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Research Paper

Removal of hydrogen sulphide from pig house using biofilter with fungi

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Biological air cleaners used for reducing emissions of odorants are often challenged by the low solubility of reduced sulphur compounds. In a recent study high removal of hydrogen sulphide (~75%) from the exhaust air from a pig house was achieved using a biofilter. The aim of this study was to investigate if this high removal could be due to the presence of fungi. The removal of reduced sulphur compounds in a 600-mm wide cellulose biofilter was measured at depths of 0, 200, 400 and 600 mm and the results compared with estimated fungal hyphae surface area per biofilm area. Over 19 months, removal of hydrogen sulphide was measured during periods with and without fungi. The results demonstrate a correlation between the fungal hyphae surface area and the removal of hydrogen sulphide with the highest removal in the first 200 mm of the biofilter and decreasing removal with depth. During periods with presence of fungi, the removal of hydrogen sulphide (64%) was significantly higher than during periods without fungi (18%). It is hypothesised that the observed fungi oxidise hydrogen sulphide and may play a major role in biofilters treating air from pig houses due to the expansion of the active surface area caused by the hyphae.

1. Introduction

Emissions of odorous gases and ammonia from intensive pig houses cause nuisance to nearby rural communities (Wing et al., 2008) and eutrophication of the environment (Hutchings, Sommer, Andersen, & Asman, 2001). Most odorous gases emitted from pig houses are formed in the anaerobic liquid manure and are emitted from the slurry pits (Mackie, Stroot, & Varel, 1998) with a smaller part coming from the floor surfaces. Reduced sulphur compounds, such as hydrogen sulphide, methanethiol and dimethyl sulphide are emitted in concentrations quoted in ppbv (Feilberg, Liu, Adamsen, Hansen, & Jonassen, 2010; Hansen, Liu, Guldberg, & Feilberg, 2012; Kim et al., 2007; Liu, Feilberg, Adamsen, & Jonassen, 2011). Reduced sulphur compounds, and especially hydrogen sulphide and methanethiol, are major contributors

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to odour nuisance due to their low odour threshold values (Nagata, 2003). Sulphur compounds also represent an energy source to aerobic bacteria in biotrickling filters (Chen & Hoff, 2009; Sheridan, Curran, & Dodd, 2003). In general, biological air cleaners work by promoting microbial growth (biofilm of bacteria and fungi) on a large surface area exposed to volatile compounds, which the biofilm can metabolise. To ensure humidification of the biofilm, it is either irrigated directly (biotrickling filter) or humidified by the process air (biofilter). In previous studies investigating biotrickling filters the treatment of exhaust air from pig production have demonstrated that water-soluble odorants such as carboxylic acids, phenols and indoles are well removed (70–99%), whereas sulphur compounds are removed to a lesser extent (10–40%) (Feilberg, Adamsen, Lindholst, Lyngbye, & Schafer, 2010; Kristiansen et al., 2011). In a recent study by Hansen et al. (2012) where a biotrickling filter was combined with a biofilter, a relatively high removal of hydrogen sulphide (~75%) was observed. A high removal rate of hydrogen sulphide in that study was observed along with fungi colonisation on the biofilter. The aim of the present study was to clarify the role of fungi in hydrogen sulphide removal by investigating 1) if there was a correlation between the surface area of fungal hyphae in the depth of the biofilter and the removal of hydrogen sulphide and 2) the removal of hydrogen sulphide during periods with and without visible fungal colonisation on the biofilter.

2. Materials and methods

2.1. Description of the biofilter

A three-step biological air cleaner (SKOV A/S, Glyngøre, Denmark) was installed at a pig production facility with 350 growing-finishing pigs, see Fig. 1. The focus of the present paper was the third biofilter step in the biological air cleaner. More information about the pig production facility and the biological air cleaner used in this study can be found in the earlier study by Hansen et al. (2012). The third step of the biological air cleaner was designed as a vertical biofilter. Dimensions of the third filter step were 2 m height, 5 m wide and 600 mm in depth. Empty-bed residence times for the biofilter section were in the range of 1–2 s. Cellulose was used as filter material with a surface to volume ratio of 384 $m^2 m^{-3} \pm 4\%$ and a porosity in the absence of biofilm of 0.98. Pressure drops were in the range of 5–10 Pa for the third step. The humidified air from filter steps 1 and 2 served as source for humidification of the biofilter in step 3 and no leachate was produced.

2.2. Gas measurements

High sensitivity proton-transfer-reaction mass spectrometry (PTR-MS, Ionicon Analytik GmbH, Innsbruck, Austria) was applied for measuring the removal of hydrogen sulphide (*m/z* 35), methanethiol (*m/z* 49) and dimethyl sulphide (*m/z* 63) in the biofilter both during continuous and discrete gas measurements. The PTR-MS was operated under standard drift tube conditions with a voltage at 600 V, a pressure between 0.21 and 0.22 kPa and a temperature at 60 °C. The inlet temperature was set at 60 °C. The rate constants of methanethiol and dimethyl sulphide were estimated based on a 5 ppmv gas standard (Air Liquid, Horsens, Denmark) and hydrogen sulphide was calibrated according to the method described by Feilberg, Liu, et al. (2010), where the humidity dependency was taken into account.

2.3. Continuous gas measurements during fungi occurrence

2.3.1. Sampling points in biofilter

A 100 mm wide, cylindrical core was cut and taken out from the centre of the third filter step and samples of the biofilter were cut out from the core in depths of 200 mm, and 400 mm from the front (see Appendix A, Fig. A.1 and A.2). Furthermore, samples were taken on the front (0 mm) and on the backside of the filter (600 mm). Polytetrafluoroethylene (PTFE) tubes

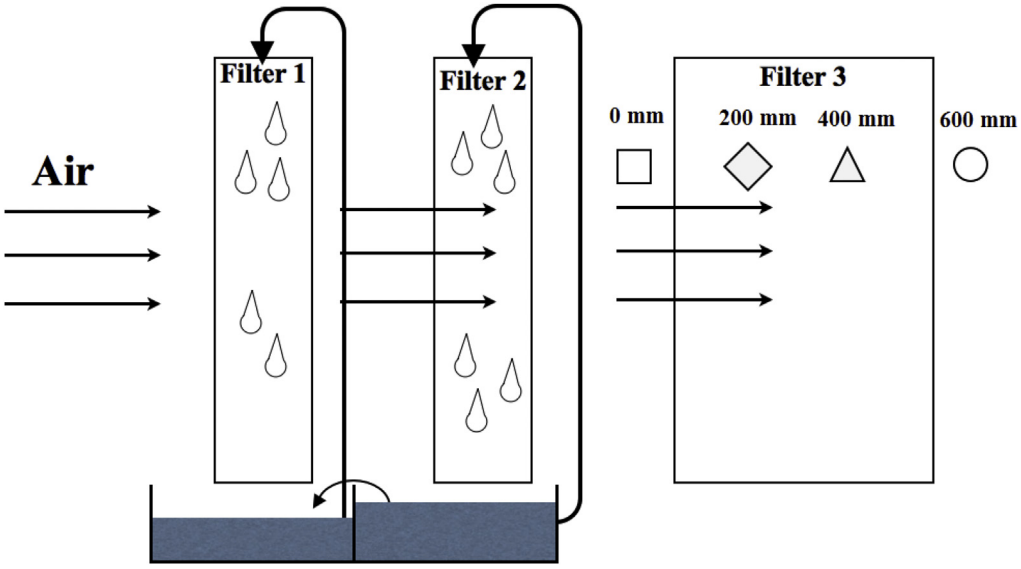

Fig. 1 – Schematic drawing of a three-step biological air cleaner with sampling points in the third biofilter step.