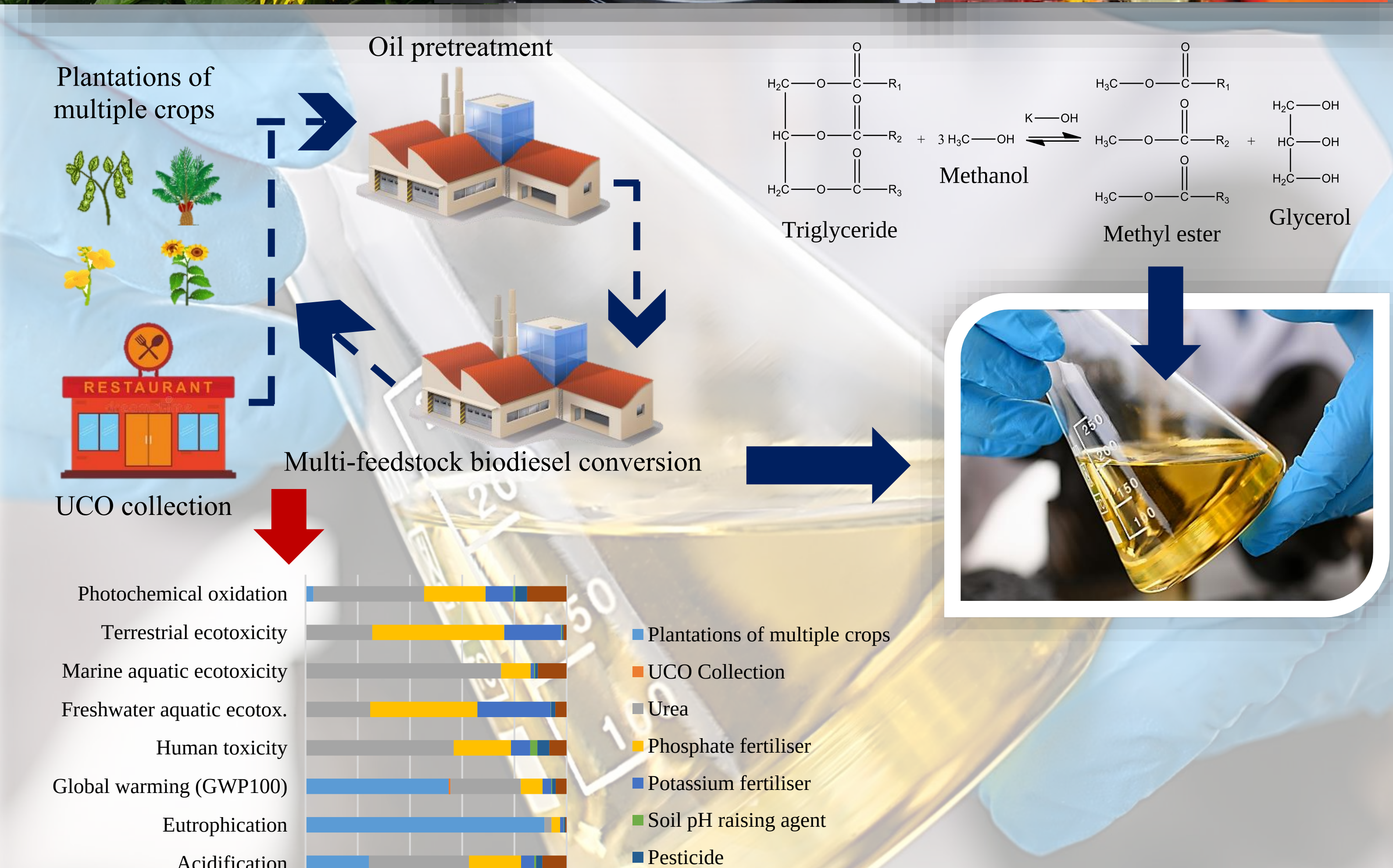
STUDY OF ENERGY AND ENVIRONMENTAL EFFECTS OF MULTI-FEEDSTOCK BIODIESEL PRODUCTION PROCESS



YOYON WAHYONO

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APPROVAL PAGE

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STUDY OF ENERGY AND ENVIRONMENTAL EFFECTS OF MULTI-FEEDSTOCK BIODIESEL PRODUCTION PROCESS

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Thesis

submitted in fulfillment of the requirements for
the degree of doctor at Diponegoro University

Yoyon Wahyono. (2022). Study of Energy and Environmental Effects of Multi-Feedstock Biodiesel Production Process

Ph.D Thesis Diponegoro University, Indonesia

With summary in English

ISBN: ……………………

Preface

Praise and thankfulness to Allah SWT for all mercies and blessings, which have enabled the author to finish his thesis with the title "study of energy and environmental effects of multi-feedstock biodiesel production process." The aim of this thesis is to meet one of the prerequisites for obtaining a Ph.D. degree in the Environmental Science Doctoral Program.

The author recognizes that there are still numerous flaws and that the thesis is far from ideal. The author anticipates constructive criticism and recommendations for improving the thesis. This thesis, hopefully, will be valuable for the advancement of research, particularly in the subject of environmental science.

Semarang, June 13, 2022

Yoyon Wahyono

Abstract

Effective biodiesel storage has proven to be an issue, with the Indonesian government investing billions of Indonesian rupiahs (IDR) to address it. As a result, it is critical to explore how different storage strategies impact the quality of biodiesel. As indicated by the findings of this study, the storage of biodiesel in a closed container at 22 °C in the dark may reduce biodiesel oxidation, particularly, the negligible development of ketone and aldehyde groups in the biodiesel oxidation process during storage, based on fourier transform infrared spectroscopy (FTIR) measurements. If not handled appropriately, the production of palm oil biodiesel in Indonesia has the potential to damage the environment. A life cycle assessment (LCA) research on the production of palm oil biodiesel was undertaken in this study to examine the environmental performance in Indonesia. The oil palm plantation processing unit contributed the most to the carbon footprint, human health damage, and ecosystem diversity damage, whereas the biodiesel production processing unit caused the most damage to resource availability. This study was carried out to produce biodiesel from a mixture of five different oils, including palm oil, used cooking oil, soybean oil, canola oil, and sunflower oil, using transesterification at varying oil:methanol mole ratios. According to the gas chromatography-mass spectrometry (GCMS) data, all mole variants had a methyl ester percentage of greater than 98 % area. For all variants, the FTIR analysis found peaks indicating the existence of a methyl ester functional group and its long-chain (–R). The methyl ester concentration, density, acid value, and total glycerol test parameters all satisfied ASTM D 6751, EN 14214, and SNI 7182–2015 quality requirements. The production of biodiesel from diverse feedstocks, which is now being done on a laboratory scale, has the potential to be scaled up to an industrial size in the future. As a result, research on the energy balance, environmental effect, and environmental damage of multi-feedstock biodiesel production is required. The energy balance study indicates that the biodiesel multi-feedstock plant is feasible to operate. The renewability of multi-feedstock biodiesel is 2.62 and that of palm oil biodiesel is 5.27. Multiple crop farming is more damaging to the environment than oil palm agriculture alone since it requires more fertiliser. The conversion of scrubland to various crop plantations (soybean, canola, sunflower, and oil palm) resulted in a contribution of 9.89 tCO_2 GHG emissions per tonne of biodiesel produced, but the conversion to exclusively oil palm plantation resulted in a value of -3.43 tCO_2. The cost of multi-feedstock biodiesel is 126 \$. The availability of resources for multi-feedstock biodiesel is more than that of palm oil biodiesel, which was 79.7 \$. Finally, using soybean, canola, and sunflower oil to produce multi-feedstock biodiesel is not advised since it has a larger environmental impact and a not as good energy balance than palm oil biodiesel.

Keywords: biodiesel; environmental impact; energy balance; environmental damage; life cycle assessment; multi-feedstock

Notations

GWP	Global warming potential
ODP	Ozone depletion potential
HCA	Human toxicological classification value for air
HCW	Human toxicological classification value for water
ECA	Aquatic ecotoxicity
POCP	Photochemical ozone generation potential
AP	Acidification potential
NP	Nitrification potential
mi	Amount of extracted resource
Mi	Reserves recoverable from that source
ρ	Density
m	Mass
v	Volume
RH	Fatty acids
$R\cdot$	Fatty acid radicals
O_2	Oxygen molecules
$ROO\cdot$	Unstable peroxide radicals
$ROOH$	Fatty acid hydroperoxide
H_2O	Water
CH_3OH	Methanol
$FAME$	Fatty acid methyl esters
As	Saponification value
Aa	Acid value
$Gttl$	Total glycerol
R'OH	Alcohol
FAAE	Fatty acid alkyl esters
CS_R	Carbon stock in previous land use (Reference land use)
CS_A	Carbon stock in plantations of multiple crops area converted from previous land use (Actual land use)
C_{VEG}	Carbon stock in above vegetation and below ground
SOC	Soil carbon stock
A	Land-use area for plantations of multiple crops
SOC_{ST}	Standard soil organic carbon in the 0-30 centimeter topsoil layer (measured as mass of carbon per hectare)
F_{LU}	Land use factor reflecting the difference in soil organic carbon associated with the type of land use compared to the standard soil organic carbon
F_{MG}	Management factor reflecting the difference in soil organic carbon associated with the principal management practice compared to the standard soil organic carbon

F_I	Input factor reflecting the difference in soil organic carbon associated with different levels of carbon input to soil compared to the standard soil organic carbon
H_2SO_4	Sulfuric acid
CaO	Calcium oxide
$CaSO_4$	Calcium sulfate
NaOH	Sodium hydroxide
Na_2SO_4	Sodium sulfate

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