Environmental Technology & Innovation 21 (2021) 101280

Contents lists available at ScienceDirect

Environmental Technology & Innovation

journal homepage: www.elsevier.com/locate/eti

Integration of bioelectricity generation from algal biophotovoltaic (BPV) devices with remediation of palm oil mill effluent (POME) as substrate for algal growth

Fong-Lee Ng [a], Siew-Moi Phang [a,b,*], Cheng-Han Thong [a,c], Vengadesh Periasamy [d], Jeccy Pindah [a], Kamran Yunus [e], Adrian C. Fisher [e]

[a] Institute of Ocean and Earth Sciences (IOES), University of Malaya, Kuala Lumpur, Malaysia
[b] Faculty of Applied Sciences, UCSI University, Kuala Lumpur, Malaysia
[c] Institute for Advanced Studies, University of Malaya, Kuala Lumpur, Malaysia
[d] Low Dimensional Materials Research Centre (LDMRC), Department of Physics, University of Malaya, Kuala Lumpur, Malaysia
[e] Department of Chemical Engineering and Biotechnology, University of Cambridge, Cambridge, United Kingdom

ARTICLE INFO

Article history:
Received 12 May 2020
Received in revised form 27 November 2020
Accepted 30 November 2020
Available online 3 December 2020

Keywords:
Algal-biophotovoltaic device
Bioelectricity
POME
Biotechnology
Bioremediation

ABSTRACT

The exploitation of renewable energy sources for delivering carbon neutral or carbon negative solutions has to be achieved through strategies involving the removal of CO_2 from the atmosphere. Agro-industries like palm oil processing are important sources of energy but are also generators of large volumes of wastewater, causing pollution problems. Bioremediation of these effluents utilizing microalgae has shown promising results. In the present study, we developed an algal-biophotovoltaic device to generate direct bioelectricity from photosynthesis while using palm oil mill effluent (POME) as substrate for microalgal growth. Nine microalgal strains from the University of Malaya Algae Culture Collection (UMACC) were cultured using POME in four different concentrations (50%, 25%, 10%, and 5%) for 12 days. *Chlorella vulgaris* Beijerinck UMACC 051 showed the highest specific growth rate (1.32 d^{-1}) and *Chlorella* UMACC 301 showed high photosynthetic performance (Alpha = 0.88) when grown in 5% POME–BBM medium. Three selected microalgal strains were grown in the control medium (Bold's Basal Medium) and 5% POME–BBM medium in an annular biophotovoltaic device. The maximum power density (0.45 mW m^{-2}) obtained from *Chlorella* UMACC 313 in the POME–BBM medium, was 15% higher than the power density generated when the microalgal cells were grown in the control medium (0.38 mW m^{-2}). When *Chlorella* UMACC 313 was cultured in a 4L round integrated fuel cell-photobioreactor prototype device, the maximum power density obtained was 0.28 mW m^{-2}. The reductions in NO_3-N, o-PO_4^{3-}, NH_3-N and COD were 54.92%, 29.41%, 80.75 and 60.09% respectively. A final biomass of 810 mg L^{-1} was obtained after 12 days' growth and the CO_2 fixation rate was 76.82 mgCO_2 L^{-1} d^{-1}. This BPV system represents a multi-functional system that generates low power density while providing wastewater bioremediation and carbon removal. This has potential as a sustainable environment-friendly carbon-neutral or carbon-reducing energy generation system.

* Corresponding author at: Institute of Ocean and Earth Sciences (IOES), University of Malaya, Kuala Lumpur, Malaysia.
E-mail address: phang@um.edu.my (S.-M. Phang).

https://doi.org/10.1016/j.eti.2020.101280
2352-1864/