HEALTH EFFECTS OF AERIAL EMISSIONS FROM ANIMAL PRODUCTION AND WASTE MANAGEMENT SYSTEMS

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Overview

The rapid proliferation over the last decade of concentrated animal feeding operations (CAFOs) has raised concerns about health effects of aerial emissions from animal production and waste management systems. These aerial emissions are predominantly a mixture of hydrogen sulfide (H_2S), ammonia (NH_3), volatile organic compounds (VOCs) and particulate matter (PM) (including bioaerosols). H_2S, NH_3 and VOCs arise from degradation of waste material. Particulates include manure, dander (hair and skin cells), molds, pollen, grains, insect parts, mineral ash, feathers, endotoxin and feed dust. Recent community studies unrelated to CAFOs suggest that chronic exposure to low levels of H_2S (in the low ppb range) may induce negative health effects. Acute health effects due to H_2S can begin to occur with exposure in the low ppm range. Levels of H_2S in CAFOs tend to range from 500 ppb to 2 ppm but can be much higher if manure is agitated. Consequently, H_2S in animal facilities can pose a risk to workers' health. H_2S levels are diluted downwind, but more research is necessary to determine if ambient (or peak) levels in neighboring communities pose a health risk. Levels of ammonia in animal facilities are often above sensory irritation thresholds and thus can impact workers' respiration. However, ammonia levels tend to be low downwind because ammonia is lighter than air and because it is chemically reactive. The aggregate impact of total VOCs may affect workers and neighbors by inducing strong odors and even sensory irritation. Dust levels within animal facilities can present a health risk to workers, but more research is necessary to determine if ambient (or peak) levels in neighboring communities pose a health risk. Further studies are necessary to quantify the specific levels of components in complex mixtures of pollutants, including H_2S, NH_3, VOCs, PM and odors that induce specific health symptoms. It must be determined if health symptoms are related to time-averaged ambient concentrations or to peak concentrations of single discrete pollutants such as H_2S and NH_3 or to simultaneous exposure to all of the components in the mixture. It is probable that health symptoms are related to the combined effects of multiple components in the emissions.

Hydrogen Sulfide H_2S

Hydrogen sulfide (H_2S) is a colorless, flammable gas that smells like rotten eggs at low concentrations. Because H_2S has a specific gravity heavier than air, it stays close to the ground and can accumulate in enclosed, poorly ventilated, and low-lying areas. The odor detection threshold for H_2S ranges from 0.5 ppb to 30 ppb for 83% of the population, while the irritant threshold ranges from 2.5 to 20 ppm. Thus, the odor threshold for H_2S (as well as other sulfur-containing compounds) is 3-4 orders of magnitude (that is 10^3 and 10^4 times) below the level that causes classical irritant symptoms.

The scientific literature on H_2S suggests that health symptoms can occur with chronic exposure to H_2S concentrations far below the levels at which acute irritation or toxicity occur. Six community investigations near paper mills, refineries, geothermal sources and meat packing plants indicate that exposure over a period of time to low levels of H_2S or other reduced sulfur compounds (below the irritant threshold) can cause health effects. In two of these community studies, health effects were found from an average daily exposure to 10-11 ppb H_2S. These health effects included eye, respiratory or neuropsychological symptoms.

Acute exposure to H_2S at levels in the low ppm range (1 to 7 ppm) can also induce health symp-

toms including headache, increased airway resistance, coughing, throat irritation and eye pain. At 30 ppm, H_2S becomes neurotoxic and induces nasal lesions in olfactory mucosa. At 200 to 1000 ppm, brief exposure to H_2S can be fatal.

Levels of H_2S inside CAFOs (e.g., 1 to 2 ppm) tend to be above those that have been reported in other settings to elicit health symptoms with chronic (and in some cases acute) exposure. Furthermore, measurements of ambient H_2S downwind of swine facilities can exceed 50 ppb. Fatal cases of H_2S poisoning have occurred in both humans and animals during processing of manure when agitation released toxic levels.

Ammonia

Ammonia is a colorless gas at ambient temperature and pressure. At concentrations above 0.7 ppm, it has a pungent, sharp, repellant and acrid odor. The eye irritation threshold (irritation just barely noticeable) for ammonia is 4 ppm (3 mg/m^3). Decrements in baseline PFT tests (pulmonary function tests) have been reported in workers exposed to NH_3 at concentrations of 7 ppm in tandem with other aerial contaminants. Ammonia is released from the natural decomposition of organic material, including manure as well as dead animals and plants. Ammonia concentrations up to 200 ppm have been found in some animal (e.g., poultry) confinement facilities, but typical levels are much lower (5 to 70 ppm). Comparison of ammonia concentrations measured in animal feeding facilities with human responses to these concentrations suggests that health symptoms (mainly nasal or respiratory irritation) can occur in some of these facilities.

Volatile organic compounds (VOCs)

An overview of studies of VOCs emitted from animal facilities indicates that hundreds of compounds are present. In a recent analysis of VOCs emitted from swine facilities in North Carolina utilizing gas chromatography and mass spectrometry (GC/MS), over 300 compounds were identified. Many more compounds were present, but the GC peaks were too small to allow identification. The compounds identified by GC/MS were diverse and included many acids, alcohols, aldehydes, amides, amines, aromatics, esters, ethers, fixed gases, halogenated hydrocarbons, hydrocarbons, ketones, nitriles, other nitrogen-containing compounds, phenols, sulfur-containing compounds, steroids and other compounds. Acids, phenolic compounds and aldehydes were present in the highest concentrations. The magnitude of total VOCs associated with animal feeding operations and/or waste management systems varies widely from as low as 0.60 mg/m^3 in a recently cleaned swine facility to 108 mg/m^3 from the headspace of a chamber containing slurries produced by weaner pigs. The effect of a large number of VOCs in aggregate is cumulative. Exposure to low concentrations of hundreds of compounds simultaneously can produce high levels of odor and irritation downwind of CAFOs. Introduction of irritant compounds into the upper and/or lower respiratory tract has been found to produce many systemic responses including altered respiration.

Particulate Matter Including Bioaerosols

Epidemiological evidence predominantly from urban settings indicates that exposure to increased levels of particulates is associated with increased mortality risk, especially among the elderly and individuals with preexisting cardiopulmonary diseases, such as chronic obstructive pulmonary disease, pneumonia and chronic heart disease. Epidemiological studies also suggest that particulate exposure can increase the risk of respiratory and cardiovascular morbidity such as increased hospital admissions or emergency room visits for asthma or other respiratory problems, increased incidence of respiratory symptoms or alterations in pulmonary function. This effect can begin to occur when ambient particles <10 microns in size reach a level of 30 to 150 micrograms/m^3, according to the Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society. The concentration of total particles as well as respirable particles (<10 microns) inside confined animal buildings far exceeds the 30 to 150 micrograms/m^3 level at which symptoms can purportedly begin, according to the Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society. Typical total particulate levels inside swine confinement houses are 5 mg/m^3, but levels

can reach from 15 mg/m^3 up to 52 mg/m^3 in some houses, with respirable dust comprising 5 to 50% of the total dust.

Odor

All of the emissions described above can induce odor sensations. Health complaints associated with odorous emissions from animal facilities include eye, nose and throat irritation, headache, nausea, diarrhea, hoarseness, sore throat, cough, chest tightness, nasal congestion, heart palpitations, shortness of breath, stress, drowsiness and alterations in mood. These symptoms typically occur at the time of exposure and remit after a short period of time. Health symptoms may persist for longer periods of time as well as aggravate existing medical conditions in sensitive individuals such as asthmatic patients. A report from a recent workshop (co-sponsored by Duke University, the Environmental Protection Agency and National Institute on Deafness and Other Communication Disorders) on our current state of knowledge regarding the health effects of ambient odors from animal operations concluded that malodorous emissions can negatively impact health.

The full text of the White Papers is available for $25 from Midwest Plan Service,

http://www.mwpshq.org/