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Air cleaning in livestock buildings by applying the granular filtration layer**

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A b s t r a c t. The assumptions and results of laboratory research on efficiency of ammonia removal from air by use of the cassette filter in the mechanical ventilation system were presented. A filtration layer consisted of polypropylene (PP) granulate of 5 mm grain diameter, enhanced during production process with NanoSilver concentrated preparation in concentration of 2 000 silver p.p.m. (nanoAg). Reduction factors came to: 45.1 and 51.4 at 16 l min^{-1} flow rate and 53.2 and 58.9% at 8 l min^{-1} flow rate for 0.5 and 1 l of granulate content in the layer respectively.

K e y w o r d s: ammonia, emission, emission reduction, granular filter

INTRODUCTION

Farms, especially animal breeding, generate risks for environment by air, water and soil pollution. Harmful gas emissions, including greenhouse gases and ammonia, dusts and odours are dangerous results of intensive animal breeding. The most dangerous is ammonia release especially in intensive pig breeding (Apsimon *et al*., 1995). Ammonia is a conversion product of urea in the urine catalyzed by the urase present in faeces. Its emission into the air is slow process governed by factors such as concentration, pH, temperature and speed of air stream flow above the faeces surface (Aarnink, 1997). In order to protect natural environment, modern concentration and emission reduction techniques are tested and implemented on various stages of pollution production within the farms (BAT, 2003; Myczko, 2006; Jugowar *et al*., 2007). The most common ones are means of reduction in protein content in excrements by proper balance of feed, additives lowering pH (Canh *et al*., 1996, 1997), and also mechanical and biological filters installed in outlets of ventilation systems.

In this project the conducted initial research concerned the efficiency of air filters in which the active layer consisted of polypropylene enhanced during its production with 10-100 nm silver particles. Nanometric sizes of reactive particles of silver, silicon or titanium cause changes of known basic physical and chemical properties of those particles. According to Armelao *et al*. (2007) the most recent research shows that there is an efficiency of decontamination, purification and deodorization of air, water and industrial effluents. In this context TiO_2, SiO and Ag particles are one of the most studies materials because of their stability and photo catalytic proprieties both in the form of powders and thin films. Photocatalytic surfaces have already been used thanks to their capability of hydrophobisation as well as self-cleaning and self-sterilizing by destruction of microorganism cells such as bacteria, fungi and algae (Jugowar *et al*., 2007).

MATERIALS AND METHODS

The main target of research was experimental checking if surface catalysis occurred on expanded surface covered with thin silver nanoparticles layer could reduce concentrations of chosen gases, and which technical parameters of filter used in ventilation channels could influence on efficiency of air cleaning in animal buildings. An air filter cassette (Fig. 1) for channel ventilating systems was designed. It gave opportunity for testing of filtration layer of 14x14 cm cross-section, and thickness between 3.5 and 14 cm, changed in 3.5 cm steps. Tests were done on 3.5 and 7 cm thick layer what correspond with respectively – 0.5 and 1 dcm^3 of granulate. Airflow rates were 8 and 12 l min^{-1} for each filtration layer volume. Air flowing through filter was sucked from fermentation chamber by a fan mounted downstream to the filter (Fig. 2).

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Basic research was done on filtration layer consisting of polypropylene granulate of 5 mm grain diameter, enhanced during production process with NanoSilver concentrated preparation of concentration 2000 silver p.p.m. (nanoAg). Among preparation properties, capability of creating catalytic surfaces neutralizing many gases and odours or hydrophobic bacteria are specified. Moreover, the surfaces covered with preparation are antistatic and easy washable.

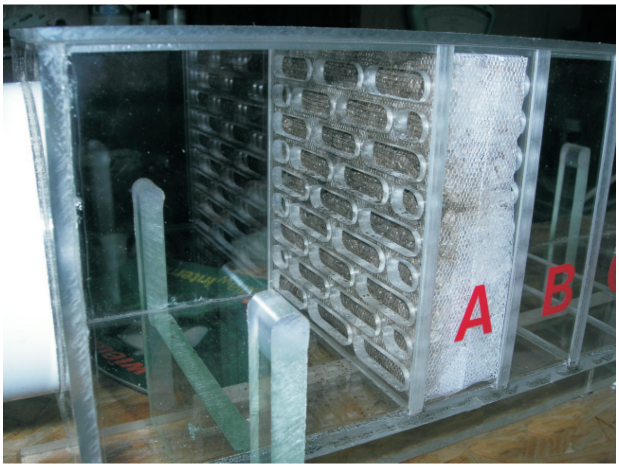

Fig. 1. Filtration layer during the experiment – blancking of filler visible.

Fig. 2. Laboratory unit with the fermentation chamber as inventory gases source and gas analyzer for evaluation filter with granular filler working.

Pig slurry stored in aerated fermentation chamber was used as a source of inventory gases in the filtered air. NH_3 control concentrations (average 51.5 mg m^{-3}) from slurry were typical for slurry tanks, and significantly exceeded threshold value (26 mg m^{-3}) acceptable in animal buildings. Multi- Gas Monitor model 1312 photo acoustic gas analyzer was used for ammonia concentration measurements in points located upstream and downstream the filter. Air samples were taken in 5 min intervals continuously for 7 days-and-nights, and then average 24 h concentration and emission of tested gas were calculated. The obtained results were used for calculation of ammonia emission reduction efficiency in ventilating air polluted with inventory gases, for each sample, on the basis of following formula:

$$R = 100 - \frac{E_{\exp} 100}{E_{contr}},$$

where: R – reduction in tested gas emission (%), $E_{\exp}$ – total emission of tested gas from experimental chamber (mg h^{-1}), E_{contr} – total emission of tested gas from control chamber (mg h^{-1}).

RESULTS

An average daily concentration of ammonia in the air sampled in measurement point located behind the filter is shown in Fig. 3. The values of ammonia emission, which were calculated for flow rates 8 and 16 l min^{-1} are presented in Fig. 4. The ammonia emission reduction indexes are presented in Table 1. Reduction indexes came to: 45.1 and 51.4% at 16 l min^{-1} flow rate and 53.2 and 58.9% at 8 l min^{-1} flow rate for 0.5 and 1 l of granulate content in the layer, respectively.

The obtained results (Table 1) show that filter filler for air cleaning, made of polypropylene granulate of nanocatalytic features, works only during 6-day sequence of constant usage. The best results were found at lower (8 l min^{-1}) airflow rate in ventilation channels. Simultaneously, progressing layer blacking and secondary emission from filtration layer after continuous six days of work, took place. Thus, the obtained results suggest a necessity of further analyses concerning filter efficiency after regeneration and with increased area and volume of the filtration layer.

T a b l e 1. Ammonia average percentage of emission reduction after applying various parameters of filter with the granular layer enhanced with nanoAg

Parameters	Airflow rate through the filter (l min^{-1})			
	8		16	
Filter filler volume (l)	0.5	1.0	0.5	1.0
NH_3 emission reduction (%)	53.2	58.9	45.1	51.4

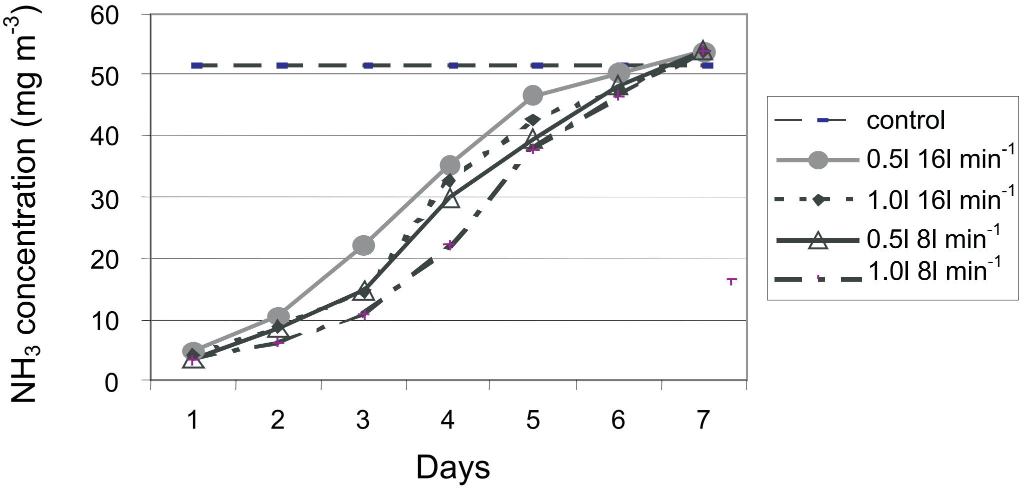

Fig. 3. NH_3 concentrations for the airflow rate 8 and 16 l min^{-1} after application of: 0.5 and 1 l of filtration filler, respectively.

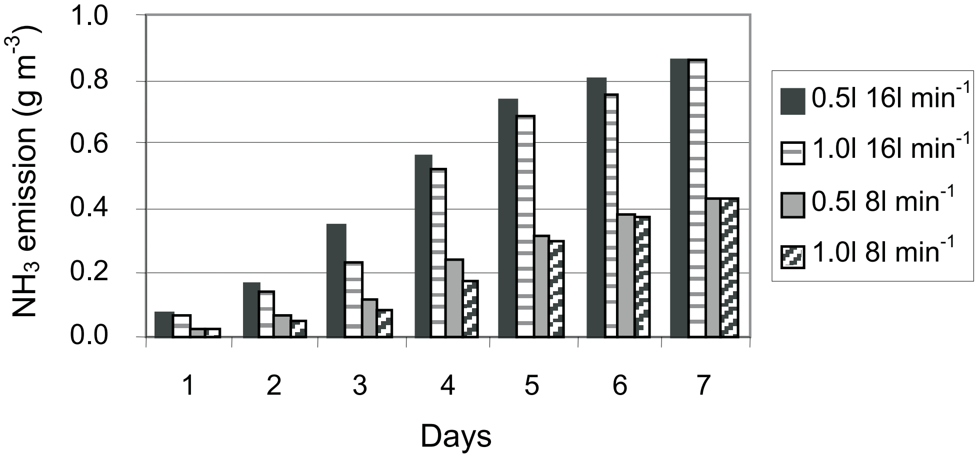

Fig. 4. NH_3 emissions for airflow rates 8 and 16 l min^{-1} after application of 0.5 and 1 l of filtration filler, respectively.

Information obtained during the project enables to design and use in practice the granular filter with a layer of nanocatalytic harmful gas emission reduction properties for air cleaning in livestock building. It contributes to improve natural environment protection by reducing the negative impact of animal production.

CONCLUSIONS

1. The obtained results confirm the effectiveness of research solution used for gas emission reduction in the livestock building ventilation systems.
2. The emission reduction index depends on filtrating layer thickness and airflow rate.

3. Maximal emission reduction index is 58.9% for granulate layer of 14x14x7 cm and volume of 1 l of polypropylene, when applying air containing in average 51.5 mg NH_3 in m^3 typical for slurry tanks.

4. For filter installed in livestock buildings, where ammonia concentration may not exceed 26 mg m^{-3}, a longer lifetime is presumed.

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