ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 6, November 2013

Performance of Ultrasonic Membrane Anaerobic System (UMAS) in Membrane Fouling Control

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Abstract*— The primary objective of this study was to evaluate the effects of the organic loading rate (OLR) on the performance of an ultrasonic-assisted membrane anaerobic system (UAMAS) treating Palm Oil Mill Effluent (POME), based on the following indicators: (i) methane gas contents, (ii) chemical oxygen demand (COD) removal efficiency, and (iii) effluent variability (phenol, suspended solids, volatile fatty acids, and pH stability).Six steady states were attained as a part of a kinetic study that considered concentration ranges of 15,830 to 21,600 mg/l for mixed liquor suspended solids (MLSS) and 9,450 to 18,200 mg/l for mixed liquor volatile suspended solids (MLVSS). Kinetic equations from Monod, Contois and Chen & Hashimoto were employed to describe the kinetics of POME treatment at organic loading rates ranging from 0.5 to 15 kg COD/m^3/d. The removal efficiency of COD was from 93 to 98.7 % with a hydraulic retention time (HRT) of 4 days. The growth yield coefficient, Y, was found to be 0.59 g VSS/g COD, the specific microorganism decay rate was 0.26 d^{-1}, and the methane gas yield production rate was between 0.264 l/g COD/d and 0.47 l/g COD/d.

Index Terms— **COD reduction, kinetics, organic loading rate, POME, UAMAS,**

I. INTRODUCTION

Palm oil mill effluent (POME) waste is characterized by a high content of organic matter and pathogenic organisms. The disposal of POME without adequate treatment can cause a drastic effect on the environment and human health. Typically, 1.0 ton of crude palm oil production requires 5.0-7.5 tons of water, over 50.0 % of which ends up as POME. Moreover, POME is high in organic content (COD 50.0 g/l, BOD 25.0 g/l) and contains appreciable amounts of plant nutrients (Borja et al., 1996; Singh et al., 1999; Ahmad et al., 2005). If discharged, the untreated POME can cause considerable environmental problems. With the increasing demand for energy and cost-effective environmental protection technology, anaerobic digestion biotechnology has become the focus of worldwide attention (Singh et al., 1999). Moreover, anaerobic digestion can offers a positive effect on the environment because it combines waste stabilization with net fuel production and allows the effluent to be used as a fertilizer. POME consists of various suspended components. The POME nutrient content is too low for aerobic treatment processes but is sufficient for anaerobic processes (Chin et al., 1996). According to the most common characteristics of this waste, anaerobic digestion could be considered one of the most promising treatment alternatives (Kimchie et al., 1988; Hobson and Shaw, 1973; Hobson, 1974, 1981, 1992; Sanchez et al., 1995; Baader, 1990; Yang and Gan, 1998; Parkin and Owen, 1986). In anaerobic wastewater treatment, the loading rate plays an important role. In the case of nonattached biomass reactors, in which the hydraulic retention time is long, overloading results in biomass washout. This, in turn, leads to process failure. Fixed film, expanded and fluidized bed reactors can withstand higher organic loading rates. Even if there is a shock load resulting in failure, the system is rapidly restored to normal. In comparison to a Continuous stirred tank reactor (CSTR) system, fixed film and other attached biomass reactors are more stable. Moreover, a high degree of COD reduction is achieved even at high loading rates for a short hydraulic retention time. Several studies have used membrane anaerobic processes to treat a variety of wastewater sources (Fakhru'l et al., 1994; Nagano et al., 1992). Table 1 presents the recommended COD loading rates for various reactor configurations. The anaerobic fluidized bed appears to be able to withstand the maximum loading rate better than other high-rate reactors. The three widely used kinetic models considered in this study are shown in Table 2.This paper introduces a new technique, the ultrasonic-assisted membrane anaerobic system (UAMAS), for treating POME and producing a large amount of methane (no membrane fouling).In the paper, the kinetic parameters of the process are also determined, based on three known models: Monod (1949), Contois (1959) and Chen and Hashimoto (Chen et al., 1980).