LIFE CYCLE ASSESSMENT OF BIOETHANOL PRODUCTION FROM WATER HYACINTH USING PROCESS SIMULATION

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Declaration of the candidate and supervisors

Declaration of the candidate

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Declaration of the supervisor

The above candidate has carried out research for the Master's thesis under my supervision.

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Abstract

Water Hyacinth (WH) is an undesirable plant in the aquatic vegetation with a proven record of the possibility as a raw material to produce bioethanol. One of the advantages of using water hyacinth as a bioethanol feedstock is that it does not require land use or significant resource consumption for cultivation. The aim of this study was to evaluate the performance of water hyacinth as a bioethanol feedstock by modelling bioethanol production plant for future industrial purposes beyond labs-scale for different bioethanol production methods using the Aspen Plus software. By alternating two feedstock pretreatment methods (alkaline and dilute acid) and two bioethanol dehydration techniques (extractive and azeotropic distillation), four process scenarios were created (WH1, WH2, WH3, and WH4) for mass and energy flow comparison. Results showed that the alkaline pretreatment provided a 254 L/tonne-WH yield which is higher compared with the obtained by yield dilute acid pretreatment method (210 L/tonne-WH). Additionally, the process pathway that used NaOH for pretreatment and extractive distillation for the dehydration (WH1) resulted the least energy usage for the plant (45,310 MJ/FU). Based on these results, a comprehensive LCA was performed for bioethanol production from WH. The total energy consumption for the cradle-to-gate life cycle to produce bioethanol from WH is 56,202 MJ/FU. The study also evaluated energy sustainability indicators resulting 0.54 net ratio and a 1.87 renewability factor. Further, the study conducted a sensitivity analysis to interpret the effects of the key process parameters at two stages within the research project; first, for the bioethanol production process; second, for the life cycle. The prominent finding is that the parameter with the highest impact on the production plant and the life cycle is the solid loading ratio. Moreover, the energy hotspot was identified as the pretreatment stage. Finally, the study discussed feasible methods water hyacinth can be used for commercial production of fuel-grade bioethanol.

Keywords: Bioethanol Production, Feedstock Pretreatment, Life Cycle Assessment, Water Hyacinth, Process Simulation.

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List of symbols/abbreviations

Symbols/Abbreviations	Terms
2G	Second Generation
BE	Bioethanol
CO_2	Carbon Dioxide
EtOH	Ethanol
EU	European Union
FU	Function Unit
G	Glucose
GHG	Green House Gas
GWP	Global Warming Potential
H_2O	Water
H_2SO_4	Sulphuric Acid
LCA	Life Cycle Assessment
LCB	Lignocellulosic Biomass
NaOH	Sodium Hydroxide
NER	Net Energy Ratio
NEV	Net Energy Value
NRnEV	Net Renewable Energy Value
O_2	Oxygen
pH	Potential of Hydrogen
Rn	Renewability factor
SHCF	Separate Hydrolysis and Co-Fermentation
SSF	Simultaneous Saccharification and Fermentation
WH	Water Hyacinth
Wt%	Weight Percentage
X	Xylose