POTENTIAL OF MARINE MICROALGAE IN WASTEWATER TREATMENT AND SIMULTANEOUS BIOFUEL FEEDSTOCK

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DECLARATION

This thesis is my original work and has not been presented for any award in any university.

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DEDICATION

I dedicate this work to all those who supported me through this academic journey. May Allah bless them abundantly.

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ABBREVIATIONS /ACRONYMS

ASTM	American Society for Testing and Materials
BOD	Biological oxygen demand
CG	Coast General
CO_2	Carbon dioxide
DA	Doa
FAMEs	Fatty acids methyl esters
FJ	Fort Jesus
GC-MS	Gas chromatography-Mass spectroscopy
MC	Makupa Creek
MK	Mkurumudzi
MP	Mapononi
MUFA	Mono unsaturated fatty acids
NB	Nyali Bridge
OD	Optical Density
TAGs	Triacylglycerols
WC	Western Creek

ABSTRACT

Rapid population growth, urbanization and industrialization have resulted in increased use of water, discharge of wastewater; massive use of fossil fuels and depletion of this energy source. Discharge of wastewater into the ocean introduces, high loads of degradable organic matter, suspended particulate matter and nutrients. In this study marine microalgae from a eutrophic environment were used to evaluate and demonstrate their potential in wastewater bioremediation and production of biodiesel. Nutrients analysis was done using a flow injection analyser, oil was extracted gravimetrically and biodiesel fatty acid composition was determined using a GC-MS instrument. The effects of physicochemical parameters on abundance and distribution of microalgae was determined in the study sites. Microalgae composition in Mombasa (Tudor and Makupa Creeks) comprised of 97 species while Gazi Bay, a relatively uncontaminated environment, had 79 species. 10 classes were recorded in the study sites namely *Bacillariophyceae, Dinophyceae, Cyanophyceae*, *Coscinodiscophyceae, Mediophyceae, Fragilariophyceae, Euglenophyceae, Chlorophyceae, Dictochophyceae* and *Zygnematophyceae*. The abundance of microalgae in Mombasa ranged from 905±112.5 to 26442±375 cells/L while in Gazi Bay it ranged from 942±50 to 14990±427 cells/L. The concentration levels of nutrients in the Mombasa sampling sites were higher compared to Gazi Bay. In Gazi Bay, the concentration of phosphates and nitrates ranged beween ranged between 0.19±0.01 to 0.35±0.07 µg/L and 0.22±0.01 to 0.36±0.1 µg/L respectively. In Mombasa concentration of phosphates and nitrates ranged beween 0.95±0.79 to 406.0±11.91 µg/L and 4.08±0.74 µg/L to 427.32±17.11 µg/L respectively. Microalgae from Tudor and Makupa Creek were co-cultured in wastewater in the laboratory so as to establish optimal conditions for effective removal of nitrates and phosphates, and production of biomass. The dominant genera of microalgae in the co-cultures were cyanobacteria (*Oscillatoria*), chlorophyte (*Chlorella*) and diatoms (*Entomoneis*). It was established that the co-cultures dominated by *Oscillatoria* thrived well in 20:80 wastewater:seawater (v/v), *Chlorella* in 40:60 wastewater:seawater (v/v) and *Entomoneis* had high biomass productivity at 20:80 wastewater:seawater (v/v). The pH range was between 7.83 to 8.34 for all cultures. Co-cultures containing *Oscillatoria* had the highest percentage decrease in the levels of phosphates with a 93.63% decrease after 14 days and corresponding decrease in nitrates of 92.70% by the 7th day. Co-cultures dominated by *Chlorella* had the highest ammonium removal within the first 7 days (84.67%). The Biomass productivity was highest in the co-cultures dominated by *Oscillatoria* (0.155±0.07 $gL^{-1}day^{-1}$) but was lowest for those dominated by *Entomoneis* (0.086±0.05 $gL^{-1}day^{-1}$). Co-cultures containing *Chlorella* had the highest oil content (55.7±2%), however, amount of oil extracted varied with method of extraction. The biodiesel produced from the microalgae biomass had a high percentage composition of palmitic acid (C16:0) (51.4-60%) and stearic acid (C18:0) (17.1-30%). These fatty acids were present in all

microalgae biodiesel samples, an indication of good biodiesel properties. Overall, biodiesel made from co-cultures containing *Oscillatoria* and *Entomoneis* had the best quality biodiesel in terms of high MUFA and saturated fatty acids, low levels of acid value and specific gravity. This study has established that marine microalgae are viable for the bioremediation of nutrients in wastewater and feedstock for production of biodiesel.

Key word: marine microalgae, wastewater treatment, biodiesel, nutrients bioremediation