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Pregledni članak
Review

EFFECT OF MICROCLIMATE ON AIR QUALITY IN INTENSIVE PIG PRODUCTION

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Summary

The ever increasing intensive pig production is known to have adverse health effects on both animals and humans working in such a setting. Animal diseases that occur in intensive pig breeding are multicausal and consequential to poor animal adaptation to their artificially created environment. Air quality as one of the most important components of animal environment has only recently been considered as a complex problem that can be divided into dust, microorganisms and gases. None of these components will cause a disease by itself but will lead to a decreased daily gain and consequential reduction in the pig breeding productivity. In addition, the animal welfare is in jeopardy. Therefore, keeping the microclimate within optimal limits could be one of the crucial elements in reducing the microorganism count in pig housing, thus also in preventing their detrimental effects on both animal and human health.

Key words: microclimate, air quality, environment, dust, microorganisms, intensive pig production

Introduction

Intensive swine production is the source of airborne pollution that is harmful of animal and human organism. The ever advancing technology and formation of large agglomerations for pig breeding and production make the optimal conditions of mass stock production questionable. That is so because a large number of animals are grown in closed housings with limited area *per*

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animal. Such technology has entailed problems related to animal health and welfare. A number of studies on air hygiene in pig production buildings have been reported in the literature (Zucker and Müller, 2000; Kluczek, 2000). The variety of microorganism strains and their count have been found to mostly depend on the pig housing conditions, local climate conditions, season, and ventilation system. This is very important for housing conditions, because continuous contact of contaminated air (microorganisms and dust) with the skin and mucosa leads to the development of inflammation and allergic reactions in the form of itch. Affected animals are restless, rubbing against the walls and other objects, thus creating conditions favoring subsequent bacterial infection. All this results in productivity loss that reflects on treatment cost and reduces gain in intensive pig production. Considering the possibility that air quality may not be readily identified as the cause of these events, the losses may persist over a prolonged period of time and eventually endanger profitability of a particular production segment. For this and other similar reasons, it is no coincidence that a number of studies have been currently under way in the world aiming at finding association between housing air quality and particular health disorders (mostly of unknown etiology).

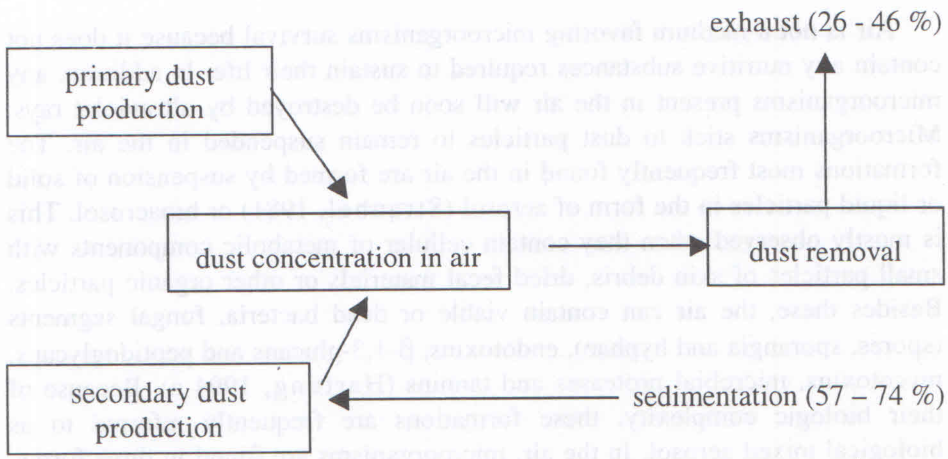
Air in Animal Housing

By its composition, air can serve as a reservoir of primary and potentially pathogenic microorganisms of major importance in the etiology of infectious and allergic diseases (Wathes, 1994). In most cases, Koch's postulates cannot be applied in their pathogenesis because the presence of environmental stress plays a major role in addition to the disease itself (Webster, 1982). Besides various microorganisms, environmental stress includes any component related to poor ambiental conditions, among them the quality of air and microclimate, conditions of animal housing, type of litter, and animal treatment being of utmost importance (Hartung, 1994 b). Air quality is a major factor at modern farms, as it has considerable effect on the health of animals kept in the farm buildings and of humans working in intensive livestock production. Poor ventilation and variable temperature are known as definite predisposing factors for the development of atrophic rhinitis in pigs (Robertson, 1994) or diarrhoea caused by the enterotoxigenic strain of *Escherichia coli* in piglets (Wathes, 1989). Microorganisms and endotoxins belonging to bioaerosols also play an important role in the occurrence of various respiratory infections in humans working on these farms (Rylander, 1986).

Dust

All solid particles in gas that are unable to circulate and drop down at a rate below common gravity represent dust (Asaj, 1972). The rate of a dust particle movement depends on its diameter, specific weight and air resistance (Hartung, 1994 a). According to composition, there is organic and inorganic dust. Organic dust is a major air contaminant in animal housing. According to its composition, it is a mixture of organic materials such as bacteria, fungi, their toxins, spores, gases, urine, feces, undigested food, pollen, and other particles originating from the feed and animals. Thus, dust is regularly found in animal environment and can enter animal housing with the air from the outside (by aeration), inappropriate feed and litter manipulation, cleaning and care of animals, and housing cleaning. Dust is deposited and distributed over the housing surfaces due to the action of some mechanical force, air circulation, human and animal activities etc. (Robertson, 1994) (Fig. 1).

Figure 1. - DUST PRODUCTION AND REMOVAL (Robertson, 1994)



The health impact of dust depends on the dust particle nature (organic, inorganic), composition (bacteria, fungi) and diameter (Hartung, 1994 a). On inhalation, the size of the particle is of major importance. The particles of large diameter will retain in upper airways, whereas those of small diameter will penetrate deep into the lungs where they can cause various infections. Dust values are generally expressed in mg/m^3 air, or number of particles/m^3, or number of particles/ml, depending on the method of sampling. The size of dust particle can vary from 0.1 to 100 μm, the range of 10 to 15 μm being usually referred to in animal housing. According to particle size, dust is divided into inhalable dust (10-30 μm) that is retained in nasal cavity, inspirable dust (5-10 μm) that is being filtered and inhaled to reach the trachea and bronchi, and respirable dust including particles of <5 μm in diameter that are inhaled down to the pulmonary alveoli. Inhaled particles adsorb humidity, thus being enlarged and entrapped in the respiratory system. The majority of dust particles of <1.0 μm in size will be exhaled again into the animal environment. According to the method of dust sampling (gravimetry, impingement, etc.), the mean values of inhalable and respirable dust measured in various European countries ranged from 0.2 to 17.2 mg/m^3 (recommended maximum 2.5-3.0 mg/m^3) and from 0.15 to 9.28 mg/m^3 (recommended maximum 0.23 mg/m^3) (Hartung, 1994 a).

Microorganisms

Air is not a medium favoring microorganisms survival because it does not contain any nutritive substances required to sustain their life. In addition, any microorganisms present in the air will soon be destroyed by ultraviolet rays. Microorganisms stick to dust particles to remain suspended in the air. The formations most frequently found in the air are formed by suspension of solid or liquid particles in the form of aerosol (Straubel, 1981) or bioaerosol. This is mostly observed when they contain cellular or metabolic components with small particles of skin debris, dried fecal materials or other organic particles. Besides these, the air can contain viable or dead bacteria, fungal segments (spores, sporangia and hyphae), endotoxins, β-1,3-glucans and peptidoglycans, mycotoxins, microbial proteases and tannins (Hartung, 1994 a). Because of their biologic complexity, these formations are frequently referred to as biological mixed aerosol. In the air, microorganisms are found in three forms: bound in aerosol, when they behave as gases; sedimented over animal housing surfaces; or as a constituent of animal body or housing area microflora (Mehlhorn et al., 1979). Accordingly, the composition of microflora in the air reflects the microbiologic status of the animal housing (Methling, 1984), with 80% of the microorganisms deriving from the animals themselves. Staphylococci account for some 60% and streptococci for 30% of these, whereas the rest are fungi, spores and other microorganisms. Enterobacteria originate from wastewater and feces, and actinomycetes from feed and litter, however, the majority of this stable microflora are apathogenic (Hartung, 1994 b). The changes caused by these microorganisms will not result in a disease but mostly in various pathohistologic lesions identifiable in slaughterhouse. So, lesions of the nasal conchae are very frequently found in pigs that have never during their life exhibited any signs of disease. These lesions lead to reduced productivity and decreased daily gain (Donham, 1995). Studies conducted at slaughterhouses have revealed pneumonia, pleuritis and other signs indicative of some inflammatory process to be found in 50% of pigs (Elbers, 1991). The microorganism count in a particular building depends on the construction works, animal density in the building, ventilation system, microclimate, presence of dust in the air, and dust sedimentation on the housing surface. Temperature and relative humidity are the main microclimate factors of microorganism survival in animal housing. Contamination of animal housing with corpuscular particles occurs due to the complex action of microclimate factors in the building. The concentration of microorganisms is especially high in swine buildings, and is expressed as colony forming units *per* m^3 of air (cfu/m^3). This figure does not represent the number but a group of bacteria, and does not include dead bacteria or non-airborne bacteria. Thus, for example, as many as about 50 million colonies of aerobic bacteria were found in one gram of dust from swine housing. Streptococci and staphylococci accounted for more than 80%, fungi and yeasts for 1%, and coli bacteria for 0.5% of these bacteria. Considering fungi, the following genera prevailed: *Penicillum, Aspergillus, Cladosporium* and *Alternaria*, which can also cause allergic reactions (Hartung, 1994 a). Most of the studies of microorganisms in intensive stock production refer to the microorganism measurement and identification, whereby colony concentration varied over a wide range from 1.3-3.4x10^5/m^3 through 6.1x10^5 to 1.25x10^6 cfu/m^3 (Clark, 1983; Donham, 1995). It should be noted that different technological steps in the production are associated with different values. So, for example, Donham (1995) reports on the microorganism count to be considerably higher in farrowing than in fattening feedlot, relating it to differences in the amount of feces and more frequent people's comings in to the former. Farrowing division normally requires more workers because there is a lot of work to be done there. This author reports on enterobacteria to account for only 7% and other gram negative bacteria for 2% of total bacterial count.

Data on the microorganism count vary. In addition to the zoohygienic conditions mentioned above, they also depend on the method of air sampling.

There are a number of devices for air sampling, their efficiency being intensively studied (Predicala, 2002). Each of the devices is characterized by specific technical possibilities, i.e. each is intended for sampling particles of a specific size, thus performing an initial selection of the microorganisms sampled. However, it should be emphasized that a method generally considered relevant for air sampling has not yet been described. Also, in spite of ever more sophisticated devices for air quality monitoring, borderline values of air contamination with bacteria, such as those defined for the concentration of various noxious gases, have not yet been determined either.

Table 1. - AIRBORNE MICROORGANISMS IN SWINE PRODUCTION BUILDINGS

(Hartmann, 1980)

Animal species	Microorganisms
Swine	Staphylococci
	β - haemolytic streptococci
	Aerobic spores
	Escherichia coli
	Pseudomonas sp.
	Moulds

Gases

The concentration of noxious gases in the air is a very important element of microclimate conditions in swine buildings. Some 136 gases that occur consequentially to intensive swine production, emanating from swine waste, have been identified to date (Verstegen et al., 1994). The following gases are most common in swine production: ammonium, carbon dioxide, methane and hydrogen sulfide. Hydrogen sulfide, the most poisonous gas, which is almost never found in swine buildings, is released from anaerobic manure pits. Carbon monoxide is found in the air in case of inadequate burning of organic material, its maximal allowed concentration being 30 ppm. The concentration of carbon dioxide in piggeries is one of the basic indicators of the housing hygienic conditions, and is produced by metabolic processes, mostly by animal breathing. Its maximal allowed concentration in animal housing is 3000 ppm (Verstegen et al., 1994).

Ammonium as the most common gas in swine production buildings is produced by microbiologic degradation of feces and urine. Ammonium is recognizable by its specific odor irritating the conjunctiva and airways, so it can cause lacrimation, cough and mouth foaming. In swine, the adverse effect of ammonium is associated with increased susceptibility to respiratory diseases, primarily rhinitis (Verstegen et al., 1994). Pigs lengthlly exposed to ammonium concentration of up to 100 ppm show inaptness and consequentially decrease gain (Barker, 1996).

Conclusion

The effect of the particles in livestock buildings on human and animal health cannot simply be attributed to dust levels or the concentration of microorganisms in the housing air, as it implies complex action of noxious gases, inappropriate air humidity, air temperature and other unfavorable microclimate conditions in the animal housing. The adverse effect of the particulates can be described as mechanical, infectious, immunosuppressive, allergic and toxic for human and animal health (Hartung, 1994 b). Accordingly, air quality monitoring is daily gaining importance, since the animal respiratory system and skin are continuously in contact with the housing air which contains various contaminants in different combinations and concentrations. There are numerous studies on the occurrence of respiratory diseases due to air contamination. Air temperature and relative humidity are the major climatic factors for the survival of microorganisms in animal housing, influencing the number and composition of the housing microflora. Therefore, maintaining the animal housing microclimate within optimal limits could be one of the substantial elements in reducing the concentration of microorganisms and preventing their detrimental effects on the human and animal health.

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UČINAK MIKROKLIME NA KVALITETU ZRAKA U INTENZIVNOJ SVINJOGOJSKOJ PROIZVODNJI

Sažetak

Poznato je da sve raširenija intenzivna svinjogojska proizvodnja ima štetan utjecaj na zdravlje životinja, ali i ljudi koji rade u takvom okruženju. Bolesti životinja koje se pojavljuju u intenzivnom uzgoju svinja multikauzalnog su karaktera i posljedica loše prilagodbe životinja na njihov umjetno stvoren okoliš. Kvaliteta zraka kao jedna od najvažnijih komponenti životinjskog okruženja tek se zadnjih godina promatra kao kompleksan problem koji se može rasčlaniti na prašinu, mikroorganizme i plinove. Nijedna od navedenih komponenti neće sama po sebi izazvati bolest ali će dovesti do smanjenog dnevnog prirasta i posljedično smanjene proizvodnje u svinjogojskoj proizvodnji. Osim toga dolazi u pitanje i dobrobit životinja. Stoga održavanje mikroklime u optimalnim granicama može biti jedan od bitnih elemenata smanjenja broja mikroorganizama u svinjogojskim objektima i ujedno sprječavanja njihovog štetnog djelovanja na organizam životinja i ljudi.

Ključne riječi: mikroklima, kvaliteta zraka, okoliš, prašina, mikroorganizmi, intenzivna svinjogojska proizvodnja

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