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INDOOR AIR QUALITY IN ANIMAL HOUSING SYSTEMS (GAS, ODOR AND DUST)

Sedat Karaman [1,*], Zeki Gökalp [2]

[1] Gaziosmanpaşa University, Agricultural Faculty, Biosystems Engineering Department, Tokat, Turkey
[2] Erciyes University Agricultural Faculty, Biosystems Engineering Department, Kayseri, Turkey

Abstract
Indoor and outdoor temperature and relative humidity are the most commonly used parameters in design of animal housing systems. However, these two parameters are not the only environmental parameters to be used in design of such facilities. Ventilation and lighting are also significant issues to be considered in design of animal housings. Ventilation is commonly performed to adjust indoor temperature and relative humidity and to remove hazardous gases, odor and dust from the facilities. Special attention should paid not to create dust while operation of livestock facilities. Noxious gases and odor should be removed regular operation of ventilation systems since they result in various health problems and animal mortalities at certain concentrations. In this study, besides basic design parameters, especially indoor air quality parameters of livestock housing systems were pointed out. Critical concentrations, harmful impacts of noxious gases, odor and dust on animal health and structural members were provided and recommendations were made to prevent or minimize such impacts of these harmful substances.

Keywords: Animal housing, indoor air quality, noxious gases, ventilation.

1. INTRODUCTION

Chemical composition of indoor air is the greatest environmental condition in livestock housings. Intensive number of animals, insufficient insulations and ineffective operation of ventilation systems increase concentrations of harmful gases, dust and odor in indoor air, thus negative influence indoor air quality. Indoor air quality parameters at limit values also negatively influence animal and worker health.

Animals like plants and humans, release gases to ambient they live in. Such gases either directly released from respiration or through intestines of the animals or they may be released from the solid manure and urine. Different gases and dust are also released during preparation, storage and processing of animal feeds.

Gases can be formed in bedding material with manure, in grain bins, spoiled feeds through the metabolisms of aerobe and anaerobe microorganism. Water vapor, carbon dioxide and ammonia always exist in livestock housings; hydrogen sulphide, carbon monoxide and hydrogen exist time to time. Release and distribution of gases vary based on density and diffusion. Increasing density and diffusion values result in higher diffusion and distribution. Ammonia can be considered among the most diffusible gases.

*Corresponding author, E-mail address: sedat.karaman@gop.edu.tr

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2. HARMFUL GASES

Ammonia: Ammonia is formed at extremely high levels in closed poultry facilities with large flocks. It is also a significant atmospheric pollutant resulted from livestock and poultry housings. Ammonia is released through digestive systems activities of the animals and microbiological decomposition of manure. It is a colorless gas with a strong odor, dissolve in water and lighter than air. Ammonia may result in serious respiratory diseases in animals and humans. Clinical symptoms vary from one animal to another. Ammonia results in weak of death born in pregnant animals, leptospirosis, fever, kidney and liver failure in calves, termination of lactation and various other pulmonary symptoms and may ultimately result in deaths.

Ammonia is lighter than air and most likely the gas you will feel the effects of first as it causes irritation of the eyes and respiratory tract. At higher concentrations, this gas may cause permanent lung damage. Ammonia concentrations are generally higher in warm buildings than cold buildings. Enclosed buildings with scrapers or with bedded packs can have ammonia levels as high as those found in shallow and deep pit buildings. The minimum perceptible level of ammonia for people is variable. NH_3 is detectable in concentrations from 1 to 5 ppm, however, concentrations higher than this can begin to result in irritation to the eyes. As concentrations increase, irritation will be noticed in the respiratory tract. The minimum perceptible level for ammonia is 0.5 to 54 ppm (Anonymous, 2017).

Ammonia concentrations of between 10-20 ppm livestock housings create undesired circumstances for production activities; the concentrations of between 25-50 ppm result in respiratory diseases in animals and ammonia concentrations of between 50-60 ppm reduce feed consumption of the animals and aggravate respiratory diseases (Akmirza, 2012). Ammonia concentrations over 60 ppm reduce the production levels in sheep and goats and concentrations over 100 ppm reduce the productions in cattle. Ammonia concentrations over 500 ppm result in deaths in poultry (Kılıç, 2013). Humans can diagnose ammonia concentrations of between 5-20 ppm. Such concentrations may exceed these values in barns and manure storages (Ergül, 1989).

Hydrogen Sulphide: Hydrogen sulfide (H_2S) is the most dangerous of manure gases. This extremely toxic gas may cause death in seconds at high concentrations. It is colorless and smells like rotten eggs, although at low concentrations this odor is easily masked by other odors and the odor isn't detectable by the human sense of smell at higher concentrations. It is heavier than air and looks to be released especially during the agitation of the storage structure. Reception pits and barns with below-floor storage and transfer areas or other confined spaces are locations where H_2S concentrations can increase rapidly upon agitation (Odgers et al., 2008; Anonymous, 2017).

Hydrogen sulphide has similar effects with ammonia at 35 ppm concentration. However, while ammonia irritates at higher doses, hydrogen sulphide may have toxic effects on respiratory and nervous systems (Ergül, 1989). Hydrogen sulphide concentrations over 20 ppm in livestock housings reduce animal feed consumption, concentrations of between 50-200 ppm may result in serious diseases. Low concentrations of hydrogen sulphide irritate animals in long-term exposures. High concentrations result in feeding disorders, intestinal diseases and diarrhea (Karaman, 2006).

Sulphur dioxide: Sulphur dioxide (SO_2) is a colorless gas. It is formed through burning of livestock manure and the greatest allowable concentration is 5 ppm. Sulphur dioxide concentrations over 5 ppm may have toxic impacts on living organisms. Based on oxidation effect, Sulphur dioxide reduce vitamin content of the products. It can result is respiratory and stomach disorders at high concentrations (Kılınç, 2013).

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In livestock housings, Sulphur dioxide gets into reaction with ammonia and forms particulate substances. High concentrations may irritate mucus membranes (eye and respiratory system). Mucus membranes of calves are more sensitive than the mature cows, thus they are influenced from high Sulphur dioxide concentrations more (Kılıç and Şimşek, 2009).

Carbon monoxide: Carbon monoxide (CO) is a colorless and odorless gas with a blue flame when burnt in stoves. The greatest allowable concentration in livestock housings is 50 ppm (Okuroğlu, 1978). Carbon monoxide is a quite strong poison. It can get into reaction with blood hemoglobin, reduce oxygen bearing capacity of the blood and ultimately result in deaths. Carbon monoxide result in headaches, vision disorders, dizziness, and mental confusion, coma, judgment and intuition disorders.

Carbon dioxide: Carbon dioxide (CO_2) is released through the respiration of animals and biological activities in manure. It is a colorless and odorless gas. Carbon dioxide is 1.5 times heavier than air. Beside animals in livestock housings, workers also release carbon dioxide to ambient air. Total carbon dioxide concentration may have significant effects on animal health and performance. High concentrations create serious disorders and reduce yield levels of the animals.

Carbon dioxide accumulates especially in closed facilities. Animal CO_2 production is directly proportional to animal heat generation. Therefore, animal CO_2 production is a function of animal mass, feeding levels and thermal environment. Animal 1 watt heat release to ambient is equal to 3.5 liters CO_2 production (Soyer, 2014).

Carbon dioxide is not highly toxic to humans or animals. Its main danger is that of contributing to an oxygen deficiency which can result in asphyxiation or suffocation. Carbon dioxide is heavier than air and will displace the oxygen especially within a confined space. Carbon dioxide exposure may result in headaches and dizziness. Death by asphyxiation is possible at high concentrations. The normal atmosphere contains about 300 ppm of CO_2. Within an animal housing facility, more CO_2 is released through respiration of the animals than by manure decomposition. Typical concentrations of CO_2 in well-ventilated buildings are in the 500–5000 ppm range for livestock, depending on season of the year. Levels for people in an office building run about 700 ppm or less for good air quality. Higher CO_2 levels can also slows animal growth and performance because it inhibits their appetite. Air containing 40,000 ppm causes deeper and faster breathing. More than 100,000 ppm may produce dizziness and unconsciousness. Death will occur after a few hours at concentrations of 450,000 250,000 ppm or more (Odgers et al., 2008; Anonymous 2017).

Methane: Methane (CH_4) is highly flammable. It is odorless, colorless, and lighter than air. Since it is lighter than air, methane can make its way through other parts of the storage and handling facilities and cause explosions away from the structures. A spark from equipment, open flames, smoking materials, faulty wiring, or welding could provide an ignition source for an explosion or fire.

Methane is generated from the anaerobic decomposition of manure. All manure storages release CH_4, but the rate of production varies with temperature. Although temperatures of approximately 35°C are considered ideal for CH_4 production from manure, a small amount of CH_4 is produced from manure at lower temperatures found in under-floor manure storages. Explosive concentrations of methane may be released during liquid manure agitation and remain for several weeks after emptying the storages. Air mixtures containing from 50,000–150,000 ppm or 5–15% CH_4 are explosive. Methane is not toxic and is unlikely to adversely affect animal and human health and performance in normally ventilated buildings. Methane is asphyxiate and can cause suffocation by displacement of oxygen from the lungs and will cause rapid breathing, dizziness, and fatigue

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(Anonymous, 2017, Kılıç 2013). Methane released from livestock housings may create an odor and pollution in close vicinity. Methane also has great contributions to global warming.

3. ODOR

Odors generated in livestock housing can exit the facility and make their way to downwind neighbors. Even systems that utilize external manure storage will have some manure within the housing itself and it can create odor. Especially hydrogen sulphide and ammonia release an odor to the ambient. The odor released from poultry houses located within close vicinity of settlement places create serious problems for local administrations. Neighbors of poultry facilities sometimes even cannot breathe because of heavy odor released from the poultry housing.

Odor can directly be released from the animal or released from manure, urine and spoiled feeds. Odor released from these sources can move quite much distance with the effects of winds. Intensive odor is released especially from open manure storages, during manure handling (loading and unloading) and composting.

4. DUST

Dust is usually exists as particulate substances in livestock housings. It can be organic or inorganic at different particle sizes and shapes. Organic dust comes from feed components, manure, hairs and flake off skin cells, pollens, fungicides, rusts, viruses and bacteria. Inorganic dust on the other hand comes from concrete pieced over the structural members, mineral or glass wool insulation materials and other inorganic substance influents through ventilation (Şener, 2013).

Suspended dust particles may have adverse effects on both animal and human health through respiration. Large size particles can be held by respiratory system organs, but small size particles can reach down the alveolus of lungs. Such particulate substances can carry bacteria, endotoxins, fungus spores and similar pollutants. Organic dust may result in asthma, chronic bronchitis and some other respiratory symptoms (Okuroğlu, 1987).

Dust formation quantities vary based on animal species, age and mass and it is usually between 50-170 mg per animal. Suspended dust quantities are reported as 1,5-3,4 mg/m^3 for laying hen and 9-17 mg/m^3 for broiler houses. Cage or ground raising has great effects on dust concentration in poultry houses and usually higher values are experienced in ground raising systems (Ergül, 1989).

Relationship between temperature, humidity and activity is an important factor affecting dust levels. Both in cages and in loose housing systems, average aerial dust concentrations have been found to be positively correlated with indoor air temperature and negatively to relative humidity (Ergül, 1989). Dust levels may also be affected by the use of ventilation to maintain a precise temperature inside the house. The aerial concentration of bacteria decreases in the summer probably because of the increased ventilation rate. Practical experience indicates that the dust-reducing effect of ventilation varies between buildings, and that commonly used air-mixing ventilation systems may not be able to reduce dust levels significantly.

5. CONCLUSION

Ventilation is the only way to remove these harmful gases and gaseous compound from the animal housing. Therefore, ventilation systems should be so designed and operated as to provide sufficient clean air into the buildings.

Several studies reported that primarily the pollutant gases, particulate materials, odor, dust, volatile organic compounds, fungi, spores, endotoxins and other polluters are released from animal housings

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to the atmosphere. Regulations inspecting emissions from animal housings do not exist in several countries and number of studies carried about gas emissions from livestock facilities is quite limited. The studies about environmental conditions mostly focus on temperature, humidity and lighting-like issues, but the studies about harmful gases is not sufficient. In this sense, research should be carried out more about indoor air quality and gas concentrations of livestock housings. Inventory studies should be carried out and such studies should be supported by state bodies.

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*Corresponding author, E-mail address: sedat.karaman@gop.edu.tr