

BUSITEMA UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY

**DEPARTMENT OF POLYMER, TEXTILE AND INDUSTRIAL
ENGINEERING**

FINAL YEAR PROJECT REPORT

**DEVELOPMENT OF MAGNETITE ZEOLITE NANOCOMPOSITE
FOR SUSTAINABLE CRUDE OIL SPILL REMEDIATION**

By

KOBUSINGE IRENE

MASTER OF SCIENCE IN MATERIAL ENGINEERING

**This Dissertation is submitted to the Directorate of Graduate Studies, Research and Innovations
in partial fulfillment of the requirement for the Award of the degree of Masters of Science in
Materials Engineering of Busitema University.**

OCTOBER 2025



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ABSTRACT

Oil spills pose a significant threat to both marine and freshwater ecosystems, affecting biodiversity, public health, and socio-economic stability. Uganda, poised to commence commercial oil production by 2026 through the Tilenga and Kingfisher projects with an estimated output of 6.5 million barrels per day, faces heightened risks of environmental contamination—particularly in ecologically sensitive areas such as the Albertine Graben. Traditional oil spill remediation methods often prove inefficient, recovering only a small fraction of spilled oil, thereby necessitating the development of more effective and sustainable alternatives.

This research investigated the effectiveness of magnetite-zeolite nanocomposites as an environmentally friendly, reusable adsorbent for crude oil spill remediation in Uganda. The nanocomposite was synthesized and characterized using several techniques, alongside adsorption isotherm studies. These analyses provided detailed insights into the material's surface morphology, structural integrity, chemical composition, and functional group interactions.

Batch adsorption experiments were conducted under varying operational conditions such as contact time, initial oil concentration, and adsorbent dosage (Eskandari et al., 2018) to evaluate the nanocomposite's performance in terms of adsorption capacity, removal efficiency. The Response Surface Methodology (RSM) was employed to statistically optimize the process parameters using Central Composite Design (CCD) in Design Expert software and graphs drawn with origin pro software.

The results demonstrated that the magnetite-zeolite nanocomposite exhibited high adsorption efficiency, magnetic recoverability, validating its potential for large-scale application in oil spill response strategies with 93% removal efficiency after Optimisation. This research contributes to the advancement of sustainable oil spill remediation technologies and aligns with Sustainable Development Goal 14 by offering an innovative and context-specific solution to Uganda's oil pollution challenges.

DECLARATION

I declare that this research work titled is original and has not been submitted to this university or any other institution before.

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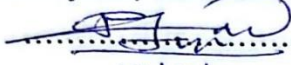
APPROVAL

This is to certify that the dissertation has been submitted for examination with the approval of the following Supervisors.

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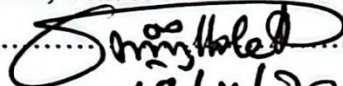
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DEDICATION

I wholeheartedly dedicate this work to my beloved parents, Mr. John Birungi and Mrs. Miriam Kisémbó, whose unwavering support, encouragement, and guidance have been the foundation of my academic journey.

I also dedicate this thesis to Dr. Apollo Ayebale, my dear siblings, lovely children and Mr. Joel Kiwanuka, whose spiritual, emotional, and financial support have been invaluable. Your belief in my ability to complete this research has been a source of strength and motivation throughout this endeavor.

May the good Lord Bless You Abundantly.

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TABLE OF CONTENTS

ABSTRACT	i
DECLARATION.....	ii
APPROVAL.....	iii
DEDICATION	iv
ACKNOWLEDGMENTS.....	v
TABLE OF CONTENTS	vi
LIST OF FIGURES	ix
LIST OF TABLES.....	x
LIST OF ABBREVIATIONS/ACRYNOMS	xi
1.0 CHAPTER ONE: INTRODUCTION.....	1
1.1 Background.....	1
1.2 Problem Statement.....	4
1.3 Objectives	5
1.3.1 Main Objective.....	5
1.3.2 Specific Objectives.....	6
1.4 Research Questions	6
1.5 Justification of the Study	6
1.6 Scope of Research	7
1.7 Conceptual Frame work of research.....	8
2 CHAPTER TWO: LITERATURE REVIEW.....	9
2.1 Challenges of Oil spill.....	9
2.2 Zeolite and their Composites.....	9
2.2.1 Types of Zeolites.....	9
2.2.2 Applications of Zeolites.....	10
2.3 Zeolite-Magnetite Nanoparticles.....	10
2.4 Synthesis and Characterization.....	10
2.5 Related studies.....	11
2.5.1 Advancements in modified nanoparticle zeolites for water treatment.....	12
2.6 Response Surface Methodology.....	13
2.7 Summary and Gaps in Literature Review	13
3 CHAPTER THREE: METHODOLOGY	15
3.1 Introduction.....	15

3.1.1 Research Design.....	15
3.1.2 Data Collection.....	15
3.1.3 Data Analysis	15
3.2 Materials	15
3.3 Preparation of the Zeolite Sample	16
3.4 Synthesis and Characterization of Magnetic Zeolite-Derived Nanoparticles (MZNPs)	17
3.4.1 Synthesis of MZNPs using Hydrothermal method	17
3.4.2 Calcination and Furnace Treatment of Magnetite-Zeolite Nanocomposite	17
3.5 Characterization	18
3.5.1 X-ray Diffraction (XRD)	18
3.5.2 X-ray Fluorescence (XRF) analysis.....	18
3.5.3 Scanning Electron Microscopy (SEM)	19
3.5.4 Fourier Transform Infrared Spectroscopy (FTIR)	19
3.6 Experiment Adsorption Studies.....	19
3.6.1 Preparation of Oil-Water Emulsion	19
3.6.2 Adsorption Experiment.....	19
3.6.3 Determination of Adsorption Capacity	20
3.6.4 Determination of Removal Efficiency	20
3.7 Design of Experiment.....	21
3.8 Model Development	22
3.9 Evaluation of the adsorption isotherms and kinetics	23
3.9.1 Adsorption Isotherms	23
4.0 Regression Analysis	24
4.0 CHAPTER FOUR: RESULTS AND DISCUSSIONS	25
4.1 Synthesis of Magnetite-Zeolite Nanocomposite	25
4.2 Physical and chemical Properties of Magnetite-Zeolite Nanocomposite	25
4.2.1 Wet Analysis of Zeolite Ore.....	25
4.2.2 Wet Analysis of Magnetite Zeolite Nano Composite.....	26
4.3 XRF Analysis	26
4.4 FTIR Analysis	28
4.5 XRD Results	30
4.6 Scanning Electron Microscopy Analysis	31
4.7 Adsorption Capacity.....	36
4.8 Experimental Design Optimization.....	36

4.9 ANOVA Analysis and Regression Model	38
4.10 Effect of Variables on Crude Oil Remediation	41
4.10.1 MZNP 1 Adsorption Capacity.....	41
4.10.2 Adsorption Capacity of MZNP 2.....	44
4.11 Predicted and Actual Graphs of the Adsorption	47
4.11 Process Optimisation	49
4.12 Isotherms under Adsorption.....	50
4.12.1 Isotherm model of Langmuir.....	50
4.12.2 Freundlich isotherm model.....	52
5.0 CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS	54
5.1 CONCLUSIONS.....	54
5.2 RECOMMENDATIONS	55
REFERENCES.....	56
APPENDICES.....	63
A.1 Introductory letter.....	63
A.2 Budget for the Research.....	64
A.3 Photos taken in the Laboratory	65

LIST OF FIGURES

Figure 1.1: Oil Spillage by major oil spill accidents (1970-2017).....	1
Figure 1.2: (a) Drilling Rig (b) Crude oil Pipeline at the HDD in the Tilenga Project.....	5
Figure 1.3: Conceptual Frame Work of the research	8
Figure 3.1: Preparation of Zeolite Powder	16
Figure 3.2: Magnetite-Zeolite Nanocomposite (MZNPs) Preparation	18
Figure 3.3: Use of Magnetic Shaker during Experimentation	20
Figure 4.1: Magnetite-Zeolite Nanocomposite.....	25
Figure 4.5: FTIR results for MZNP of the Nanocomposite.....	29
Figure 4.6: Results obtained from XRD for MZNP.....	31
Figure 4.7: SEM MZNP 10 micron results of the Nanocomposite	32
Figure 4.8: SEM MZNP 20 and 50 micron results of the Nanocomposite	34
Figure 4.9: SEM MZNP 100 and 200 micron results of the Nanocomposite.....	35
Figure 4.10: Three-dimensional plots (a) showing relationship of Concentration of Oil and dosage of the adsorbent	42
Figure 4.11: Three-dimensional plots (b) showing the relationship of Concentration of oil and Adsorbent Dose	42
Figure 4.12: Three-dimensional plots (c) showing the relationship of Concentration of oil and Contact Time	43
Figure 4. 13: Three-dimensional plots (A) to (G) showing the interaction effect of the parameters	47
Figure 4. 14: Predicted Vs Actual Removal Efficiency Plot of MZNP 1	48
Figure 4. 15: Predicted and Actual Removal Efficiency Plot of MZNP 2.....	49
Figure 4. 16: Plot of Residual Oil Concentration C_e against Equilibrium Adsorption Capacity q_e	51
Figure 4. 17: Plot of versus Residual Oil Concentration C_e against Equilibrium Adsorption Capacity q_e	52
Figure A.1: Grinding Machine at Tororo Cement Limited Laboratory	66
Figure A.2: Mosimeter for Moisture Analysis	66
Figure A.3: Pellets for Grinding.....	67
Figure A.4: XRF Equipment in the Laboratory	67

LIST OF TABLES

Table 3.1: The parameters and levels for oil spill removal using CCD	21
Table 4.1: Wet Analysis of Zeolite Ore	26
Table 4.2: Wet Analysis of Magnetite-Zeolite Nano Composite Sample.....	26
Table 4.3: Composition of Zeolite as analysed by XRF Technique.....	27
Table 4.4: The results for composition of Magnetite-Zeolite Nano Composite as analysed by XRF Technique.....	27
Table 4.5: Factors used in the CCD Experimental Runs	37
Table 4.6: Levels of Variables and Experimental Results from CCD Run.....	37
Table 4.7: Results of MZNP under Analysis of Variance (ANOVA).....	38
Table 4.8: Quadratic Model Response Summary of MZNP 1.....	40
Table 4.9: Maximum Parameters of Crude Oil spill Remediation	50
Table A.1: Expenditure Budget during research	64

LIST OF ABBREVIATIONS/ACRYNOMS

MZNP:	Magnetite-zeolite nanocomposites
Fe₃O₄:	Magnetite nanoparticles
q:	Amount of oil adsorbed per unit mass of MZN
q_e:	Equilibrium adsorption capacity
k:	Adsorption rate constant
R₂:	Correlation coefficient
COD:	Chemical oxygen demand
BOD:	Biological oxygen demand
NTU:	Nephelometric turbidity unit
S:	Salinity
XRD:	X-ray diffraction
SEM:	Scanning electron microscopy
TEM:	Transmission electron microscopy
BET:	Brunauer-Emmett-Teller
FTIR:	Fourier-transform infrared spectroscopy
XPS:	X-ray photoelectron spectroscopy
RSM:	Response surface methodology
SDG:	Sustainable Development Goal
NEMA:	National Environment Management Authority
C:	mg/l
q, q_e:	mg/g
k:	mg/g/min
HDD:	Horizontal Directional Drilling

KEYWORDS: Magnetite–zeolite nanocomposite; oil spill remediation; adsorption; Response Surface Methodology.

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