# Analisis Hidrodinamika dan Life Cycle Assessment (LCA) terhadap Kultivasi Synechococcus HS-9 Menggunakan Rectangular Airlift Photobioreactor Using Baffles (RAPBR-Bs) untuk Memproduksi Biomassa sebagai Bahan Baku Biodiesel yang Ramah Lingkungan = Hydrodynamic Analysis and Life Cycle Assessment (LCA) of Cultivation of Synechococcus HS-9 Using Rectangular Airlift Photobioreactor Using Baffles (RAPBR-Bs) for Producing Biomass as Raw Material of Environmentally Friendly Biodiesel

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Abstrak

Pengembangan dan pemanfaatan bahan bakar cair alternatif seperti biodiesel dari mikroalga menjadi perhatian utama oleh banyak kalangan. Hal tersebut disebabkan oleh peningkatan kebutuhan bahan bakar minyak (BBM) disaat kondisi cadangan dan produksi minyak yang terus menyusut dan pemanfaatan BBM yang berdampak terhadap pemanasan global. Penelitian bertujuan untuk mengetahui produktivitas biomassa Synechococcus HS-9 sebagai kandidat bahan baku yang potensial untuk menghasilkan biodiesel, mengetahui pengaruh hidrodinamik terhadap proses pertumbuhan Synechococcus HS-9 selama proses kultivasi, proses optimasi mulitiobjektif untuk mendapatkan konsentrasi biomassa dan efisiensi energi yang optimal, serta mengetahui potensi dampak lingkungan melalui analisis LCA. Proses kultivasi Synechococcus HS-9 dilakukan menggunakan Rectangular Airlift Photobioreactor Using Baffles (RAPBR-Bs). Data gambar dan video gelembung di dalam RAPBR-Bs diambil dengan menggunakan high speed camera Fastec TS5 untuk keperluan analisis hidrodinamik. Optimasi multiobjektif dilakukan dengan menggunakan Artificial Neural Network (ANN) dan Multi-Objective Genetic Algorithms (MOGA). Analisis LCA menggunakan software LCA GABI versi 10.5.1.124 commercial license dan database Ecoinvent 3.7.1. Berdasarkan analisis data hasil eksperimen diperoleh hasil proses kultivasi Synechococcus HS-9 berupa biomassa kering sebesar 3,226 g dengan produktivitas biomassa 0,0117 mg/l/hari dan laju pertumbuhan sel sebesar 0,012 per hari. Parameter hidrodinamik seperti propertis gelembung, yaitu kecepatan gelembung, diameter gelembung, bilangan non dimensional, superficial gas velocity, bubble rise velocity, dan gas holdup, serta proses perpindahan massa yang terjadi di dalam RAPBR-Bs sangat berpengaruh dan meningkatkan proses pertumbuhan Synechococcus HS-9 selama proses kultivasi. Hasil optimasi menggunakan ANN-GA diperoleh nilai optimum target, yaitu konsentrasi biomaas (C)= 4,61x10-5 mg/ml dan efisiensi energi () = 0,043 %. Nilai target tersebut paling optimum pada nilai input T = 29,7 0C; I= 254,7 mol m-2s-1; pH = 8,6; CO2 = 83,4 ppm; ORP =149,1 mV; dan DO =6 mg/l. Analisis LCA yang dilakukan selama proses produksi biomassa Synechococcus HS-9 menunjukkan penggunaan listrik dan kompresor berkontribusi paling tinggi terhadap dampak lingkungan. Proses produksi biomassa kering Synechococcus HS-9 menyebabkan dampak terhadap lingkungan sebesar 8,38x10-9 Pt. Lima kategori dampak yang merasakan secara signifikan, yaitu Marine Aquatic Ecotoxicity Potential, Human Toxicity Potential, Freshwater Aquatic Ecotoxicity Pot, Abiotic Depletion, dan Global Warming Potential (GWP 100 years).

.....The development and utilization of alternative liquid fuels such as biodiesel from microalgae is a major

concern for many people. This is due to the increasing demand for fuel oil when the condition of oil reserves and production are shringking and the use of fuel oil has an impact on global warming. The aims of the study were to determine the biomass productivity of Synechococcus HS-9 as a potential raw material candidate to produce biodiesel, the effect of hydrodynamics on the growth process of Synechococcus HS-9 during the cultivation process, the multi-objective optimization process to obtain optimal biomass concentration and energy efficiency, and the LCA analysis. The cultivation of Synechococcus HS-9 was carried out in a Rectangular Airlift Photobioreactor with Baffle (RAPBR-Bs). For hydrodynamic analysis, image and video data of bubbles in the RAPBR-Bs were taken using a Fastec TS5 high speed camera. Artificial Neural Network (ANN) and Multi-Objective Genetic Algorithms (MOGA) were used for multi-objective optimization. LCA analysis was performed with the LCA GABI software version 10.5.1.124 commercial license and the Ecoinvent 3.7.1 database. Based on the analysis of experimental data, Synechococcus HS-9 cultivation process produced 3,226 g of dry biomass with a biomass productivity of 0,0117 mg/L/day and a cell growth rate of 0,012 per day. Hydrodynamic parameters such as bubble properties, such as bubble velocity, bubble diameter, non-dimensional number, superficial gas velocity, bubble rise velocity, and gas holdup, as well as mass transfer processes that occur in RAPBR-Bs, have a large influence on the growth of Synechococcus HS-9 during cultivation. Optimization results using ANN-GA obtained the optimum target value, namely biomass concentration (C) = 4,61x10-5 mg/ml and energy efficiency () = 0,043 %. The target value is the most optimum at the input value T = 29,7 0C; I= 254,7 mol m-2s-1; pH = 8,6; CO2 = 83,4 ppm; ORP = 149,1 mV; and DO = 6 mg/l. LCA analysis conducted during the Synechococcus HS-9 biomass production process showed that the use of electricity and compressors contributed the most to the environmental impact. The dry biomass production process of Synechococcus HS-9 causes an environmental impact of 8,38x10-9 Pt. Five categories of impacts that felt significantly, namely Marine Aquatic Ecotoxicity Pot, Human Toxicity Potential, Freshwater Aquatic Ecotoxicity Pot, Abiotic Depletion, and Global Warming Potential (GWP 100 years).