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Biotrickling filtration of complex pharmaceutical VOC emissions along with chloroform

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ABSTRACT

Biodegradation of chloroform along with a mixture of VOCs (methanol, ethanol, acetone and toluene) commonly found in pharmaceutical emissions using a biotrickling filter (BTF) was evaluated. The performance of the BTF was evaluated for both steady and transient conditions, for different inlet loading rates (ILR), empty bed residence time (EBRT) and inlet chloroform concentrations. Among the VOCs studied before chloroform feeding, toluene removal was the least, under all the operating conditions. Complete removal of all pollutants was achieved up to a chloroform loading rate of 14.22 g/m^3/h. Increase in loading rate of chloroform adversely affected the removal efficiency of toluene and declined the overall performance of BTF. The results suggest that biodegradation of VOCs is influenced by the inlet loading rate and complexity of pollutants in the inlet air stream. Results from studies on shock loading and starvation indicated that the system was highly resilient to transient operating conditions.

1. Introduction

Volatile organic compounds (VOCs) are an important class of emerging atmospheric pollutants due to their ozone depletion and global warming potential and toxicity. They are also carcinogenic. In particular, chlorinated VOCs (CVOCs) are of prime concern due to the severe impact they have on ecosystems. Application of biofiltration techniques such as biofilters (BF), bioscrubbers (BS), biotrickling filters (BTF) to control these emissions have gained attention in recent past due to their cost effectiveness and ability for complete mineralization of toxic pollutants (Dorado et al., 2008). A number of studies have been carried out to assess the viability of these technologies at an industrial scale (Sempere et al., 2011). Rene et al. (2012) investigated removal of styrene removal in a single and two phase BTF (without and with the addition of silicone oil) inoculated with fungi (*Sporothrix variecibatus*) under steady and transient state conditions. The transient nature of industrial gaseous emissions, with complex mixture of highly degradable and relatively recalcitrant VOC compounds, makes the process complicated (Atoche and Moe, 2004). Most of the earlier biofiltration studies have focused on the treatment of a single pollutant, mixtures of aromatic compounds such as benzene, toluene, ethyl benzene, and *o*-xylene (BTEX) (Chen et al., 2010; Mohammad et al., 2007), hydrophobic and hydrophilic compounds (Paca et al., 2007; Sempere et al., 2010) and mixture of hydrophobic VOCs and sulfur compounds (Lebrero et al., 2012). However, biofiltration studies for mixed pollutant removal along with chlorinated solvents are scant.

Feasibility of conventional biofiltration techniques such as BF and BTF for controlling various chlorinated compounds was demonstrated at laboratory scale by a few researchers. Studies on biodegradation of chlorinated compounds in BTF as single primary substrates such as chlorophenols (Nicolella et al., 2009), dichloromethane (Ravi et al., 2010), monochlorobenzene (Mpanias and Baltzis, 1998) and a mixture of monochlorobenzene and dichlorobenzene (Seignez et al., 2004) were reported earlier. These studies demonstrated that BTF is suitable for the effective treatment of CVOCs since the presence of trickling liquid retards the possible accumulation of toxic and acidifying compounds on the fixed bed. Higher order chlorinated compounds cannot contribute sufficient energy for metabolic activity during biodegradation (Field and Alvarez, 2004). The biodegradation of higher order CVOCs occurs mostly under cometabolic conditions in presence of primary substrates such as methane, propane, phenol and toluene. Although many studies have been carried out on aerobic biotransformation of chlorinated ethanes such as trichloroethene (TCE) and perchloroethene (PCE), not much work has focused on aerobic biotransformation of chlorinated methanes such as chloroform (CF) and carbon tetrachloride (CT). Hecht et al. (1995) have found that the removal efficiency of TCE in a column bioreactor varied between 30–80% when the inlet concentration of TCE was in the range of 0.07–0.40 mg/L. Removal efficiency was affected in presence of phenol as a primary substrate. It has also been found that the presence of chlorinated solvents can change the kinetics of pri-

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