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Benchmark study on algae harvesting with backwashable submerged flat panel membranes

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HIGHLIGHTS

- ▶ Membrane performance on algae harvesting and water polishing was examined.
- ▶ Backwashable membranes were compared to a commercial non-backwashable membrane.
- ▶ Influences on critical flux for backwashable and benchmark membranes were examined.
- ▶ Backwashing showed significant advantage compared to relaxation.
- ▶ Membranes combined with centrifugation uses less energy than centrifugation alone.

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ABSTRACT

The feasibility of algae harvesting with submerged flat panel membranes was investigated as pre-concentration step prior to centrifugation. Polishing of the supernatant coming from the centrifuge was evaluated as well. The effect of membrane polymer (polyvinyl chloride [PVC], polyethersulfone polyvinyl-pyrollidone [PES–PVP], poly vinylidene fluoride [PVDF]), pore size (microfiltration [MF], ultrafiltration [UF]), algae cell concentrations and species were investigated at lab-scale. In addition, backwashing as fouling control was compared to standard relaxation. PVDF was the superior polymer, and UF showed better fouling resistance. Backwashing outperformed relaxation in fouling control. The backwashable membranes allowed up to 300% higher fluxes compared to commercial flat panel benchmark (PVC) membranes. Estimations on energy consumption for membrane filtration followed by centrifugation revealed relatively low values of 0.169 kW h/kg of dry weight of algae compared to 0.5 kW h/kg for algae harvesting via classical centrifuge alone.

1. Introduction

Microalgae represent a vast potential of high value chemicals, such as poly unsaturated fatty acids, carotenoids, and pigments. They are currently considered as a strong and emerging market for feed and food as well as for renewable chemicals production (Grima et al., 2003; Dragone et al., 2010; Wolkers et al., 2011; Mata et al., 2010; Becker, 2007; Singh and Gu, 2010). Since each species of microalgae contains different amounts of compounds, a careful selection of the algae species is necessary. After cultivation the microalgae have to be harvested in an intact state. Several harvesting techniques are already commercially available such as centrifugation, flocculation, flotation, coarse filtration and sedimentation (Borowitzka, 2005; Grima et al., 2003; Spolaore et al., 2006). A novel technique for microalgae harvesting is the use of membrane filtration (Rossignol et al., 1999; Greenwell et al., 2010; Ladner et al., 2010). Grima et al. (2003) reported cross-flow microfiltration (MF) and ultrafiltration (UF) as possible alternative techniques for microalgae harvesting. Membrane filtration was suitable to completely remove debris and microalgal cells from the culture medium. The removal of debris and bacterial loads is considered advantageous towards water recycling. Using tangential cross flow filtration for the recovery of microalgae over a membrane with pore size of

Abbreviations: CFM, critical flux measurement; CF, critical flux; CWP, clean water permeability (l/m^2 h bar); DCW, dry cell weight of algae (g/l); E_W, estimated energy consumption based on dry weight of harvested biomass (kW h/kg); E_v, Estimated energy consumption based on biomass volume (kW h/m^3); MTC, mass transfer coefficient or permeability (l/m^2 h bar); PES–PVP, polyether sulfone polyvinylpyrrolidone; PVC, polyvinyl chloride; PVDF, polyvinylidene fluoride; TMP, trans-membrane pressure (bar); VCF, volume concentration factor.

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