

Agricultural Engineering

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Ventilation and Animal Health

Barn ventilation is often associated with animal respiratory health. But ventilation—directly and indirectly—impacts many other aspects of animal health as well. Good ventilation in the freestall area of the lactating cow helps to keep bedding dry, a factor in favor of good udder health. Good ventilation along floors helps to keep walking surfaces dry, a condition that contributes to healthy feet. Good ventilation may lead to greater productivity; e.g., maintaining air movement in the area of the feed manger makes the cow more comfortable, especially important during hot weather as an aid to maintaining dry matter intake. A comfortable, well-ventilated stall area encourages animals to lie down, an important contribution to many aspects of animal health.

During ventilation, outside air is brought into a barn where it collects moisture, heat and other contaminants, all produced by the animals. Air is then exhausted to the outside. Ventilation is an air exchange process—contaminated air inside the barn is exchanged for fresh outside air.

Air Quality

Animal health and disease are influenced by air quality. Air quality, in turn, is related to ventilation and its impact on removing contaminants from the air; e.g., pathogens. Excess moisture, gases and other contaminants in the air are considered to be problems as well.

With respect to animal spaces, good air quality generally implies that the characteristics of the ambient air bear no harmful effects on the animals in the space. Actually, the ambient air is not at issue—it is the contaminants in the air that are of concern. Ambient air, in itself, begins as a mixture of clean, dry air (a mixture of gases, chiefly nitrogen and oxygen) and varying amounts of water vapor. When moisture in the air in an animal space is considered to be a problem, it is actually the concentration of moisture in the air above some arbitrary level that is of concern. Above some concentration, moisture can be considered an air contaminant. Other contaminants may include pathogens, harmful gases, dust and undesirable odors. The contaminant itself does not give rise to concern. Rather, it is the concentration of a contaminant above some predetermined level that causes concern with air quality. Even excessive quantities of heat in the air can be a problem for an animal.

Many animal pathogens are spread by the airborne route¹ and concentration is a factor. The bacterial content of the air in cattle barns can be as high as 10^6 organisms per cubic meter and many of these are

¹ Constantine, D.G. Airborne microorganisms: Their relevance to veterinary medicine, in Dimmick, R.L., et al.,: An Introduction to Experimental Aerobiology. New York, Hiley Interscience, 1969.

potential pathogens². Numerous viral pathogens also are known to survive in the air³. Two factors can be significant with respect to causing disease: i) the survival duration of the aerosolized pathogen and ii) the total number of pathogens per volume of air (concentration). Survival is influenced by conditions of the ambient air, whereas conditions of the ambient air and concentration relate to ventilation.

Relative humidity is the most important factor influencing pathogen survival, but its effects vary greatly between pathogens—some survive best in humid conditions, others survive best in dry air. Note that, with respect to air quality and animal health, the influence of relative humidity on concentration of pathogens is important.

Maintaining a relative humidity in the range of 55% to 75% apparently results in the shortest survival time for the greatest number of potential pathogens. Ventilation is used to remove moisture from an animal space with the intention of maintaining relative humidity in this range. In effect, inside air is diluted with outside air and, in the process, concentrations of moisture in inside air are reduced. Interestingly, continuous replacement of contaminated air with fresh outside air is the most effective way to reduce the concentration of aerosol pathogens also.

Most likely, reducing the concentration of any air contaminant, including gases, is important to reducing its detrimental effect. For example, ammonia is produced by the decay of feces and urine and is probably the most significant air pollutant in cattle barns⁴. Allowed to accumulate, ammonia's irritating effects on the respiratory epithelium apparently directly reduce the number of ciliated cells and thus decrease the efficiency of mucociliary transport^{5,6}.

The Dilution Effect of Ventilation

Ventilation is truly a process of dilution. Air moved through a barn actually serves to dilute the inside air and, very importantly, to dilute all of its components. Dilution reduces concentrations of moisture and heat. Dilution reduces concentrations of airborne disease organisms, harmful gases and dust, and undesirable odors as well. One air change can theoretically reduce the concentrations of air pollutants by 63.2%.

Conversely, concentrations of air pollutants increase when ventilation is lacking. A 7.8 fold increase in airborne bacteria was noted when the outlet ventilation openings in a fifteen stall dairy barn were closed⁷. Odors increase also and, in fact, can be an important indicator of the poor air quality that results from underventilation. Terms like “barny”, “close” and “stuffy” are sometimes used to describe the environment inside a barn that is suffering from underventilation and poor air quality.

² Fisher, A. Microbial air contamination on large farms. *Acta Vet Brno* 45(4):235-244, 1976.

³ Donaldson, A.L. Factors influencing the dispersal, survival and deposition of airborne pathogens of farm animals. *Vet Bull* 48:83-94, 1978.

⁴ Marschang, F. Review: Ammonia, losses and production in large animal stables. *Dtsch Tierarztl Wochenschr* 80:73-120. 1973.

⁵ Gosselin, R.E. Physiological regulators of ciliary motion. *Am Rev Respir Dis (Suppl, 2)* 93:41-60. 1966

⁶ Kilburn, K.H. Cilia and mucus transport as determinants of the response of lung to air pollution. *Arch Environ Health* 14:77-91. 1967.

⁷ Malecki, J., S. Gorski, C. Tupaj, M. Lasoryszczak. Effect of gravity ventilation facilities control on the microclimate condition in home stockfarm buildings. *Proc. Of the Fourth International Livestock Environment Symposium, Coventry, ASAE, St. Joseph, MI. 1993.*

Indeed, concentrations of gases are related to ventilation as found in an Alberta study of air quality in six freestall barns⁸. Average ventilation rates could, in fact, be estimated by measuring building carbon dioxide concentrations.

When ventilation is reduced below recommended levels—usually in a misguided effort to warm the barn using animal heat—less moisture is removed. Sometimes the consequences of the resulting moisture buildup and lack of proper ventilation are masked by: i) insulating the barn, ii) using a greenhouse effect, iii) providing supplemental heat, or iv) dehumidifying the inside air. For example, adding heat to the air reduces relative humidity, without the need for air exchange. Indeed, it is quite possible to have substantial quantities of moisture added to the air and, if accompanied by heating of the air, have the relative humidity remain in an acceptable range. Thus, if relative humidity is the only measure of air quality, air quality may appear to be satisfactory. But even though excess moisture may not be apparent, the reduced dilution does indeed result in increased concentrations of airborne disease organisms, harmful gases and dust, and undesirable odors. If these increases are ignored, animal health problems are inevitable.

Underventilation of barns in winter is one of the most serious threats to the health of animals. Underventilation in summer is a threat to health also, besides leading to substantial drops in milk yield of lactating cows.

Summary

Essential to maintaining a healthy animal is providing an environment that does not needlessly stress or challenge the animal. Maintaining good air quality is a fundamental aspect of a healthy environment and ventilation provides the key. Through ventilation the air inside the barn is continually diluted, assuring that the air the animal breathes has low concentrations of all contaminants that threaten the animal's health.

⁸ Clark, P.C. and J.B. McQuitty. Air quality in six Alberta commercial free-stall dairy barns. Canadian Agricultural Engineering 29(1):77-80. 1987.