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Integrated thermophilic submerged aerobic membrane bioreactor and electrochemical oxidation for pulp and paper effluent treatment – towards system closure

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ABSTRACT

A novel integrated thermophilic submerged aerobic membrane bioreactor (TSAMBR) and electrochemical oxidation (EO) technology was developed for thermomechanical pulping pressate treatment with the aim of system closure. The TSAMBR was able to achieve a chemical oxygen demand (COD) removal efficiency of 88.6 ± 1.9–92.3 ± 0.7% under the organic loading rate of 2.76 ± 0.13–3.98 ± 0.23 kgCOD/(m^3 d). An optimal hydraulic retention time (HRT) of 1.1 ± 0.1 d was identified for COD removal. Cake formation was identified as the dominant mechanism of membrane fouling. The EO of the TSAMBR permeate was performed using a $Ti/SnO_2–Sb_2O_5–IrO_2$ electrode. After 6-h EO, a complete decolourization was achieved and the COD removal efficiency was increased to 96.2 ± 1.2–98.2 ± 0.3%. The high-quality effluent produced by the TSAMBR-EO system can be reused as process water for system closure in pulp and paper mill.

1. Introduction

The pulp and paper industry is undergoing significant reforms in its processes and environmental practices in order to respond to more competitive markets and meet more stringent environmental regulations. The industry has been seeking promising technologies to conserve and reuse water with the aim of system closure (Judd and Jefferson, 2003). One appealing option is to reuse the wastewaters after effective in-mill treatment. Most of the waste streams in the pulp and paper industry, for instance, thermomechanical pulping pressate produced by crushing or grinding of the wood chips in the thermomechanical pulping processes, are high strength in chemical oxygen demand (COD) and high temperature (60–70 °C) in nature. For the treatment of pulp and paper effluents, thermophilic aerobic biological process (TABP) holds great promise (Lapara and Alleman, 1999).

The TABP harnesses the energy content (i.e. rich in organic matters and/or high temperature) in the wastewaters to facilitate the autothermal operation without the exogenous heat input and thus eliminates the pre-cooling for conventional biological treatment and the post-heating for subsequent reuse of the treated effluent. In addition, compared to the analogous mesophilic treatment, thermophilic treatment has the advantages of low sludge yield, high reaction rate, and excellent process stability (Lapara and Alleman, 1999). However, it is believed that the elevated operating temperature in the TABP usually leads to the deterioration of the sludge settle ability and thus raises the problem of biomass separation (Liao et al., 2011). The incorporation of membrane separation technology into the TABP to construct unique thermophilic submerged aerobic membrane bioreactors (TSAMBRs) may overcome this problem.

The TSAMBRs have been successfully used for the treatment of wastewaters from pulp and paper industry, food industry and landfill sites (Berube and Hall, 2000; Kurian et al., 2005; Visvanathan et al., 2007). All the findings demonstrated that TSAMBR could achieve high effluent quality, low sludge yield and good process stability.

Hydraulic retention time (HRT) is an important operation parameter for MBR systems. HRT correlates not only to the treatment efficiency of the MBR (Ren et al., 2005), but also to the sludge properties in the MBR (Meng et al., 2007; Fallah et al., 2010). For example, Ren et al. (2005) reported that the COD removal efficiency decreased with an increase in HRT in domestic sewage treatment. Moreover, Meng et al. (2007) found that MLSS concentration, extracellular polymeric substances (EPS) concentration and sludge viscosity increased significantly as HRT decreased in a mesophilic aerobic MBR. However, to the best of our knowledge, no investigation has been reported to date on the influence of HRT on the TSAMBR system.

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