UNIVERSITI TEKNOLOGI MARA

SCALE-UP OF MICROALGAE GROWTH FROM 1 L FLASK TO 60 L FED-BATCH RACEWAY POND (FRP) AND ITS GROWTH AT QUASI-STEADY STATE IN POME MEDIUM

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Microalgae cultivation system has been proposed to be incorporated into palm oil industry for simultaneous palm oil mill effluent (POME) bioremediation and CO_2 sequestration. In this context, raceway pond is the most suitable cultivation method to be used nevertheless its tendency to degas the supplied dissolved carbon dioxide (DCO_2) into the atmosphere. Accordingly, a 220 L Fed-batch Raceway Pond (FRP) was designed to address this problem where it embodies a variable-volume fed-batch culture [from 60 L (batch stage) to 220 L (fed-batch stage)], with a movable-semi-circular barrier for ensuring a constant liquid depth level, a movable vertical flow separator for flow circulation, a variable-speed paddlewheel for flow generation, and a membrane contactor for the carbonation of fresh growth medium. The first objective of this study include determining the growth kinetics of *Chlorella* sp. UKM2 in untreated POME medium at various CO_2 levels in 1 L flask in order to provide information valuable to the design and operation of the FRP. Secondly, this study attempts to scale-up microalgae growth from 1 L flask to 60 L FRP, and subsequently to demonstrate its growth at quasi-steady state in fed-batch stage of the FRP. In the first experimental part which involved *Chlorella* sp. UKM2 cultivation in 1 L flask showed that its maximum specific growth rate (μ_{max}) in untreated POME medium with 10,000 lux lighting has a maximum value of 1.18 d^{-1} at CO_2 level varied from 0.04–10% (v/v). Following that, the scale-up of *Chlorella* sp. UKM2 growth at 60 L FRP scale was attempted with Bold's basal Medium (BBM) through a stepwise experimental approach. However, the attempt failed and the problem areas were narrowed down to be related with variables mixing and inoculum, as identified through The Monitor Experiments, given the mixing in the FRP was not able to sustain *Chlorella* sp. UKM2 in suspension resulting in its sedimentation and collapsed, nonetheless that the said variables have been upgraded to reach their operational limits from 2,500 lux to 10,000 lux and from 4-bladed, fixed-speed, paddlewheel to 8-bladed, variable-speed paddlewheel, respectively. In the same operational conditions, scale-up was again conducted with *Scenedesmus* sp. UKM9, and appropriate growth with maximum biomass concentration (X_{max}) of 1.067 g/L and μ_{max} = 0.2842 d^{-1} was obtained, even though considerable difference against the 1 L flask scale cultivation was still observable in particular to its half reduction in its biomass productivity. Thereafter, *Scenedesmus* sp. UKM9 cultivations at fed-batch stage of the FRP were demonstrated using BBM and POME medium, where both cultivations reached quasi-steady state since their biomass concentration (X) remained fairly constant at 0.92 ± 0.04 g/L and 0.42 ± 0.036 g/L when dilution rate (D) was set at 0.0792 d^{-1} and 0.14 d^{-1}, respectively. The CO_2 recovery ($C_{recovery}$) for both cultivations was determined at 115.29% and 129.6% respectively, based on assumption that *Scenedesmus* sp. UKM9 in the culture conducted growth entirely by photosynthesis. The more than 100% recovery obtained in this study signifies that all the supplied DCO_2 had been captured in the quasi-steady state growth and incorporated into the biomass, and none degassed out from the liquid culture, with some CO_2 dissolved from the atmosphere too being captured and incorporated into biomass, bridging the recovery to higher than 100%.

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