Research Article

Received: 26 November 2013 Revised: 12 February 2014 Accepted article published: 20 February 2014 Published online in Wiley Online Library: 20 March 2014

(wileyonlinelibrary.com) DOI 10.1002/jctb.4354

Influence of the organic loading rate on the hydraulic behaviour and the azo-dye removal in an anaerobic filter

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Abstract

BACKGROUND: Biofilm processes have proven to more efficiently remove xenobiotics than suspended growth systems. They offer higher solid retention times to prevent washout of adapted microorganisms. The main problem with anaerobic filters is clogging when the biofilm develops rapidly or after long operating periods. In this work, an anaerobic filter was operated for 466 days to evaluate the degradation of Direct Blue 2 (DB2) azo dye and the influence of organic loading rate on the hydraulic behaviour and on azo dye removal. Axial Dispersion and Wolf and Resnick models were used for the analysis of tracer curves.

RESULTS: Tracer tests showed that the anaerobic filter behaves predominantly as a plug flow reactor and as the biofilm grows thicker with increasing organic load, the void volume and the hydraulic retention time decrease. In addition, with increasing organic loading rate, the dispersion coefficient increases. The anaerobic biofilm removed up to 60% of the Direct Blue 2 azo dye.

CONCLUSION: The higher the organic load, the better the azo dye was removed. Both the dye Direct Blue 2 and its degradation products (benzidine and 4-aminobiphenyl) can be removed by an anaerobic biofilm. The anaerobic biofilm did not only break the azo bonds but also decomposed benzidine to 4-aminobiphenyl.

Keywords: anaerobic filter; lava stones; azo dyes; hydraulic behaviour; tracer tests

INTRODUCTION

With increasing demand for textile products, the textile industry and its production of wastewater have increased making this industry one of the main sources of severe pollution worldwide. In particular, the release of coloured effluents into the environment is undesirable, not only for their colour, but also because many of the dyes and their breakdown products in wastewater are toxic and/or mutagenic. Textile wastewaters are characterized by extreme fluctuations in many parameters such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), pH, colour and salinity.[1−3]

The biodegradation of azo (—N=N—) dyes takes place in two steps: the first is the decolourization that occurs due to microbial nonspecific activity in which the azo bond is cleaved to aromatic amines and the second step is the mineralization of intermediates.[1,4] Cleavage of the azo bonds generates aromatic amines which, with few exceptions, are not further metabolized under anaerobic conditions. Some azo dyes are not normally toxic but the amines resulting from the anaerobic digestion of these substances may possess these characteristics.[5] Some authors have found that the cleavage of azo bonds in benzidine based azo dyes or direct dyes produce benzidine and 4-aminobiphenyl which are classified as carcinogenic and mutagenic.[6−8] Table 1 presents studies of the degradation of different direct dyes and their by-products in reactors with different configurations.

In recent years, biofilm reactors have attracted much attention especially for the treatment of wastewaters containing recalcitrant, inhibitory and toxic compounds.[4] Biofilm processes have proven to be more efficient to remove xenobiotics than suspended growth systems. Anaerobic filters offer higher solid retention times to prevent washout of adapted microorganisms. Nevertheless, the main problem with this technology is clogging when the biofilm develops rapidly or after long operating periods.[12] Because of biofilm growth, part of the reactor volume becomes idle as 'dead volume' because the liquid flows through 'preferential' pathways.[13]

Several researchers have conducted hydrodynamic studies on anaerobic filters.[8−11] Filters are considered to operate as plug flow reactors. Generally, higher substrate and biomass concentrations are present at the bottom (influent) of the reactor while relatively lower concentrations are observed at the top (effluent). The packing media provides interstitial pathways for liquid to flow and the flow rates are usually too low to behave as the classic plug flow model. The hydraulic characteristics are more complex when considering also the nature of anaerobic processes characterized by biogas generation and biomass accumulation.[14,17]

The hydraulic characteristics of bioreactors are commonly determined using tracer studies to obtain the residence time

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