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EVALUATION AND OPTIMIZATION OF PHOTOSYNTHETIC BIOGAS UPGRADING IN CLOSED PHOTOBIOREACTORS COMBINED WITH ALGAL BIOMASS PRODUCTION

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ABSTRACT

Photosynthetic biogas upgrading in microalgae photobioreactors constitutes a sustainable and environmentally friendly technology for the simultaneous removal of CO_2 and H_2S from raw biogas. The potential of algal-bacterial symbiosis for biogas purification has been already studied and demonstrated in open photobioreactors. However, few studies have focused on the implementation of this process in closed photobioreactors, which offer higher photosynthetic efficiencies, enhanced biomass productivities, a limited N_2 contamination and improved CO_2 mass transfer. In this study, the influence of alkalinity (inorganic carbon concentrations from ~200 to ~1700 mg L^{-1}), and nitrogen (N) deprivation strategies (24 or 48 h limitation) on both biomethane quality and biomass composition has been evaluated and optimized in a closed tubular photobioreactor (TPBR) interconnected to a mixing chamber and a biogas scrubbing column (total working volume of 132 L). The increase in the alkalinity of the cultivation broth mediated an increase in the upgrading performance of the TPBR, reaching CO_2 removals of 96.3±0.8%, and a complete H_2S abatement, resulting in an enhanced biomethane composition (CH_4= 97.2±0.9%). Moreover, process operation under N deprivation did not affect the quality of biomethane, which complied with standards required for injection into natural gas grids or use as vehicle fuel. N-deprivation promoted the continuous storage of intracellular carbohydrates (29.0±4.4% compared with 14.3±2.1% obtained under N excess). Maximum biomass productivity obtained was 15.8±4.3 g m^{-2} d^{-1} during N excess *vs.* 11.2±3.3 g m^{-2} d^{-1} during N-deprivation at 26.8 d of hydraulic retention time. During the N feast-famine cycles, the cyanobacterial species *Pseudanabaena* sp. was dominant over green algae.

Keywords: *algal-bacterial technology, alkalinity, biogas upgrading, biomethane, carbohydrates storage.*