

A cooling water system as a biofilm reactor for the treatment of municipal wastewater

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Abstract

In this study, a water cooling tower was used as a low-rate biofilm reactor for treating municipal wastewater. The performance of the system was evaluated at three different flow rates ($5 \text{ l}\cdot\text{s}^{-1}$, $2 \text{ l}\cdot\text{s}^{-1}$ and $1.6 \text{ l}\cdot\text{s}^{-1}$). The biofilm reactor gave the best results at a flow rate of $1.6 \text{ l}\cdot\text{s}^{-1}$, namely: 43.3% nitrogen removal, 42.3% chemical oxygen demand (COD) removal, 1.7% phosphorus removal and 39.8% suspended solids (SS) removal. These results were achieved with a once-through flow and low organic ($19 \text{ g COD}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$) and hydraulic loads ($0.173 \text{ m}^3\cdot\text{m}^{-2}\cdot\text{d}^{-1}$). This type of biofilter system is being used in West Malaysia to treat municipal effluents. Our system performance, at a flow rate of $1.6 \text{ l}\cdot\text{s}^{-1}$ was capable of treating municipal wastewater to meet general effluent standards in South Africa (*Government Gazette*, 1984). This is sufficient for treating effluent for a population equivalent of 2 800 people.

Nomenclature

Symbol	Description	Unit
a) T	temperature	C
pH	pH value	-
TKN	total Kjeldahl nitrogen	$\text{mg N}\cdot\text{l}^{-1}$
$\text{NH}_4\text{-N}$	ammonia nitrogen	$\text{mg}\cdot\text{l}^{-1}$
$\text{NO}_3\text{-N}$	nitrate nitrogen	$\text{mg}\cdot\text{l}^{-1}$
TP	total phosphorus	$\text{mg}\cdot\text{l}^{-1}$
$\text{PO}_4\text{-P}$	orthophosphate	$\text{mg}\cdot\text{l}^{-1}$
SS	suspended solids	$\text{mg}\cdot\text{l}^{-1}$
-	settleable solids	$\text{ml}\cdot\text{l}^{-1}$
HRT	hydraulic residence time	min
-	alkalinity	$\text{mg CaCO}_3\cdot\text{l}^{-1}$
COD	chemical oxygen demand	$\text{mg}\cdot\text{l}^{-1}$
b) N	nitrogen	$\text{mg}\cdot\text{l}^{-1}$
TDS	total dissolved solids	$\text{mg}\cdot\text{l}^{-1}$
-	conductivity	$\text{mS}\cdot\text{m}^{-1}$

Introduction

Water is a valuable resource that needs to be conserved, especially in a country like South Africa which is in a semi-arid region (Schutte and Pretorius, 1997). Population growth and industrial development demand increasing water supplies which emphasises the importance of wastewater treatment (Tebbutt, 1977).

A suitable wastewater treatment method should be economical, effective and reliable. One such a system is the activated sludge process, used mainly for large-scale treatment of municipal effluents. This system is based on the suspended growth of bacteria (Gray, 1989). Although effective, activated sludge treatment sys-

tems have some disadvantages, such as: long sludge age, vast quantities of sludge production and high energy consumption. For smaller populations, trickling filters (fixed film reactors), are often used offering advantages such as: effective land utilisation, low initial capital outlay, low operation and maintenance costs, no specialised mechanical equipment, non-clogging configuration, efficient BOD reduction and an aesthetic advantage over conventional systems (Gray, 1989; Characklis and Marshall, 1990; Le Tallec et al., 1997).

Many different types of fixed film reactors are currently in use (Muyima et al., 1997). One such a system is a modified cooling tower biofilm reactor (P.E. Biofilter System¹) used for the treatment of sewage of small communities (650 to 4 757 people) in Malaysia. This type of system has not yet been used in South Africa and very few data are available in the literature on the effectivity of this type of system. The objective of our study was therefore to determine the effectivity of a cooling water system used as a biofilm reactor, to treat municipal wastewater.

Materials and methods

Biofilm reactor

A conventional cooling water system (SULZER, EWK Range, Type 661/09) was used as a biofilm reactor (Fig. 1). This system provided a fill surface area of approximately 800 m^2 and a sump volume of 2.5 m^3 . The fill material was corrugated at a 60° angle and assembled in a cross-corrugated pattern with adjacent sheets (Fig. 2). The system was operated with the fans in the "off" position.

Feed and inoculum

Primary settled sewage from Daspoort Water Care, Pretoria, South Africa, was used to feed the biofilm reactor. The natural bacterial community was allowed to develop and form biofilms in the reactor. A start-up period of 3 d was allowed before monitoring started.

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