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ORIGINAL PAPER

Model-based sensitivity analysis of a fluidised-bed bioreactor for mercury uptake by immobilised *Pseudomonas putida* cells

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A model-based sensitivity analysis was performed in order to evaluate the importance of the individual operating parameters of a three-phase fluidised-bed biological reactor used for removing mercury ions from wastewater. The parameters analysed involve the immobilised biomass load (bacteria *P. putida*) on alginate beads, particle size, inlet flow-rate, mercury ion loads in the fed wastewater, and the solid fraction in the reactor. Predictions were generated by using pseudo-first-order, Michaelis–Menten, or pseudo-Haldane kinetic models. The results highlight the major influence of the biomass/solid load and of the liquid residence time on the reactor efficiency. Also, the resultant significant differences in the model predictions underline the importance of using a more accurate kinetic model for process design and control purposes.

Keywords: mercury uptake by *P. putida*, fluidised-bed biological reactor, sensitivity analysis, kinetic model simplification

Introduction

Heavy metal pollution of the aquatic environment, particularly mercury pollution due to mining and industrial activities, continues to represent a major concern worldwide. The main source of mercury is the combustion of fossil fuels and solid waste, with traces of mercury up to 0.3 mg kg^{-1} in coal, and up to 3 mg kg^{-1} in municipal solid wastes (Di Natale et al., 2006). However, other significant sources of pollution need to be recognised, such as the use of mercury as cathode in chloralkali electrolysis on a large scale leading to significant mercury emissions (ca 1 g of Hg per t of chlorine, Leonhäuser et al. (2006)), and highly polluted wastewater (up to 7.6 mg L^{-1}, Green-Ruiz (2006)). Mercury is also used in numerous industrial and medical applications (fungicides, disinfectants, dental products, catalysts, igniters, dye production, etc., Deckwer et al. (2004)).

Mercury is considered to be a priority hazardous pollutant due to its high toxicity, and a maximum permissible concentration of 50 μg L^{-1} is imposed on discharged wastewaters (Deckwer et al., 2004). Moreover, the European Union required, under Directive 2000/60/CE (European Commission, 2000), the cessation or phasing out of discharges, emissions, and losses of mercury by 2020, with complete remediation of polluted water bodies (Di Natale et al., 2006). Among possible treatment procedures for removing mercury from wastewaters are the following: i) precipitation with toxic H_2S, resulting in the need for safe disposal of large volumes of mercury-contaminated sludge (mercury recycling from HgS is not possible, Wagner-Döbler et al. (2000)); ii) mercuric ion retention by ion exchange columns (albeit renewable adsorbents are very expensive, Hosseini-Bandegharaei et al. (2011)); iii) retention on cheap sorbents, such as activated carbon, char from coal, volcanic tuff (Di Natale et al., 2006), immobilised enzymes on alginate (Bhattacharyya et al., 2010), modified agro-waste materials

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