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Hydrodynamic analysis of a biofilter affected by biofilm growth

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Abstract

Biofilters are used to treat liquid waste effluents or gas waste streams. A high biomass concentration can be maintained within systems treating fluids with attached microorganisms that lead to an efficient treatment with a more compact treatment system. The great problem in biofiltration systems remains that in many cases the growth of the biofilm cannot be effectively controlled. The biofilm growth leads to a progressive clogging of the biofilter resulting in changes of the effective porosity, the hydraulic conductivity, and the dispersivity. The bioreactor clogging increases the pressure loss and makes the system discontinuous. In this research, the hydrodynamic properties influenced by biofilm growth are verified in an experimental biofilter apparatus on a laboratory scale. For this reason three flow rates of 5, 10 and 20 liter/hour were applied through the packed bed in laminar regime. Phenol has been selected as a carbon source for the microorganisms in concentration of 200 ppm. The Results showed that the reduction of permeability is very sharp as soon as the biofilm appears, and this sharp decrease seems related with the existence of biopolymers. The relationships between permeability and porosity allowed the reconstruction of the porosity and biomass concentration profiles from the pressure loss measured during the experiments.

Keywords: biofilter, biofilm, permeability reduction, bioclogging

1. INTRODUCTION

To optimize the design and operating conditions of biofilters, it is necessary to have a better understanding of the complex interactions occurring in these bioreactors. If experimental or numerical works have been done on the coupling between the local hydrodynamic and biofilm growth (Picionaru, 1999; Wanner et al, 2004) as well as the coupling between hydrodynamic and bio-clogging in porous media, (Taylor and Jaffe, 1990, Thullner et al, 2004; Stewart and Kim, 2003; Kapellos et al, 2007) few reliable experiments are available at pilot scale or industrial biofilter scale on this problem. Such experiments are however essential to better understand these systems and help their modeling and design. This paper aims to present an experiment performed on a laboratory scale pilot to study the coupling between biomass growth, hydrodynamic and pollution removal efficiency in a biofilter. An experimental setup build in LEGI is presented and preliminary results are shown, concerning the coupling between permeability reduction and biomass growth. The experimental results are compared with existing theoretical work. These results, gained from an analysis of the system at the steady state, are the key point to develop a methodology aiming to analyse the dynamic behaviour of the system and predict it in a simple 1D model.

2. MATERIAL AND METHODS

2.1 Experimental setup

The experimental setup is mainly based on a transparent PVC column (1) whose dimensiosn are presented on figure1. The column is filled with expanded clay beads (Biolite®, Degrémont). The Biolite© beads are maintained between two grids to form a granular packed bed and avoid a possible expansion during the experiment. The beads were selected in order to get a size distribution as uniform as possible: their equivalent diameter is about 4.2 mm with an uniformity coefficient around 1.2. The beads size distribution can be then considered to be fairly uniform.