Bioresource Technology 127 (2013) 366–377

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Biofiltration of a mixture of ethylene, ammonia, *n*-butanol, and acetone gases

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HIGHLIGHTS

- ▶ Removal of gases using biofiltration strongly depends on the individual solubility of each gas.
- ▶ We examine highly various ethylene removals in biofilters according to reaction conditions.
- ▶ We examine trickle water flow and media surface areas strongly affect ethylene biofiltration.

ARTICLE INFO

Article history:
Received 11 July 2012
Received in revised form 26 September 2012
Accepted 27 September 2012
Available online 6 October 2012

Keywords:
Biofiltration
Biodegradation
Ethylene
Henry's law constant

ABSTRACT

This study describes cleaning of a waste gas stream using bench scale biofilters (BFs) or biotrickling filters (BTFs). The gas stream contained a mixture of acetone, *n*-butanol, methane, ethylene, and ammonia, and was diverted uniformly to six biofilters and four biotrickling filters. The biofilters were packed with either perlite (BF-P), polyurethane foam (BF-F), or a mixture of compost, wood chips, and straw (BF-C), whereas the biotrickling filters contained either perlite (BTF-P) or polyurethane foam (BTF-F). Experimental results showed that both BFs and BTFs packed with various media were able to achieve complete removal of highly soluble compounds such as acetone, *n*-butanol, and ammonia of which the dimensionless Henry's constants (H) are less than 0.01. Methane was not removed due to its extreme insolubility ($H > 30$). However, the ethylene ($H \approx 9$) removal efficiencies depended on trickle water flow rates, media surface areas, and ammonia gas levels.

1. Introduction

Various atmospheric gaseous contaminants can be generated from anthropologic, industrial, waste treatment, and biogenic sources. Gas contaminants exceeding allowable concentrations can threaten human and ecological health as well as environmental pollution such as global warming, thus gas pollution control of emitting gas streams is sometimes required for maintaining the air quality below the regulated levels (Devinny et al., 1999; Lee et al., 2010).

Air pollution control technologies include physicochemical methods such as activated carbon adsorption, thermal oxidation, and catalytic oxidation. These technologies have been effective in controlling trace contaminants, but maintaining high temperatures or regenerating of adsorbents is expensive. Furthermore, physicochemical systems may produce secondary pollutants such as incineration ash or unused adsorbents, and the generation rates of these pollutants increase as removal rates of the physicochemical systems increase. Therefore, there is a need for alternative technologies that have the potential of replacing physicochemical treatment technologies for air pollution control (Devinny et al., 1999; Fu et al., 2011).

Biofiltration as an emerging air pollution control technology has been successfully applied to remove biodegradable volatile organic compounds, and inorganic compounds such as NH_3 and H_2S from a wide variety of industrial processes and waste treatment operations. Biofiltration has gained increasing popularity because of its low operational costs, high removal efficiency, and lack of secondary pollutant generation (Devinny et al., 1999). The most widely utilized biofiltration systems for air pollution control are biofilters and biotrickling filters. In a biofilter, contaminated air flows through a packed bed, fixed-film bioreactor, air pollutants are transferred from the gas phase into a biofilm growing immobilized on a solid medium (either inorganic or organic), and contaminants are biodegraded into environmentally acceptable end products by mixed microbial cultures growing in the biofilm (Devinny et al., 1999). Biotrickling filters are similar to biofilters, except that a free liquid phase with dissolved mineral nutrients is continuously recirculated over the packed bed made of inorganic materials (Devinny et al., 1999). The term bioreactor in this article refers to both types.

A complex mixture of compounds, including inorganic gases such as ammonia (NH_3), and organic compounds such as methane (CH_4), ethylene (C_2H_4), acetone (C_3H_6O), and *n*-butanol ($C_4H_{10}O$)

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0960-8524/$ - see front matter
http://dx.doi.org/10.1016/j.biortech.2012.09.110