# Air–water mass transfer of sparingly soluble odorous compounds in granular biofilter media

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## HIGHLIGHTS

► Air–water mass transfer was measured for individual hydrophobic odorous compounds without using chemical reactions.
► Mass transfer increased with increasing gas phase velocity, media specific surface area and compound solubility.
► Mass transfer was satisfactorily modeled across three gas velocities, six compounds and seven medium particle size distributions.

## ARTICLE INFO

## ABSTRACT

Mass transfer from air to the liquid phase is a key parameter controlling the efficiency of air cleaning biofilters. Especially the removal of sparingly soluble organic compounds such as volatile odorous sulfur compounds is mass transfer limited. When determining mass transfer rates of sparingly soluble organic compounds the approach have been to either conduct measurements using highly soluble compounds or sparingly soluble compounds with chemical removal of the compounds in the water phase to maintain maximum mass transfer. These data may, therefore, not represent the correct mass transfer rates for sparingly soluble compounds. As a consequence existing mass transfer models may not be accurate for these compounds. In addition most studies of mass transfer in granular media are based on materials consisting of uniform particles. This study investigates the impact of particle size (considering materials with multiple particle sizes), gas velocity and contaminant chemical properties on the overall volumetric mass transfer coefficient based on direct measurements (without the use of chemical reactions) of volatile, sparingly soluble, odorous organic compounds in granular media. Mass transfer was found closely related to particle size, compound solubility, particle size range, specific surface area and gas velocity. Predictive models linking mass transfer, gas velocity, contaminant solubility, media specific surface area, particle size and medium $CO_2$ mass transfer were developed.

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## 1. Introduction

During recent decades global pork production has increased rapidly with the annual production exceeding 100 million tons in 2005 (a 50% increase over the previous 15 years [2]). Also pig farms have increased in size producing increased emissions of air-borne odorous compounds, a source of nuisance to people living in the vicinity, thus, increasing the pressure for reducing odor emissions [3]. Odor emissions are primarily associated with the large quantities of ventilation air from the animal facilities [4]. At present biofiltration seems to be one of the most cost effective technologies for odor removal from the exhaust air [4,5]. Biofilter efficiency is closely connected to the biofilter reactors volumetric elimination capacity (mol s$^{-1}$ m$^{-3}$). The volumetric elimination capacity is generally controlled by either the microbial degradation rate or the rate of mass transfer across the gas–liquid interface [6]. In air fed biofilters the overall volumetric mass transfer across the air–water interface ($K_G a_e$ (mol s$^{-1}$ m$^{-2}$ (mol m$^{-3}$)$^{-1}$ (m$^2$ m$^{-3}$)) or simply (s$^{-1}$) is proportional to the contaminant solubility in the water phase [6]. The efficiency of biofilters for removal of sparingly soluble odorous compounds such as $H_2S$ or methane thiol's is therefore likely to be limited by the air–water interface mass transfer [7]. $K_G a_e$ is closely linked to medium specific surface area, $a$ (m$^2$ m$^{-3}$) [8] and can easily be increased by increasing $a$ for instance by decreasing filter material particle size. However, decreasing the particle size will also increase the air pressure drop across the biofilter [1,9] thereby increasing filter energy consumption and operation costs [5,10,11]. Optimization of biofilter cost-efficiency is, thus, a trade-off, between contaminant removal efficiency and operation

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