Bioresource Technology 125 (2012) 318–327

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Anaerobic treatment of methanol condensate from pulp mill compared with anaerobic treatment of methanol using mesophilic UASB reactors

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HIGHLIGHTS

- Methanol condensate was evaluated for the anaerobic treatment for the first time.
- COD removal of the condensate was 84–86% and that of methanol was 86–98%.
- 92% and 89% of degraded COD converted to CH_4 in methanol condensate and methanol.
- Adaptation of microbes to the toxicity of methanol condensate over period of time.
- The anaerobic treatment markedly reduces the bad smell of the condensate.

ARTICLE INFO

Article history:
Received 28 May 2012
Received in revised form 24 August 2012
Accepted 25 August 2012
Available online 31 August 2012

Keywords:
Anaerobic treatment
Methanol condensate
Pulp and paper mill
Biogas production
UASB reactor

ABSTRACT

The feasibility of anaerobic treatment of methanol condensate from pulp and paper mill in UASB reactor was investigated and compared with the anaerobic treatment of methanol. The UASB reactor treating methanol condensate was operated for 480 days with minimum problems of overload. COD removal from methanol condensate and methanol under normal operating conditions ranged from 84–86% to 86–98%, respectively. Under optimal conditions (OLR = 5.0 g COD L^{-1} day^{-1}, $COD_{influent}$ = 11.40 g L^{-1}) a methane yield of 0.29 NL CH_4 per g $COD_{removed}$ (at standard temperature and pressure) was achieved during the treatment of methanol condensate. The recovery time of the microorganisms after several overloads was decreasing each time probably due to the adaptation to methanol condensate. These findings indicate that methanol condensate can be efficiently treated in a UASB reactor with the benefit of biogas production. As a bonus effect of the treatment, much of the smell of the feed was eliminated.

1. Introduction

The pulp and paper industry is one of the most important industries in Sweden and the products constitute important industrial trade in terms of value of production (Thollander and Ottosson, 2008). Sweden is the one the largest producers of bleached Kraft pulp (Harrisson, 2002). In Sweden there are 52 pulp mills; Kraft pulp (20), sulphite pulp (2), ground wood pulp (5), recycled fibre pulp (8), market pulp (17).

(http://www.skogsindustrierna.org/web/Skogsindustrier-nas_miljodatabas.aspx). Chemical pulp mills use chemicals such as sodium hydroxide and sodium sulphide (Kraft process) for dissolving the non-cellulosic fraction from the wood chip and liberate the cellulose fibers, which are subsequently used for a wide range of paper products (Driessen et al., 2000; Mockos et al., 2008).

In Kraft pulping, condensates contain hazardous air polluting (HAP) substances that are condensed from the vent streams of the pulping system. These condensates result from the contact of organic compounds in the pulping process with water or steam that condenses and is collected (Bradfield and Spence, 2011). In Kraft evaporator condensate from pulping mills, methanol is the main organic pollutant and may account for up to 80–96% of the total chemical oxygen demand (COD), with concentration of methanol in the range of 1–46 g L^{-1} (Dufresne et al., 2001; Liao et al., 2010; Minami, 1994; Mockos et al., 2008; Weijma et al., 2003). In the pulping process methanol is produced by two generally accepted mechanisms: about 85% is formed by demethylation of xylan and 15% by demethylation of lignin (Zhu et al., 1999). Kraft pulp mill condensate represents only 5% of the mill effluent volume and accounts for 15–40% of the total BOD (Rintala and Puhakka, 1994; Xie et al., 2010). Kraft pulp mill condensates are alkaline due to the presence of ammonia produced in pulping process during caustic digestion of proteins in the wood (Driessen et al., 2000; Mockos et al., 2008). These Kraft pulp mill condensates are also characterised by a strong foul smell due to the presence of

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0960-8524/$ - see front matter © 2012 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.biortech.2012.08.109