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Evaluation of Osmotic Photobioreactor (OPBR) For the Removal of Nutrients from Anaerobic Digestion Effluents

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Extended Abstract

Anaerobic digestion effluent (ADE) is high in nutrients and contains excessive suspended solids and non-degradable carbon sources. Microalgae have been extensively studied for the ADE treatment due to their high growth rate, strong adaptability, and desirable nutrient degradation in the photobioreactor (PBR). It was reported that ADE can provide sufficient nutrients (nitrogen and phosphorous) that can be beneficial in the growth of microalgae. The nutrients within the ADE could be utilized to enhance the growth of microalgae, and the microalgae can be used for bioenergy production, which includes lipid and protein [1].

Several microalgae species including *Chlorella* sp. and *Scenedesmus* sp. have been considered as promising candidates for wastewater treatment due to their high nutrient removal efficiencies and tolerance to different wastewater conditions. However, harvesting and dewatering microalgae for bioenergy is energy intensive process, which accounts for about 20 – 30% of the operational cost. Therefore, it is necessary to develop a harvesting method that is less energy intensive [2].

Forward osmosis (FO) is a process driven by a naturally occurring osmotic pressure. It uses concentration difference between the draw solution (DS) and the feed solution as the driving force for water permeation, which means it doesn't require energy for hydraulic pressure to drive the process. However, the existence of DS is a problem, since it requires regeneration process, or use DS that can be directly applied. Use of fertilizer as the DS has been proven to be an effective way to maximize the potential of FO application [3].

In this study, an osmotic photobioreactor (OPBR) system, where FO process is integrated with the PBR in a side-stream configuration. Treated effluents from the PBR is re-concentrated by the FO process and was continuously recycled in order to sustain the cultivation of the *C. vulgaris* and improve the nutrient removal efficiency. Diammonium phosphate (DAP), one of the most commonly used fertilizer, was used as the DS, because its reverse solute flux could serve as the additional nutrient source.

The objective of this study is to determine the long-term efficiency of OPBR with DAP as the DS. Growth conditions of microalgae, such as light/dark (L/D) ratio and CO_2 concentration, for higher nutrient removal was determined. Microalgae growth with L/D ratios of 12:12, 16:8, and 24:0 were evaluated, with the highest growth rate occurring at 24:0, followed by 16:8 and 12:12. Although 24:0 had the highest growth rate, there was minimal difference in growth rates between 24:0 and 16:8, with the similar trends. Considering the energy efficiency, L/D ratio of 16:8 was chosen for further steps. Further, to optimize the CO_2 concentration, CO_2 concentrations of 3, 5, and 7% were tested. The growth rate was the highest at 7%, which is due to the higher amount of carbon sources that microalgae can consume for their growth. The integration of FO process with PBR allowed for its continuous operation, where the feed water containing microalgae was concentrated via FO process, for maintaining the concentration of nutrients within the PBR. We believe that OPBR process can help achieve carbon neutrality by consuming the CO_2 as the carbon source, while removing the excessive nutrients within the ADE.

References

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