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ORIGINAL PAPER

Modelling of kinetics of microbial degradation of simulated leachate from tobacco dust waste‡

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This paper presents a kinetic analysis of the biodegradation of organic pollutants in a batch bioreactor and investigates the kinetic properties of activated sludge using different mathematical models. The treatment was conducted for different initial concentrations of leachate from 500 mg dm^{-3} to 5000 mg dm^{-3} and initial concentrations of activated sludge from 1.84 g dm^{-3} to 6.62 g dm^{-3} over 48 h. Four different kinetic models were applied to the data. The kinetic analysis was performed with the traditional Monod model, the modified Monod model with endogenous metabolism, the Haldane model, and the Haldane model extended to include endogenous metabolic consumption and known as the Endo-Haldane model. Kinetic parameters for each model were determined using differential analysis and the Nelder–Mead method of non-linear regression. The lowest deviations and very good matches with the experimental data were achieved using the Endo-Haldane model. This indicated that this model best described the process of biodegradation of leachate from tobacco waste composting. This is due to this model incorporating the effects both of inhibition and endogenous metabolism.

Keywords: activated sludge, biodegradation, kinetic parameters, leachate, tobacco waste

Introduction

In cigarette manufacture, large quantities of tobacco waste are produced annually, the disposal of which represents a serious ecological problem. Tobacco-related processes can produce solid or liquid wastes. The uncontrolled disposal of tobacco waste can be a serious threat to the environment and endangers public health. The major problem is the continuing growth of tobacco products accompanied by the increasing level of various tobacco wastes containing toxic and hazardous compounds, especially nicotine. Nicotine is highly soluble in water; consequently, this toxic compound can be transferred from the solid phase to an aqueous solution through efficient percolation. It may also be leached from the wastes and may permeate into ground waters and surface waters (Piotrowska-Cyplik et al., 2009; Tyrrel et al., 2008; Wang et al., 2009; Zhong et al., 2010).

With characteristics such as high chemical oxygen demand (COD), total organic carbon (TOC), colour, and potential toxicity, the wastewater has become a further aspect of the solid waste problem (Veli et al., 2008). The COD value in the leachate and the tobacco industry wastewater is estimated to be from 1.0 g dm^{-3} to 70.9 g dm^{-3}. Only a limited number of studies concerning the treatability and toxicity of tobacco wastewaters have been carried out. The biological processes for the treatment of tobacco wastewaters are aerobic or anaerobic biodegradation (Renou et al., 2008; Sponza, 2001; Wang et al., 2009). For many years, conventional biological treatments and physical–chemical methods have been regarded as the most appropriate technologies for the manipulation

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