A laboratory simulation of in situ leachate treatment in semi-aerobic bioreactor landfill

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Abstract

In this study, two laboratory-scale simulated landfill bioreactors were established, of which Reactor A was operated only with leachate recirculation and served as the control, and Reactor B was operated as semi-aerobic bioreactor landfill with leachate recirculation. In situ leachate treatment and accelerating organic decomposition in semi-aerobic bioreactor landfill was investigated. The results indicated that the introduction of air into the landfill was favourable for optimising the micro-organism growth environment and accelerating the degradation of organic matter. It can be seen clearly from the results that NH3-N can be removed in situ in the semi-aerobic bioreactor landfill with leachate recirculation. Moreover, semi-aerobic bioreactor landfill showed lower emissions for leachate than those in leachate from anaerobic landfill, with low concentrations of COD, VFA, NH3-N and TKN, and which saved the disposing process of the discharged leachate. The three-dimensional excitation-emission matrix fluorescence spectroscopy (EEMs) of dissolved organic matter (DOM) in Reactor B changed greatly, and fluorescence peak changed from protein-like fluorescence at Day 60 to humic-like fluorescence at Day 95 and 250, while in Reactor A, fluorescence peak of DOM was always protein-like fluorescence. The comparison of the EEMs indicated that the semi-aerobic landfill accelerated the organic decomposition.

Keywords: semi-aerobic landfill, bioreactor landfill, three-dimensional excitation-emission matrix fluorescence spectroscopy (EEMs), in situ leachate treatment

Introduction

In 2002, approximately 94% of the municipal solid waste (MSW) generated in China was disposed of in landfills (Wang et al., 2006). However, anaerobic degradation of solid waste results in the production of leachate and landfill gas for a very long time in a conventional landfill. Leachate and landfill gas are the potential pollution sources for the surrounding environment, and the long-term environmental impacts will last for several decades (Cossu et al., 2003; Bilgili et al., 2006). Therefore, there has been increased emphasis on the operation of landfills as bioreactors to enhance decomposition of solid waste, provide a reduction in landfill emissions over a relatively short time, and dispose leachate in situ (Price et al., 2003; Mehta et al., 2002; Pohland et al., 2000; Reinhart et al., 2002; Reinhart, 1996; Pohland et al., 1994; Townsend et al., 1996; Chan et al., 2002; Demir et al., 2004; Bilgili et al., 2004; Mark and Cristina; 2006). However, ammonia nitrogen typically accumulates because ammonia is stable under anaerobic conditions. Thus, higher concentrations of ammonia than those found in leachate from conventional landfills last long even after the organic fraction of the waste is stabilised (Burton and Watson-Craig, 1998; Onay and Pohland, 1998; Price et al., 2003). That is the reason why ammonia removal is an important aspect of long-term landfill pollution control.

However, ex situ leachate treatment of high concentration COD and NH3-N can be costly (Ferhan and Aktas 2000; Maree et al., 2004). Recently, in situ biological nitrogen removal for bioreactor landfills attracted more and more attention of the researchers. Air addition has recently been practised at a number of pilot-scale and field-scale landfills worldwide, where it was found that the organic fraction of the waste decomposed far more rapidly under aerobic conditions than under anaerobic conditions, and ammonia was removed in situ by nitrification and denitrification in aerobic landfills (Berge et al., 2006; Onay et al., 2001; Reinhart et al., 2002; Read et al., 2001; Das et al., 2002; Themelis et al., 2001; Borglin et al., 2004; Boni et al., 1997). However, there are some disadvantages for the aerobic bioreactor landfills, such as needing forced ventilation systems, complex operation and management, and large energy consumption. Semi-aerobic landfills use natural ventilation instead of mechanical ventilation for oxygen supply, and which create an aerobic region in the landfill. Semi-aerobic landfill system is propitious to the simultaneously occurring nitrification and denitrification and thus in situ disposes the leachate effectively and accelerates the stabilisation of the waste (Theng et al., 2005). In China, only a few researchers studied the semi-aerobic landfill technology, but no systematic and comprehensive studies have been conducted (Wang et al., 2006).

Moreover, fluorescence excitation-emission matrix spectroscopy (EEMs) provides much more detailed information about fluorescence properties of the organic matter that may reveal important information about its composition and biogeochemical cycling (Burdige, et al., 2004). Fluorescence spectroscopy has high sensitivity and specificity, and has already been used in natural water quality monitoring. Rapid analyses are now possible using fluorescence spectrophotometers such that the EEMs

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