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Microalgae cultivation in wastewater: Nutrient removal from anaerobic membrane bioreactor effluent

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HIGHLIGHTS

- A mixed microalgal culture is grown in anaerobically pretreated wastewater.
- Cultivation is in semi-continuous mode and biomass productivity is 234 $mg\,l^{-1}\,d^{-1}$.
- High nutrient removal rates are maintained for 42 days.
- The water quality of the effluent is excellent in terms of soluble inorganic N and P.

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ABSTRACT

This study investigated the removal of nitrogen and phosphorus from the effluent of a submerged anaerobic membrane bioreactor (SAnMBR) by means of a lab-scale photobioreactor in which algae biomass was cultured in a semi-continuous mode for a period of 42 days. Solids retention time was 2 days and a stable pH value in the system was maintained by adding CO_2. Nitrogen and phosphorus concentrations in the SAnMBR effluent fluctuated according to the operating performance of the bioreactor and the properties of its actual wastewater load. Despite these variations, the anaerobic effluent proved to be a suitable growth medium for microalgae (mean biomass productivity was 234 $mg\,l^{-1}\,d^{-1}$), achieving a nutrient removal efficiency of 67.2% for ammonium (NH_4^+–N) and 97.8% for phosphate (PO_4^{-3}–P). When conditions were optimum, excellent water quality with very low ammonium and phosphate concentrations was obtained.

1. Introduction

Urban and industrial wastewater must be treated before being discharged into the environment in order to prevent undesirable effects such as pollution and eutrophication. Anaerobic treatments have several advantages over more traditional aerobic systems i.e. they consume less energy and produce less sludge whilst generating biomethane (Ho and Sung, 2010). The combination of anaerobic wastewater treatment with membrane technology gave rise to anaerobic membrane bioreactors, the main advantage of which is the possibility of separating solids retention time (SRT) from hydraulic retention time (HRT), whilst reducing the footprint and achieving high quality effluent in terms of suspended solids. Pilot-scale submerged anaerobic membrane bioreactors (submerged AnMBR or SAnMBR) have been evaluated with promising COD removal rates (Giménez et al., 2011), but discharge into the aquatic environment or water reuse is not possible without further nitrogen and phosphorus removal (Stuckey, 2012). There is a clear need for research on post-treatments which allow the extended and full-scale use of AnMBR for domestic wastewater treatment (Smith et al., 2012). Possible traditional treatments such as biological nitrification–denitrification process or enhanced biological phosphorus removal are energy-intense. Partial nitritation/nitrification with Anammox bacteria has lately received increasing attention. However, there is still little literature available for low strength wastewaters, and we have not found any author describing AnMBR effluent treatment with Anammox bacteria. The present study is a novel approach to AnMBR effluent post-treatment using microalgae for nutrient removal and biomass generation. The generated biomass allows nutrient recovery and presents an added value for various industrial applications or energy recovery, as it is presented in this section.

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