

Process Simulation-based Life Cycle Mass Flow Analysis for Fuel-grade Bioethanol Production from Water Hyacinth

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Abstract

Water hyacinth is an invasive aquatic weed that rapidly grows and spreads on eutrophic surface water bodies. The significant cellulose and hemicellulose contents along with the low lignin content in water hyacinth make it a potential feedstock for bioethanol production. In particular, the life cycle of bioethanol production from water hyacinth has no cultivation stage, thus free from agricultural operations with harmful environmental emissions as compared to other bioethanol feedstocks. To-date, laboratory-scale studies have been conducted to evaluate the performance of bioethanol production using water hyacinth. Still, comprehensive studies on scaled-up plants are required to assess the feasibility of commercial-scale implementations and the sustainability of bioethanol production using water hyacinth as the feedstock. Hence, this study focuses on evaluating the cradle-to-gate life cycle mass flows of a scaled-up bioethanol production plant using water hyacinth as the feedstock and analysing the mass flows in each process stage. The scaled-up bioethanol production plant was simulated using the Aspen Plus V10 process simulator based on experimental process parameters in the published literature. The mass flow analysis results show that water hyacinth contains 19.2% cellulose, 40.0% hemicellulose, and 4.8% lignin in dry basis after feedstock preparation and drying operations. During the alkali pre-treatment operation, 88% of cellulose has been converted to glucose, whereas 43% of hemicellulose has been converted to xylose and glucose. The yield of simultaneous saccharification and fermentation was reported to be 82% and bioethanol up to 99.7 vol% purity could be obtained after dehydration operation. Further, an overall bioethanol yield of 11.32 L/tonne of water hyacinth which corresponds to 0.17 kg of bioethanol/kg of water hyacinth (in dry basis) was obtained through the mass flow analysis in this study. These findings would support future life cycle assessments and decision-making in implementations of fuel-grade bioethanol production utilizing water hyacinth as the feedstock.

Keywords: *Life cycle assessment (LCA), mass flow analysis, bioethanol production, water hyacinth, process simulation*

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