Possibilities to Reduce Methane and Hydrogen Sulphide Emissions in Pig Farming By Application of Zeolite

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Abstract: *This paper deals with the possibility of using environmentally friendly materials applied to the floor in pig housing to reduce the emission of greenhouse gases. We have focused on the possibility of reducing the methane (CH_4) and hydrogen sulphide (H_2S) emissions by application of zeolite. That has been applied at the rate of 1.2 kg on the floor. The results show that temperature and relative humidity have an impact on H_2S and CH_4 emissions. With zeolite treatment, we obtained a statistically significant difference in H_2S emissions ($P = 0.00 < \alpha = 0.05$) and CH4 ($P = 0.00 < \alpha = 0.05$) between the zeolite-treated and untreated sections.*

Keywords: *fattening pigs, greenhouse gases, reduction, zeolite, CH_4, H_2S*

INTRODUCTION

Pig housing on farms poses a risky business for the farmer. The risk of swine fever from neighbouring countries, low feed-in tariffs, outdated technology and the lack of funds for the construction of new farms has resulted in end for many farms. Gas emissions from livestock farming result in fees due the production of harmful substances. Around 20–35 % of greenhouse gas emissions come from agriculture (IPCC, 2001). The globally, pork production is estimated to emitabout 668 million tonnes CO2-eq, representing 9 percent of the livestock sector emissions (Food and Agriculture Organization of the United Nations, 2013). The methane (CH_4) greenhouse gas is involved in global warming and climate change (IPCC, 2007). Global concentrations of these two gases have increased significantly over the last 150 years (IPCC, 2001) and are affecting the environment – increased greenhouse gas emissions (Zavattaro et al., 2012), as well as animal housing where straw is used as litter (Brown et al., 2001). The warming potential of nitrous oxide is 290–310 times higher than that of carbon dioxide (IPCC, 2007). It can usually be estimated that the carbon dioxide produced by livestock is compensated by photosynthesis of plants (Philippe et al., 2011). Carbon dioxide emissions differ from the pig rearing, weaning and fattening systems (Dubeňová et al., 2011; Dubeňová et al., 2013; Philippe et al., 2007a; Philippe et al., 2007b; Cabaraux et al., 2009). Manure removal methods affect the production of harmful gases in pig fattening (Mihina et al., 2011). The process of releasing greenhouse gases into the atmosphere depends on livestock housing, nutrition, manure management, its storage and land application (Palkovičová et al., 2009). The number and weight of animals, manure removal method and time of its removal, temperature, humidity, pH, litter reaction, C:N ratio and ventilation system performance have a significant impact on gas emissions in the farm (Topisirovic et al., 2010a; Topisirovic et al., 2010b). Many factors have to be considered for a successful emission assessment, including the season time and amount of litter, animal density, type of floor area, feeding and watering procedures, ventilation, temperature and relative humidity (Brouček 2018; Philippe et al., 2016). Changing manure management from liquid systems to solid/liquid separation systems together with mitigation measures could simultaneously reduce greenhouse gas emissions (Wang et al., 2017). The emissions of gases from animal housing are thus dependent on breeding technology (Cabaraux et al., 2009). However, there is also the possibility of reducing greenhouse gas emissions with biological agents (Jelínek et al., 2004). As reported by Galajda et al. (2000), the use of zeolite as bio-filter to eliminate greenhouse gases and ammonia is suitable.

MATERIAL AND METHODS

In the farm, we investigated the possibilities of harmful gases reduction by applying the natural raw material zeolite. It is used for cleaning natural and other gases CO_2, H_2S, SO_2, and

NH_3. The seller recommends dosing by 10 % of the consumed feed. In the housing, pigs were fattened in a hall with two sections, each with ten pens. The measurement was realized in winter time. The windows were closed as well as all the doors. The air was exchanged naturally through the chimney in the roof of the section with a diameter of 500 mm. There was one chimney in each section. During feeding and cleaning of the pens, fans were turned on to extract the air from the farm. After that, the section was closed and the fans turned off to maintain the temperature in. In one part of the section, we applied 150 kg of zeolite over two weeks at an average of 1.2 kg per pen and per day. The zeolite was preferably applied to the sites from which the excrements were removed. Subsequently, we measured pollutant emissions. In the first part of the section, where zeolite was not applied, a total of 72 pigs with an average live weight of 85 kg were placed. In the second part of the section, where zeolite was applied, there were a total of 89 pigs with an average live weight of 40 kg. During 24 hours, we monitored the emission of pollutants in the buildings as well as the speed of air flow in the exhaust chimney. To measure the H_2S and CH_4 emissions, we used the INNOVA 1412 gas analyser and the INNOVA 1309 multipoint sampler together with Comet R3120 to record the temperature both inside and outside the housing. We used the Almemo 2190–2 anemometer to measure the air flow rate. The data were processed using the statistical program Excel and ANOVA. The level of significance was $\alpha = 0.05$.

RESULTS AND DISCUSSION

We found that the average values of H_2S in the untreated and treated sections were 1587.7 $mg \cdot m^{-3}$ and 1241.7 $mg \cdot m^{-3}$, respectively. This represents a decrease of 21.8 %. The measured and calculated values for H_2S are shown in Table 1. There was a statistically significant difference in H_2S emission between the untreated section and the zeolite-treated section ($P = 0.00 < \alpha = 0.05$).

***Table 1** Measured and calculated values for H_2S*

Measuring	N	Air velociy ($m^3 \cdot s^{-1}$)	Applied agent	Temperature (°C)	Relative air humidity (%)	Average concentration of H_2S ($mg \cdot m^{-3}$)	Emission factor H_2S (kg $H_2S \cdot$animal place$\cdot$year $^{-1}$)
No. 1	139	0.06	untreated	14.9 ±1.9	61.8 ±5.5	1587.7 ±1651.7	253.1
No. 2	139	0.16	zeolite	14.1 ±2.35	63.5 ±6.5	1241.6 ±266.5	223.9

When comparing the effect of air temperature on H_2S emission, we noticed a statistically significant difference in the section with and without treatment with zeolite ($P = 0.002 < \alpha = 0.05$) resp. ($P = 0.00 < \alpha = 0.05$). When comparing the effect of relative humidity on H_2S emission with and without treatment with zeolite, we also noted a statistically significant difference ($P = 0.00 < \alpha = 0.05$ resp. $P = 0.00 < \alpha = 0.05$).

***Table 2** Measured and calculated values for CH_4*

Measuring	N	Average air velocity ($m^3 \cdot s^{-1}$)	Applied agent	Average temperature (°C)	Average relative air humidity (%)	Average concentration of CH_4 ($mg \cdot m^3$)	Emission factor CH_4 (kg CH_4 $\cdot$animal place$\cdot$year $^{-1}$)
No. 1	139	0.06	untreated	14.9 ±1.9	61.8 ±5.5	12.4 ±6.3	2.0
No. 2	139	0.16	zeolite	14.1 ±2.35	63.5 ±6.5	7.1 ±2.6	1.3

When monitoring the CH_4 emission, an average value of 12.4 $mg \cdot m^{-3}$ was recorded. An average of 7.1 $mg \cdot m^{-3}$ was measured with zeolite. This represents a decrease of 42.7 %. The measured and calculated values for CH_4 are shown in Table 2.

There is a statistically significant difference in the CH_4 emission between the untreated section and the zeolite-treated section ($P = 0.00 < \alpha = 0.05$ and $P = 0.029 < \alpha = 0.05$). When comparing the effect of temperature on the CH_4 concentration with and without treatment with zeolite, we observed a statistically significant difference ($P = 0.00 < \alpha = 0.05$ and $P = 0.00 < \alpha = 0.05$). When comparing the effect of relative humidity on CH_4 emission without and with zeolite treatment, we also noted a statistically significant difference ($P = 0.00 < \alpha = 0.05$ and $P = 0.00 < \alpha = 0.05$).

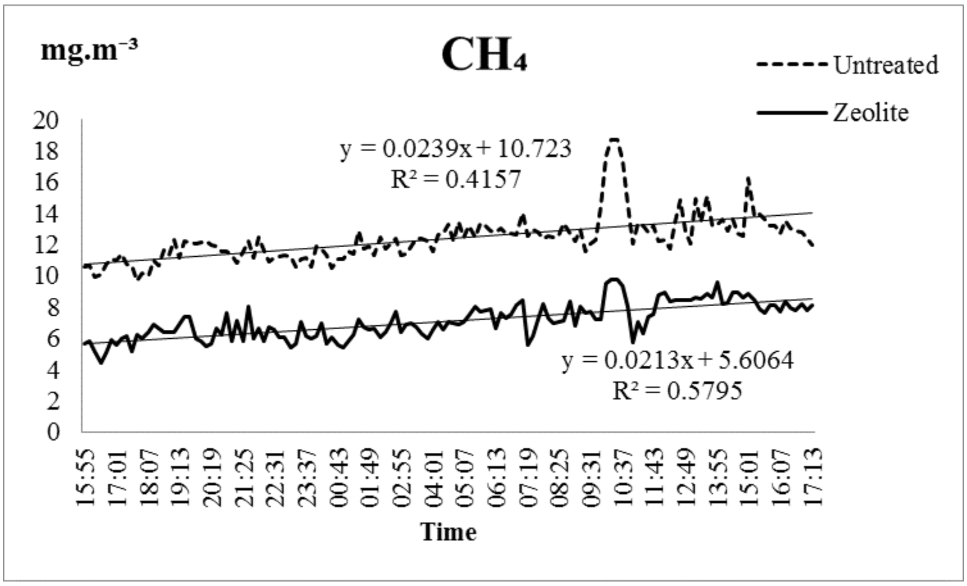

Fig. 1 Behaviour of CH_4 emission in the section untreated and treated with zeolite

When testing the dependence between qualitative characteristics (the effect of temperature and relative humidity on H_2S and CH_4 emissions), we observed the mean value of the coefficient of determination between temperature and H_2S when treated with zeolite ($R^2 = 0.47$). The determination coefficient R^2 indicates that the selected regression model (linear regression line) explains the variability in this case at 47 %. When testing the dependence between qualitative features of zeolite exposure time on CH_4 emission (Fig. 1), the equation is $y = 0.0213x + 5.6064$. The regression relationship shows that every seven minutes the CH_4 emission increases by 0.0213 $mg \cdot m^{-3}$. The determination coefficient is $R^2 = 0.579$. The results show that temperature and relative humidity have an impact on H_2S and CH_4 emissions. In comparison, we noticed a statistically significant difference in H_2S and CH_4 emissions in the zeolite-treated section and the untreated section. In this case, we observed a reduction in the emission of harmful substances H_2S and CH_4 in the zeolite-treated section, as reported by Galajda et al. (2000) versus the untreated section. Our measurements show that air temperature and humidity have a large impact on pollutant emissions, as reported by Topisirovic et al. (2010a; 2010b). In conclusion, as mentioned by Jelínek et al. (2004), the emissions of harmful substances can be reduced by means of biotechnological products.

CONCLUSION

Our measurements show that one of the possibilities of reducing the emission of harmful substances in pig farming is the application of biotechnological products. By zeolite application, H_2S emissions decreased by 21.8 % and CH_4 emissions by 42.7 %. There was a statistically significant difference in the emissions of noxious gases between the section without zeolite treatment and with zeolite treatment. We can assume that it is possible to achieve a reduction in greenhouse gas emissions by the above-mentioned biotechnological product and thus to meet the EU requirement for reducing greenhouse gas emissions. It would be advisable to repeat the measurement, but on a bigger farm which is engaged in intensive rearing of pigs. An important aspect in the use of biotechnological products is the cost and carbon footprint of the product, especially for such small farms.

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