usually found in livestock facilities (<100 ppm), the primary impact of aerial ammonia is as an irritant of the eye and respiratory membranes; and as a chronic stressor that can affect the course of infectious disease as well as directly influence the growth of healthy young animals (Lillie, 1972; Curtis, 1983).

A series of experiments at the University of Illinois measured the effects of various levels of aerial ammonia on young pigs. The rate of gain of young pigs was reduced by 12% during exposure to aerial ammonia at 50 ppm, but no lesions were observed in the respiratory system. At both 100 and 150 ppm aerial ammonia, rate of gain was reduced by 30% and tracheal epithelium and nasal turbinates showed lesions consitent with a tissue irritant (Drummond et al., 1980). Aerial ammonia at 50 and 75 ppm reduced the ability of healthy young pigs to clear bacteria from their lungs (Drummond et al., 1978). At 50 and 100 ppm, aerial ammonia exacerbated nasal turbinate lesions in young pigs infected with *Bordetella bronchiseptica,* but did not add to the infection-induced reduction in the pig's growth rate (Drummond et al., 1981a). In another study, 100 ppm aerial ammonia reduced the rate of gain by 32%; while effects of 100 ppm ammonia and concurrent ascarid infection were additive to where the rate of gain was reduced by 61% (Drummond, et al., 1981b). In a study of 28 swine farms in Sweden, a higher incidence of arthritis, porcine stress syndrome lesions, and abscesses had a positive correlation with levels of aerial ammonia in the facilities (Donham, 1991)

It has recently been recommended that the maximum long-term ammonia exposure limit for swine should be less than 20 ppm as both pathological data (Hamilton, 1996) and immunological data (Urbain, 1994) suggest that exposure to ammonia concentrations of 10 to 15 ppm reduce resistance to infection (Jones, 1997). British workers utilized operant conditioning techniques giving pigs the choice between ambient ammonia levels of 0, 10, 20, and 40 ppm to demonstrate that pigs have an aversion to atmospheres containing even relatively low levels of ammonia (Jones, 1997).

Ammonia has been considered as the most significant air pollutant in cattle barns as its irritating effect on the respiratory epithelium appears to directly reduce the number of ciliated cells and thus decrease the efficiency of mucociliary transport (Marschang, 1973). Ammonia concentrations within cattle facilities varied greatly from 80 to 2001 mg/h per animal depending on the type of housing (concrete floors vs slatted flooring, ventilated vs closed), bedding, age of animals, environmental conditions, waste storage system employed, frequency of cleaning, and ration (Koerkamp et al, 1998; Wathes et al, 1998; Pitcairn et al, 1998; Gurk et al, 1997). At concentrations less than 100 ppm and in a poorly ventilated facility, ammonia appears to affect pulmonary function in cattle. Five mechanisms protect the lungs from invasion of foreign materials: cellular and humoral immunity, mucociliary transport, macrophage function, cough reflex, and nasopharyngeal filtration. Of these defensive mechanisms, mucociliary transport and alveolar macrophage functions are most severely affected by ammonia and possibly hydrogen sulfide (Lillie and Thompson, 1972).

In poultry, ammonia is considered the most harmful gas in broiler chicken housing (Carlile, 1984). Ambient ammonia levels of 50 ppm for prolonged periods irritate respiratory airways and predispose chickens to respiratory infections with the added risk of secondary infections; and development of lesions of keratoconjunctivitis of the eye is associated with ambient ammonia levels of 60 ppm (Hauser, 1988). A reduced rate of bacterial clearance from the lungs was measured in turkeys exposed to 40 ppm aerial ammonia (Nagaraja, 1984). Excessive mucous production, matted cilia, and deterioration of normal mucociliary apparatus was found in turkeys exposed to ammonia concentrations as low as 10 ppm for 7 weeks (Nagaraja, 1983).

6.2.2 Hydrogen Sulfide - Livestock Health Effects

Hydrogen sulfide is a potentially lethal gas produced by anaerobic bacterial decomposition of protein and other sulfur containing organic matter. This colorless gas with the distinctive odor of rotten eggs is heavier than air and may accumulate in manure pits, holding tanks, and other low areas in a facility. The sources of hydrogen sulfide presenting the greatest hazard in an agricultural setting are liquid manure holding pits which are commonly under slatted floors of livestock facilities. Although most of the continuously produced hydrogen sulfide is retained within the liquid of the pit, the gas is rapidly released into the ambient air when the waste slurry is agitated to suspend solids prior to being pumped out. While the concentration of hydrogen sulfide usually found in closed animal facilities (<10 ppm) is not harmful, the release of this gas from manure slurry agitation may produce concentrations up to 1000 ppm or higher (Lillie, 1972; Carson, 1998; Donham, 2000).

Hydrogen sulfide is an irritant gas producing local inflammation of the moist membranes of the eye and respiratory tract. The irritant action of hydrogen sulfide is fairly uniform throughout the respiratory tract, although the deeper pulmonary structures suffer the greatest damage often producing pulmonary edema (Curtis, 1983).

Differences between mammalian species susceptibility to toxic concentrations of hydrogen sulfide are small, as demonstrated by the following reported acutely toxic levels of hydrogen sulfide: goat – 900 ppm; guinea pig – 750 ppm; dog – 600 ppm; rat – 500 ppm (Sayer, 1923). However, chickens were found to be less sensitive to hydrogen sulfide than mammals, with exposures of 4,000 ppm not resulting in immediate death (Klentz, 1978).

Early experiments examining various levels of acute hydrogen sulfide gas exposure in pigs reported the following associated clinical effects; 50 to 100 ppm - nothing significant; 250 ppm – distress; 500 to 700 ppm – semicomatose; 1000 ppm – intermittent spasms, cyanosis, unconsciousness, convulsions, death (O'Donoghue, 1961). At low levels of hydrogen sulfide exposure, no effect was measured on rate of body weight gain or respiratory tract structure in young pigs breathing air containing 8.5 ppm hydrogen sulfide for 17 days (Curtis, 1975)

6.3.3 Particulates

Particulates are derived from two primary sources: pigs and feed. The primary particulate component from the pigs is dried fecal material. After drying fecal material becomes aerosolized by movement of the pigs and air currents. This dust is very fine, and up to 40% is inhalable (Donham, 2000). Dried fecal material is heavily contaminated with microbes and microbial by-products. Animals and workers in nursery and farrowing facilities would be exposed to greater concentrations of fecal dust than would those in finishing facilities where feed dust would predominate (Donham, 2000).

6.3.4 Bioaerosols and Endotoxins

Air quality, as defined in ventilation parameters, influences the aerosol spread of potential viral and bacterial pathogens that colonize the respiratory epithelium. However, rarely does one find pathogens in the air. They generally are less viable and found in fewer numbers relative to the nonpathogens and saprophytes (Donham, 2000). Bacteria, fungi, and yeast heavily contaminated the atmosphere of swine confinement facilities. Total microbial concentration (cfu per cubic meter) range from 100,000 – 10,000,000 (Donham, 2000). Maximum concentration for swine health is approximately 430,000 (Donham, 2000).

Of recent importance is the concentration of endotoxin detected in the atmosphere of confinement facilities. Endotoxin is a phospholipid-polysaccharide macromolecule that comprises the cell wall of Gram-negative bacteria. It is released when the integrity of the cell wall is disturbed. A typical range for endotoxin in the atmosphere of a confined building is 150 -1000 units (Donham, 2000). Maximum concentration for swine health has been approximated at 150 units. Endotoxin is a highly inflammatory substance and is believed to play a major role in respiratory disease of workers (Donham, 2000).

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