

Effect of recycle on treatment of aircraft de-icing fluid in an anaerobic baffled reactor

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Abstract

Aircraft de-icing fluid at 7 000 mg COD/l was successfully treated in an anaerobic baffled reactor operated with and without recycle at volumetric organic loading rate of between 4 and 11 g COD/l_{reactor}·d. Reactor recycle was found to improve reactor performance. The anaerobic baffled reactor operated with a 6:1 recycle ratio achieved a minimum hydraulic retention time of 17 h with an acceptable COD removal efficiency of 93% at a volumetric organic loading rate of 9.9 g COD/l_{reactor}·d. This corresponded to a specific organic loading rate of 0.35 g COD/g VSS·d and specific organic removal rate of 0.32 g COD_{rem}/g VSS·d. Without recycle similar removal efficiency was achieved; however, the loading rates were about 40% less. Due to biomass growth specific organic loading rate was not found to vary significantly through most of the experimental period despite loading rate increases.

Hydrodynamically, an anaerobic baffled reactor may be characterised as an in-series continuously stirred tank reactor where the number of continuously stirred tank reactors corresponded to the number of actual compartments. Volatile fatty acid profiles tend to indicate that anaerobic baffled reactor compartmentalisation served to separate acidogenic and methanogenic activities longitudinally through the reactor, with the highest proportion of acidogenic activity in the first compartments. The net accumulated yield within the anaerobic baffled reactor was found to be of 0.007 g VSS/g COD_{rem} when the ABR was operated without recycle and of 0.016 g VSS/g COD_{rem} for the ABR operated with recycle.

Keywords: anaerobic baffled reactor, de-icing fluid, treatment

Nomenclature

ABR	=	anaerobic baffled reactors
ADF	=	aircraft de-icing fluid
COD	=	chemical oxygen demand
CSTR	=	continuously stirred tank reactor
HRT	=	hydraulic retention time
ID	=	internal diameter
OLR	=	volumetric organic loading rate
RTD	=	residence time distribution
SOLR	=	specific organic loading rate
SORR	=	specific organic removal rate
SRT	=	solids retention time
SS	=	steady state
STP	=	standard temperature and pressure
TSS	=	total suspended solids
UASB	=	upflow anaerobic sludge blanket
VFA	=	volatile fatty acids
VSS	=	volatile suspended solids

Introduction

Successful treatment of ADF has already been achieved using high-rate anaerobic reactors. Albany International Airport (Albany, NY), achieved 95% removal efficiencies for propylene glycol based ADF using a 700 l anaerobic fluidised bed reactor (Switzenbaum et al., 2001) at an OLR of 15 kg COD/m³_{reactor}·d. However, high fluidisation costs limited this tech-

nology. Mulligan et al. (1997) successfully treated 90% COD removal of ethylene glycol based ADF in an anaerobic multi-plate reactor at an OLR of 16.5 kg COD/m³_{reactor}·d. However, the complex multi-plate arrangement resulted in high capital costs as well as operational problems. Darlington and Kennedy (1998) and Pham and Kennedy (2004) reported treatment of ethylene glycol-based ADF wastewaters (5 to 20 g COD/l) using UASB reactors. At an OLR up to 38.7 kg COD/m³_{reactor}·d, COD removal efficiencies ranged between 70 to 98%. Although treatment of ADF by UASB reactors proved to be successful, treatment was limited by the maximum flow rate attainable before washout of biomass occurred. At high OLR, excess biogas production increased solids loss as gas bubbles attached themselves to the anaerobic biomass and failed to detach before the granules were entrained into the effluent line. The simple design and particular flow characteristics within an ABR which lead to long SRT may overcome the inherent problems associated with treatment of ADF in other high-rate anaerobic reactors (Tilche and Yang, 1987; Grobicki and Stuckey, 1991; Barber and Stuckey, 1999).

The ABR (Fig. 1) has no moving parts and merely uses a series of baffles to force the wastewater to flow over and then under them as it travels through the reactor and creates conditions approaching plug flow (Bachman et al., 1985). Bacteria within the reactor may rise, and then settle within the reactor due to gas production and flow characteristics, yet their movement through the reactor occurs at a very slow rate, thus producing long SRT. Furthermore, the compartmentalisation of the bacteria may provide the ability to separate acidogenesis and methanogenesis longitudinally down the reactor, allowing the different bacterial groups to operate at their preferred conditions (i.e. pH, Barber and Stuckey, 1999). It is believed that the use of granular sludge will enhance the inherent advantages of ABRs described by Barber and Stuckey (1999).

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