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Application of mineral sorbents to filtration of air contaminated by odorous compounds

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The aim of investigation was to develop the efficient method of purification of air contaminated by odorous compounds in livestock buildings. The experiment with the use of filtrating device ODOR1 was conducted. The following sorbents were investigated as filtration bed: raw halloysite, roasted halloysite, activated halloysite, raw bentonite, roasted bentonite, expanded vermiculite. The samples of air were collected before and after 24 hours of filtration process to define the most effective sorbent. It was stated, that all investigated sorbents reduced the concentration of ammonia and tentatively identified volatile odorous compounds in the air of experimental containers. The highest removal efficiency was determined for activated halloysite and roasted bentonite.

1. Introduction

Intensification of animal production is related to the increase of odorous compounds emission from livestock buildings. The main odorants generated by animal production, that may present a health hazard for both livestock and staff of animal farms, are ammonia, sulphur compounds (hydrogen sulphide, thiols), VFA and phenolic compounds (Kim et al., 2007, Mackie et al., 1998, O'Neil et al., 1992, Schiffman et al., 2001, Zahn et al., 1997). Almost total ammonia emission in Poland originates from agriculture practices and more than 70 % of that emission is connected with animal farming (Olendrzynski et al., 2007). Ammonia is responsible for the acidification of water and soil, may cause forest damage and it also contributes to the eutrophication of terrestrial ecosystems and surface waters (Bouwman et al., 1997, Hyde et al., 2003, Sutton et al., 1998). Intensive examination of methods that aiming to reduce gaseous pollutants emission from livestock buildings have been observed in the last years (Dobrzanski 2000, Grela et al., 2009, Gutarowska et al., 2009, McCrory and Hobbs, 2001). The goal of the investigation was to estimate the potential capacity of selected aluminosilicates for removal of ammonia and volatile organic compounds from air.

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2. Material and Methods

The investigation was conducted in 3 identical containers where fresh cow's manure were placed (the surface of emission about 8 m^2). The filtrating device ODOR1 (patent application no. P-388329) was in the middle of each container. The time of filtration was 24 hours. During the experiment the filtrating device contained filter packs filled with investigated aluminosilicates except the first container (control) where filter packs were empty. The following sorbents were investigated as filtration bed: raw halloysite (H), roasted halloysite (HR), activated halloysite (HA), raw bentonite (B), roasted bentonite (BR), expanded vermiculite (EV). The filtration efficiency of ODOR1 device was about 1000 m^3/h, considering the volume of container (about 23 m^3) the inside air was filtrating 40 times per hour. The samples of air were collected before and after 24 hours of filtration process with the use of AMZ-1 aspirator (Rotametr, Poland). The concentrations of ammonia in sampled air were determined with the use of spectrophotometer UV-VIS according to polish standards. Odour compounds were extracted (sampling time=60 min.) from the air of containers after 24 hours of filtration process. The extraction of analyzed substances was carried out by the SPME technique, a manual SPME holder with StableFlex 50/30 μm divinylbenzene /Carboxen /polydimethylsiloxane fibre was used (Supelco, USA). Before each sampling fibres were conditioned for 1 hour in the injection port at 270 °C. The injection port operated at 240 °C for SPME desorption (time of desorption - 7 min.). Chromatographic separation was performed using Restec column (5% diphenyl; 30m x 250μm x 0,25μm) in Thermo Electron, Finnigan Focus Polaris Q type gas chromatograph coupled with mass spectrometer (GC/MS method). The tentative identification of odorous compounds was based on comparative analysis of determined mass spectrum and MS from spectrum commercial library NIST.

There were three replicates for each of the investigated aluminosilicates and results given are the averages. Data were analyzed by analysis of significant differences assessed by Duncan test.

3. Results and Discussion

It was found that the concentration of ammonia in air samples from experimental containers (ODOR1 with investigated sorbents) was always lower after 24 hours of filtration than in the control container and the differences were statistically confirmed. The highest reduction level was about 68 and 77% for roasted bentonite and activated halloysite, respectively (fig. 1) while for other examined sorbents reduction of ammonia concentration was between 23 and 37%. It is worth to add, that the main goal of experiment was to define, in a short time, the most effective sorbent. Therefore, the time of filtration (24h) was too short to assess breakthrough behaviour of investigated sorbents; over time measurements have to be done in a future. The ability of aluminosilicates to reduce ammonia content in the air was confirmed in laboratory-scale investigation. It was found, that the potential for removal of ammonia by investigated sorbents was in order of HA>H>HR>B>EV (Opalinski et al., 2009). The capacity for decreasing NH_3 concentration in case of bentonite was found by Seredych et al. (2008). Moreover, the use of aluminosilicates as efficient litter additives to optimize the microclimate in livestock buildings was often examined. Korczynski et al. (2008) applied raw bentonite and expanded vermiculite to the manure mixed with straw in amount of 0,5 and 1,0%. The concentration of ammonia in the air of experimental room

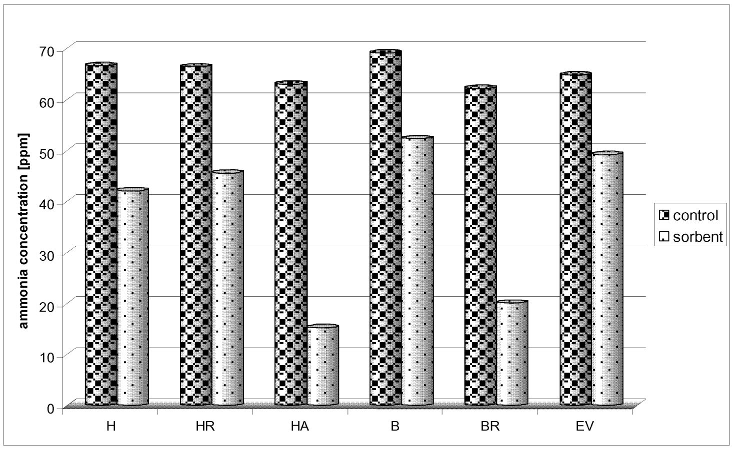

Fig.1 Mean ammonia concentration (ppm) in air samples collected from control and experimental (sorbent) containers after 24 h of filtration process

where bentonite was added was lower by 30% in comparison to the control room and lower by almost 70% in the room with vermiculite.

It was found, that all investigated aluminosilicates used for air filtration were reducing the concentration of tentatively identified odorants. The level of reduction was between 75 and 94% for raw halloysite and roasted bentonite, respectively (fig. 2). In air samples collected from experimental containers 26 volatile organic compounds were found and tentatively identified (table 1).

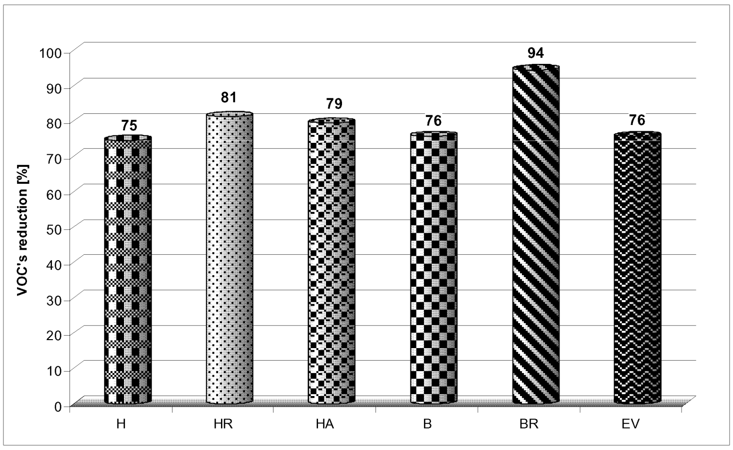

Fig. 2 Mean reduction level (%) of tentatively identified volatile organic compounds by investigated sorbents

In the available literature, it was difficult to find investigation concerning application of aluminosilicates to decrease concentration of volatile organic compounds. Opalinski and Dobrzanski (2007) were purifying the air in the small room (60 m^2) for laying hens. In the prototype of filtrating device raw bentonite and raw halloysite were applied. The level of reduction for tentatively identified volatile compounds was 43,4% and 59,7% for bentonite and halloysite, respectively. However, in case of tentatively identified compounds containing sulfur (methanothiol, ethanothiol etc.) the reduction was on the level of 26% for both sorbents. Turan et al. (2009) were investigating, in laboratory scale, the use of natural sorbents to decrease a concentration of volatile organic compounds emitted during composting of poultry litter. The level of reduction for expanded vermiculite was 61,53%.

Table 1 The list of volatile organic compounds tentatively identified in air samples

Lp.	Organic compound (IUPAC names)	Time of retention [min.]
1.	butanal	13,80
2.	ethyldisulfanylethane	14,48
3.	(E)-hept-3-ene	16,78
4.	1-ethyl-2-methylcyclohexane	17,22
5.	butane-2,3-diol	18,33
6.	3,7,7-trimethylbicyclo[4.1.0]hept-3-ene	18,66
7.	nonan-3-one	19,82
8.	(E)-tetradec-3-ene	20,49
9.	octan-1-ol	21,61
10.	(3E)-penta-1,3-diene	23,52
11.	4-methylhexan-2-one	24,35
12.	bis(methylsulfanyl)methane	25,32
13.	pentanal	29,71
14.	6-methylheptan-2-one	30,88
15.	5-methylheptan-3-one	31,39
16.	methylsulfanyldisulfanylmethane	33,81
17.	1,4-dichlorobenzene	33,92
18.	dodecane	34,01
19.	1-methoxy-4-methylbenzene	34,15
20.	3-methylnonan-4-one	35,00
21.	4,6-dimethylpyrimidine	35,36
22.	5-methylheptan-2-one	37,11
23.	pentadec-1-ene	37,89
24.	phenol	38,66
25.	methyldisulfanyldisulfanylmethane	39,53
26.	1H-indole	44,53

4. Conclusions

It was stated, that all investigated sorbents reduced the concentration of ammonia and tentatively identified odorous compounds in the air of experimental containers. The highest removal efficiency was determined for activated halloysite and roasted bentonite. It is worth to add, that examined method of air filtration with the use of ODOR1 device and aluminosilicates sorbents as filtrating bed looks promising and could be supplemented to optimize microclimate of livestock buildings.

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