

**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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TABLE OF CONTENTS

DECLARATION.....	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS.....	v
LIST OF FIGURES	xi
LIST OF TABLES	xv
ABBREVIATIONS /ACRONYMS	xvii
ABSTRACT	xviii
CHAPTER ONE.....	1
INTRODUCTION.....	1
1.1 Background Information.....	1
1.2 Statement of the Problem.....	5
1.3 Justification.....	5
1.4 Objectives	6
1.4.1 Main Objective.....	6
1.4.2 Specific Objectives.....	6
1.5 Research Questions.....	7
1.6 Scope of the Study.....	7
CHAPTER TWO.....	9
LITERATURE REVIEW	9

2.1	Microalgae Description and Occurrence	9
2.2	Environmental Conditions for Microalgae Growth.....	10
2.2.1	Nutrients.....	10
2.2.2	Light	11
2.2.3	Temperature.....	11
2.2.4	pH.....	11
2.2.5	Salinity	12
2.3	Wastewater Treatment	12
2.4	Microalgae in Wastewater Treatment	15
2.5	Harvesting of Microalgae from Wastewater	19
2.6	Sources of Biofuel.....	20
2.7	Biofuel from Microalgae.....	22
2.8	Lipid Quantification, Analysis and Conversion to Biodiesel	24
2.9	The Summary.....	26
CHAPTER THREE		28
MATERIALS AND METHODS.....		28
3.1	Description of the Study Area.....	28
3.3.1	Mombasa City.....	29
3.3.2	Gazi Bay.....	31

3.2	Sampling.....	32
3.2.1	Microalgae Samples	32
3.2.2	Sea Water Samples	33
3.2.3	Wastewater Samples and Culture Media	33
3.3	Analysis of Samples	34
3.3.1	Microalgae Identification.....	34
3.3.2	Analysis of Nutrients.....	34
3.3.2.1	Determination of Phosphates.....	35
3.3.2.2	Determination of Nitrates.....	35
3.3.2.3	Determination of Ammonium	35
3.3.3	Culturing of Microalgae.....	35
3.3.4	Nutrients Removal from Wastewater	38
3.3.5	Microalgae Growth Estimation.....	38
3.3.5.1	Dry Weight Method.....	38
3.3.5.2	Optical Density (OD).....	39
3.3.5.3	Microalgae Growth Rate.....	39
3.3.5.4	Biomass Productivity (Pr).....	39
3.3.6	Lipid Extraction.....	40

3.3.6.1	Organic Solvent Suspended Evaporation	41
3.3.6.2	Pellet Extraction Method	41
3.3.7	Physicochemical Properties Determination of Biodiesel.....	43
3.3.7.1	Fatty Acid Profile Determination	43
3.3.7.2	Refractive Index	44
3.3.7.3	Specific Gravity	44
3.3.7.4	Acid Value.....	44
3.3.7.5	Saponification Value.....	45
3.3.8	Data Analysis and Presentation	45
CHAPTER FOUR		47
RESULTS AND DISCUSSION		47
4.1	Microalgae Species Composition, Distribution and Abundance in Tudor, Makupa Creek and Gazi Bay	47
4.1.1	Microalgae Abundance and Distribution in Mombasa City.....	47
4.1.2	Microalgae Abundance and Distribution in Gazi Bay.....	56
4.1.3	Discussion of Microalgae Species Abundance and Diversity.....	63
4.2	Influence of Environmental Factors on Microalgae Abundance and Diversity	68
4.2.1	Physicochemical Properties of Water in Mombasa City	68

4.2.2	Physicochemical Properties of Water in Gazi Bay	74
4.2.3	Discussion of Influence of Environmental Factors on Microalgae Abundance and Diversity	81
4.3	Potential of Marine Microalgae Grown in Wastewater in the Removal of Nutrients and Production of Biomass.....	83
4.3.1	Dominant Microalgae Genus in the Wastewater Cultures	83
4.3.2	Nitrates and Phosphates Removal.....	84
4.3.3	pH and Temperature	91
4.3.4	Discussion of the Potential of Marine Microalgae Grown in Wastewater in the Removal of Nutrients and Production of Biomass.....	94
4.4	Production of Biofuel from Wastewater-Grown Microalgae.....	96
4.4.1	Phosphates Ammonium and Nitrate Removal from Wastewater	96
4.4.2	pH and Temperature Variation During the Culturing Period	99
4.4.3	Growth Rates and Biomass Production from Microalgae.....	102
4.4.4	Lipid Content.....	106
4.4.5	Properties of Microalgae Biodiesel	106
4.4.6	Discussion of Production of Biofuel from Wastewater-Grown Microalgae.....	118
CHAPTER FIVE.....		122

CONCLUSIONS AND RECOMMENDATIONS	122
5.1 Conclusions.....	122
5.2 Recommendations.....	123
REFERENCES	125

LIST OF FIGURES

Figure 2.1: The first, second and third generation biofuels, the production yields and cost of production (Rastogi <i>et al.</i> , 2018).....	21
Figure 2.2: Transesterification of triglyceride using an alkaline catalyst	26
Figure 3.1: Sewage disposal in Makupa Creek (MC), Nyali Bridge (NB), Fort Jesus (FJ) and Coast General (CG).	29
Figure 3.2: Map showing Mombasa sampling stations in Tudor Creek Fort Jesus, Coast General and Nyali Bridge and Makupa Creek.	30
Figure 3.3: Map of Gazi Bay showing sampling sites Mkurumudzi (MR), Doa (DA), Mapononi (MP), Western Creek (WC).....	31
Figure 3.4: Images showing the sampling activities	32
Figure 3.5: The sampling activities at Makupa Creek and Tudor Creek (Nyali Bridge (NB), Coast General (CG) and Fort Jesus (FJ)). Showing sewage and wastewater is disposal at the sea shore	33
Figure 3.6: Culturing of microalgae at room temperature in 12h:12h light: dark photoperiod in Walne's media.....	36
Figure 3.7: Batch experiments containing mixtures of wastewater and seawater in varying ratios, i.e., 0:100, 20:80, 40:60 and 60:40 v/v.....	37
Figure 3.8: Extraction of oil from <i>Oscillatoria</i> , <i>Entomoneis</i> and <i>Chlorella</i> biomass using organic solvent suspended extraction method.....	41
Figure 3.9: Extraction of oil from <i>Oscillatoria</i> , <i>Entomoneis</i> and <i>Chlorella</i> biomass using pellet extaction method	42

Figure 3.10: GC-MS settings during analysis	44
Figure 4.1: Total distribution of the top four classes documented in Mombasa in Makupa Creek (MC), Fort Jesus (FJ), Coast General (CG) and Nyali Bridge (NB). T-1, T-2, T-3 is sampling in November 2018, February 2019 and March 2021 respectively.....	48
Figure 4.2: Images of the most abundant microalgae species from Mombasa (Coast General, Makupa Creek, Fort Jesus and Nyali Bridge) as viewed using an inverted fluorescence microscope at x40 magnification	53
Figure 4.3: Species richness (S), diversity (H') and evenness (J') of microalgae community at Nyali Bridge (NB), Coast General (CG), Makupa Creek (MC) and Fort Jesus (FJ) in Mombasa. T-1, T-2, T-3 is sampling in November 2018, February 2019 and March 2021 respectively.....	55
Figure 4.4: Total distribution of the top four classes documented in Mombasa in Mapononi (MP). Doa (DA), Mkurumudzi (MK) and Western Creek (WC). T-1, T-2, T-3 is sampling in February 2019, July 2019 and October 2021 respectively.	56
Figure 4.5: Images of the most abundant microalgae species from Gazi bay as viewed under an inverted fluorescence microscope at x40 magnification	61
Figure 4.6: Species richness (S), diversity (H') and evenness (J') of microalgae community at Mapononi (MP), Doa (DA), Mkurumudzi (MK) and Western Creek (WC). T-1, T-2, T-3 is sampling in February 2019, July 2019 and October 2021 respectively.	63
Figure 4.7: Spatial and temporal variation of physicochemical parameters in Mombasa in February, March and November. A- Salinity, B- TDS, C- Temperature	68

Figure 4.8: Spatial and temporal variations of nitrates and phosphates in Mombasa City. A- Nitrates, B-Phosphates	71
Figure 4.9: Principal Component Analysis biplot graph showing variability and correlation in physico-chemical parameters in Mombasa City	73
Figure 4.10: Principal Component Analysis biplot showing the effect of physicochemical parameters on microalgae species in Mombasa City	74
Figure 4.11: Spatial and temporal variations of environmental parameters between the sites of Gazi Bay, Kenya. A- Salinity, B- TDS, C- Temperature.....	75
Figure 4.12: Spatial and temporal variations of nitrates and phosphates in Gazi Bay.....	77
Figure 4.13: Principal Component Analysis biplot graph showing variability and correlation in physico-chemical parameters from Gazi Bay	79
Figure 4.14: Principal Component Analysis biplot showing the effect of physicochemical parameters on microalgae species in Gazi Bay.	80
Figure 4.15: Images of the most abundant microalgae species <i>Oscillatoria</i> , <i>Entomoneis</i> and <i>Chlorella</i> from the experimental setups as viewed under microscope at 40x magnification	84
Figure 4.16: The percentage of nutrients (PO_4^{3-} and NO_3^-) extracted from the wastewater cultures	87
Figure 4.17: Microalgae growth in the different batch experiments using optical density (OD_{680}) for the culturing period.....	89
Figure 4.18: Biomass growth parameters for the different batch experiments at various percentages of wastewater concentration (0, 20, 40,60) for a period of seven days. A: Biomass growth rates, B: Biomass productivity.....	90

Figure 4.19: Change in pH (A) and temperature (B) of microalgae wastewater cultures with time in days	93
Figure 4.20: The concentration levels of phosphates (A), nitrates (B) and ammonium (C) in the microalgae cultures for 14 days of culturing period	98
Figure 4.21: Biomass of microalgae in the co-cultures dominated by <i>Oscillatoria</i> , <i>Entomoneis</i> and <i>Chlorella</i> . A: OD ₆₈₀ and B: Biomass in g/L.....	102
Figure 4.22: Growth of microalgae in 15,000 ml of wastewater in glass tanks.....	103
Figure 4.23: Biodiesel made from microalgae oil.....	107
Figure 4.24: The fatty acid composition of biodiesel produced from <i>Entomoneis</i> dominated cultures	108
Figure 4.25: GC-MS profile of biodiesel produced from <i>Oscillatoria</i> dominated cultures	109
Figure 4.26: GC-MS profile of biodiesel produced from <i>Chlorella</i> dominated culture	110

LIST OF TABLES

Table 4.1: Distribution of Microalgae species found in Makupa Creek, Nyali Bridge, Coast General and Fort Jesus in Mombasa.....	49
Table 4.2: Abundance (cells/L) of microalgae genus in Mombasa County, Kenya	54
Table 4.3: Distribution of Microalgae species found in Western Creek, Maapononi, Doa and Mkurumudzi in Gazi Bay.....	58
Table 4.4: Abundance (cells/l) of microalgae genus in Gazi Bay, Kwale County, Kenya	62
Table 4.5: The physicochemical parameters in Mombasa City	70
Table 4.6: Phosphates and nitrates concentration in Mombasa City sampling sites.....	72
Table 4.7: Physicochemical parametrs in Gazi Bay	76
Table 4.8: Phosphates and Nitrates in Gazi Bay	78
Table 4.9: The initial and final concentration amounts of Nitrates in the cultures in mg/L	85
Table 4.10: The initial and final concentration amounts of phosphates in the cultures in mg/L	85
Table 4.11: pH and Temperature values for seven days, (Mean±SD, N=7).....	91
Table 4.12: Removal efficiency of Phosphates, Nitrates and Ammonium by microalgae type.....	97
Table 4.13: Temperature variations in the <i>Oscillatoria</i> dominated co-cultures, <i>Entonomeis</i> dominated co-cultures and <i>Chlorella</i> dominated co-cultures	100
Table 4.14: pH variation in the <i>Oscillatoria</i> dominated co-cultures, <i>Entonomeis</i> dominated co-cultures and <i>Chlorella</i> dominated co-cultures.....	101

Table 4.15: Amount of biomass (g/L) and OD ₆₈₀ in the co-cultures containing <i>Oscillatoria</i> , <i>Entomoneis</i> and <i>Chlorella</i> for a period of 14 days.....	104
Table 4.16: Specific growth rates (μ) and biomass production for <i>Oscillatoria</i> , <i>Entomoneis</i> and <i>Chlorella</i> for a period of 14 days.....	105
Table 4.17: Oil content from microalgae biomass using method 1 (M1) and method 2 (M2)	106
Table 4.18: Physical and chemical properties of biodiesel made from <i>Chlorella</i> , <i>Oscillatoria</i> and <i>Entomoneis</i> dominated cultures	107
Table 4.19: Fatty acids methyl esters composition for biodiesel made from <i>Oscillatoria</i> dominated microalgae biodiesel.....	112
Table 4.20: Fatty acids methyl esters composition for biodiesel made from <i>Chlorella</i> microalgae dominated biodiesel.....	113
Table 4.21: Fatty acids methyl esters composition for biodiesel made from <i>Entomoneis</i> microalgae dominated biodiesel.....	114
Table 4.22: Structures of Fatty acids methyl esters identified from biodiesel made from dominant microalgae co-cultures	116

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*, *Coccolithophyceae*, *Mediophyceae*, *Fragilariophyceae*, *Euglenophyceae*, *Chlorophyceae*, *Dictyochophyceae* 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 between 0.19 ± 0.01 to 0.35 ± 0.07 $\mu\text{g/L}$ and 0.22 ± 0.01 to 0.36 ± 0.1 $\mu\text{g/L}$ respectively. In Mombasa concentration of phosphates and nitrates ranged between 0.95 ± 0.79 to 406.0 ± 11.91 $\mu\text{g/L}$ and 4.08 ± 0.74 $\mu\text{g/L}$ to 427.32 ± 17.11 $\mu\text{g/L}$ 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 $\text{gL}^{-1}\text{day}^{-1}$) but was lowest for those dominated by *Entomoneis* (0.086 ± 0.05 $\text{gL}^{-1}\text{day}^{-1}$). Co-cultures containing *Chlorella* had the highest oil content ($55.7 \pm 2\%$), 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

