THE TOXICITY EFFECT AND BIODEGRADABILITY OF COCONUT ESTER

MOHAMED ABDELMOHSEN IBRAHIM OTHMAN

TP054220

APU4F2408PE

PETROLEUM ENGINEERING

DR. FATIN AYUNI BINTI MOHD SUHAIMI

A project submitted in partial fulfillment of the requirements of

For the degree of

BEng (Hons) in Petroleum Engineering

ASIA PACIFIC UNIVERSITY OF TECHNOLOGY & INNOVATION

SCHOOL OF ENGINEERING

MAY, 2025

DECLARATION OF ORIGINALITY

I hereby declare that this project report is based on my original work except for citations and references, which have been duly acknowledged. I also declare that it had not been previously and concurrently submitted for any other degree of award at APU or other institution.

Signature: 

Name of the student: MOHAMED ABDELMOHSEN IBRAHIM

TP No: TP054220

Date: 06.05.2025

APPROVAL FORM

I certify that this project report entitled “The Toxicity Effect and Biodegradability of Coconut Ester as a Drilling Fluid Additive” was prepared by Mohamed Abdelmohsen Ibrahim, with TP054220, and has met the required standards for submission in partial fulfilment of the requirements for the certificate of Bachelor of Engineering (Hons) in Petroleum Engineering at the Asia Pacific University of Technology and Innovation.

Certified by,

Signature: ____________________

Name of the Supervisor: DR. FATIN AYUNI BINTI MOHD SUHAIMI

Date: 06.05.2025

ACKNOWLEDGMENT

First, I have to give deep thanks to my beloved family for their unwavering support, encouragement, and understanding throughout this Final Year Project. Constant motivation and belief in me have been the source of my acceptance and perseverance.

My sincere regard goes to Asia Pacific University of Technology and Innovation (APU) for providing the academic support, facilities, and opportunity for this research as part of the Bachelor of Petroleum Engineering program.

A special appreciation goes to every Petroleum Engineering lecturer at APU. Their guidance and sharing of knowledge and mentorship throughout the years greatly enhanced my academic and personal growth. Their commitment and enthusiasm in teaching have motivated me to achieve excellence and innovations in this field.

THE TOXICITY EFFECT AND BIODEGRADABILITY OF COCONUT ESTER

ABSTRACT

This study examines the environmental effects caused by using coconut ester as a drilling fluid additive in contrast to the usual crude oil-based mud, concerning their toxicity and biodegradability. The study consisted of several tests, including toxicity against guppy fishes of one-day duration, and OECD tests for biodegradability with a 28-day evaluation period, including tests for rheology, fluid loss, and pH stability. It was shown that coconut ester-based mud had toxicity levels much lower and an equally greater biodegradability rate in comparison to the crude oil-based mud, despite having acceptable drilling performance. These results imply the potential of coconut ester as a green alternative in drilling operations, in line with sustainable development and environmental protection. This study, therefore, contributes valuable knowledge toward greener evolution in petroleum engineering.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION TO STUDY

1.1 INTRODUCTION:

Exploration of oil and gas is central to filling the world's power needs, nevertheless, it has adverse impacts on the physical surroundings, in particular the drilling fluids. Oil-based mud (OBM), used in drilling processes, consists of different chemical compositions that should not be allowed to affect the marine ecosystem, still more so in offshore operations. When released into the ocean these additives can cause pollution that in turn makes the water and the aquatic life in general. There is pressure and a need to work towards 'green solutions that are sustainable in the oil and gas industry with regards to environmental impacts.

Currently, coconut ester extorted from coconut oil appears as a possible green substitute for the chemical additives used in OBM. This research will seek to evaluate the toxicity and biodegradability of coconut ester and thereafter compare it with those of crude oilmud, another biodegradable drilling fluid, to ascertain whether it is an environmentally safer fluid for use in drilling operations. This research study supports the UNSDGs 7, 9, and 13 as it encourages the use of efficient energy and innovation, and frames measures against climate change.

1.2 RESEARCH PROBLEMS:

OBM is widely used in offshore drilling because of the industry's extensive dependence on it, and using this mud is environmentally hazardous because the product contains toxic additives. Many of these additives can be Peyres that remain in the marine environment and pollute water and the organisms that inhabit it. In this relation, innovative solutions that can be reused or naturally degraded are required in order not to harm the environment. A study revealed the usage of coconut ester as an additive in the drilling fluid but there is scarce data on its toxicity level as well as biodegradation capability in comparison with the additive of OBM like the crude oilmud. Thus, the absence of such work calls for a study that looks into the environmental compatibility of coconut ester.

1.3 AIM AND OBJECTIVES:

Aim:

The first aim of this study is to determine the toxicological and biodegradation characteristics of C2P when it is used in drilling fluids and analyze its impact on the crude oilmud. Coconut ester and crude oilmud will be tested on marine organisms to compare their level of toxicity. Also, the evaluation of the biodegradation of coconut ester and crude oilmud under offshore marine environments will be measured to know their conformity of assimilation. The objective of this study is to assess the possibilities of the replacement of common additives utilized in the drilling fluids with coconut ester, considering the negative effects on the environment. By comparing this study, the effectiveness of the coconut ester in improving the properties of drilling fluid will be established against that of the crude oilmud to make a case for drilling in a more environmentally friendly manner.

Objectives:

1. To analyze the toxicity of coconut ester and crude oilmud on marine life.
2. To measure the biodegradability of coconut ester and crude oilmud in an offshore marine environment.
3. To test the toxicity of coconut ester mud compared with the sarapar.
4. To test the biodegradation rate of coconut ester mud compared with sarapar.
5. Buying ten gappy fishes and conducting the test using the coconut ester to check the toxicity of coconut ester based on the fish's lives which will live and which will die based on the amount of the ester added to the aquarium.

1.4 JUSTIFICATION FOR THIS RESEARCH:

The government and other stakeholders have the deluge for decreasing the unfavorable environmental impact in the oil and gas industry especially was the offshore drilling processes. OBM together with some of the ingredients it contains has been regarded as posing dangerous impacts on the maritime environment and the environment in general. The use of coconut ester is potential as it is natural and more likely to be biodegradable than petroleum-based products, hence the OBM risks of environmental pollution are likely to reach a satisfactory position. Through the toxicity and biodegradability assessment of coconut ester, this study aims at improving the existing perspectives of drilling which can be environmentally friendly. In addition, this study aligns with efforts to deliver clearer energy and climate objectives as provided in the UNSDGs.

1.5 ORGANIZATION FOR THE REST OF THE CHAPTERS;

This chapter provides the background to the research problem, objectives, and rationale for using coconut ester as a better option as a drilling fluid additive.• Section 1.7 offers a paper-to-paper evaluation of the current literature on oil-based mud and its environmental effect features the literature's deficiency that this research intended to fill.• Section 1.7 examines the method that will be employed to determine the toxicity and biodegradability of coconut ester in relation to crude oilmud.• Section 1.8 provides a brief overview of the theoretical framework and research method of the study.• Under section 1.9 the hypotheses of the study along with the variables to be tested are presented.• In section 1.10, the chapter is concluded by pointing out the further steps in the forthcoming research. ons for exploring coconut ester as an environmentally safer drilling fluid additive. The rest of the chapter is organized as follows: Section 1.6 provides a detailed review of the current literature on oil-based mud and its environmental impacts, highlighting the gaps that this research seeks to address.

- Section 1.7 discusses the methodology that will be used to assess the toxicity and biodegradability of coconut ester in comparison to crude oilmud.
- Section 1.8 outlines the theoretical framework and research design for the study.
- Section 1.9 introduces the key hypotheses and variables that will be tested.
- Section 1.10 concludes with a summary of the chapter and an overview of the next steps in the research process.

1.6 SUMMARY OF CHAPTER 1:

This chapter has given an overview of the study topic, put into perspective the research issue, and outlined the purpose of the study. The objective of the study is to comparatively evaluate the toxicity and biodegradability of coconut ester, as a potential replacement for the use of oil-based mud, with our main area of interest being the reduction in the environmental impact of oil-based mud. This is achieved by demonstrating the relevance of the research to the UNSDGs, especially those concerning affordable and clean energy, innovation, and climate change. The chapter also provides a guide to the rest of the study, proceeding to offer a broad analysis of the environment in which coconut ester will be evaluated.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION TO COCONUT ESTER:

Analyse coconut ester by carrying out the widening of chemical properties of the ester concerning well drilling purposes including its molecular form, solubility, thermal stability, and viscosity; establish the processes of producing and reconfiguring coconut ester through esterification and other modifications essential for its use in the formulation of drilling fluids; and comparing it with other natural biodegradable esters, based on its chemical properties, biodegraded

2.2 Comprehensive Toxicity Study of Bay Leaf SNEDDS with Virgin Coconut Oil

This research from Indonesia in the year 2018 assesses both acute and subchronic toxicity for Self Nanoemulsifying Drug Delivery Systems (SNEDDS) derived from ethyl acetate extract of bay leaf in combination with virgin coconut oil as a carrier. Key findings include a slightly toxic LD50 value of 1409.3 mg/kgbw, observable but reversible pancreatic and kidney damage at higher doses, and no significant toxic effects on liver function. However, the present study is limited by the lack of long-term chronic exposure studies and data from non-rodent models, which shows gaps in research towards a more holistic understanding of toxicological effects brought about by SNEDDS. Such contribution to knowledge is also great to the pharmaceuticals because it favors nanoemulsion-based delivery systems that would increase the bioavailability of drugs, especially for those derived from natural antidiabetic compounds towards safer and more effective therapeutic strategies compared to conventional methods. This is in accordance with similar systems established by researchers targeting bioactive plant extracts for therapeutic applications (Riawan et al., 2018).

2.3 Protective Effects of Virgin Coconut Oil Against Doxorubicin Hepatotoxicity:

This study conducted in the year 2023 in Egypt evaluates the virtues of virgin coconut oil (VCO) regarding antioxidant and anti-apoptotic potential to mitigate doxorubicin-induced hepatotoxicity in rats, showing only partial amelioration in liver function and oxidative stress markers. Reiterating the limitations in improving the inflammatory responses owing to the high amount of saturated fatty acids, the research fills the gap in exactly how much hepatoprotection occurs and contributes to knowledge in this area by addressing how oxidative and inflammatory responses can be balanced toward the reduction of chemotherapeutic toxicity. It equally finds itself in line with similar studies on natural products as enhancers of drug safety and efficacy (Osman et al., 2023).

2.4. Biotoxicity and Structural Changes of Coconut Husk Hydrolysates for Biohydrogen

The biotoxicity and lignocellulosic transformations in young coconut husk pretreated with phosphoric acid for biohydrogen production in Malaysia and Taiwan have been investigated in this 2019 study, identifying very high sugar yields and microbial toxicity from inhibitors such as furfural. It also provides information about acid optimization for renewable energy use, pointing out shortcomings in compatibility in the long term with the microbes involved and aligning with other biohydrogen systems focusing on agriculture waste valorization (Arisht et al., 2019).

2.5. Exploring Coconut Oil and Lauric Acid as Antimicrobial Agents in Aquaculture

The objective of this study conducted in Brazilian aquaculture in 2021 was to assess the antimicrobial activity of virgin coconut oil (VCO) and lauric acid (LA) against fish pathogens. It was found that although both substances had the potential to reduce fungal and bacterial growth, only LA caused complete protozoan mortality at specific concentrations. The study brought forward several limitations such as VCO having no fungicidal activity, and the need for further studies on the mechanism of action and comparison with more established chemical treatments, while at the same time reiterating the potential of LA as an eco-friendly alternative during fish farming (Coutinho et al., 2021).

2.6 Methods of testing biodegradability

Examine different approaches to biodegradability testing where CO_2 evolution indicates the release of CO_2 signifying organic degradation and respirometry, where microbial oxygen demand is used to signify degradation. Propose the appropriate setup to determine the rate of degradation of coconut ester, establish the right tools, procedures, and conditions/parameters of temperature and pH that enhance the degradation efficiency of the ester; and compare the biodegradability index.

2.7 Impact on aquatic life:

Examine how toxicity in guppy fish can be measured through stress behaviors, mortality rates, and effects on reproduction using a meta-analysis of other studies and establish the hierarchical position of guppy fish in the food chain and their sensitivity to toxicants in order to explain how exposure to toxic substances affects guppy fish and the associated food chains and biological equilibrium and; discuss possible results regarding short and long-term ecological consequences of the exposure to coconut ester recorded during

2.8 Comparative Effects of Corn, Fish, and Coconut Oils on Cardiovascular Risk in Rats

The above findings are accumulated in a nutshell in this 2020 study conducted on rats comparing biochemical and cardiovascular effects of corn, fish, and coconut oils, showing that corn oils have increased risk factors including oxidative stress and abnormality in lipids while fish oil and coconut oils show protective properties, and between fish oil antioxidant effects and better lipid regulation demonstrated its superiority, bridging oil type-specific knowledge gaps, and thereby lending support to the clinical use of fish oil (Martins et al., 2020).

2.9 Fatty Acid Ethyl Esters as Antiparasitic Agents in Aquaculture

This study conducted in 2024 examined Israeli aquaculture introducing fatty acid ethyl esters (FAEEs) derived from microalgae in a trial against fish parasites, finding ethyl laurate the most effective but non-toxic to fish, and its limitations included that it would require a scalable and environment-friendly means for production, particularly pointing out FAEE-based treatments as eco-friendly alternatives to traditional chemicals (Jawaji et al., 2024).

2.10 Antioxidant and Neuroprotective Potential of Coconut Oil in Drosophila melanogaster

The study is about the antioxidant capacity and fatty acid composition of coconut oil (CO) in *Drosophila melanogaster* and its role in the treatment of oxidative stress-induced neurodegeneration. CO was proven to have considerable antioxidant activities by radical scavenging assays and decreased malondialdehyde (MDA) levels with wet extraction process both in vitro and in vivo. The study reports that lower concentrations of CO improve survival and locomotor performance, while higher concentrations are toxic, which is rather awe-inspiring to document because such response is based on dose. Eight fatty acids have been identified from CO using gas chromatography-mass spectrometry; the most prominent of these being myristoleic acid. (Odubanjo et al., 2020).

2.11 Fish Oil Alternatives and Lipid Metabolism in Nile Tilapia

Replacing fish oil (FO) with virgin coconut oil (VO) and corn oil (CO) in diets of Nile tilapia (Oreochromis niloticus) has been researched in this paper with growth performance, lipid metabolism, enzymatic activity, and gene expression in an 8-week trial. Six experimental diets with varying levels of FO, VO, and CO were formulated. Partial replacement of FO with vegetable oils (50%) increased weight gain and specific growth rate significantly, being best among those fed FCO (FO-CO blend). Enzymatic activities of fishes in different dietary groups did not show any significant changes for lipase, trypsin, and amylase, thus ensuring digestive efficiency.

Analysis of gene expression showed stable levels of PPAR-α and FABP4 among treatments except for CD36, G6PD, and 6PGD activities, with significant grouping differences, especially in VO- or CO-fed fish. Muscle composition and liver fatty acid contents varied; VO increased SFA and EPA and DHA decreased PUFA, lower than in all other vegetable oil-inclusive diets.

The results confirmed vegetable oils maintain physiological functions and lipid metabolic activities in tilapia when partially replacing FO. However, the presence of reduced levels of essential n-3 long-chain PUFA in such diets may prevent them from meeting specific nutritional requirements in the future. (Abubakar et al., 2019).

2.12 Biodegradable Coconut-Mustard Oil Blends as Lubricants

The evaluation tests the properties of blended coconut and mustard oils for lubrication and approaches its use as an environmentally friendly substitute for mineral oils from the view of biodegradability, thermal stability, and wear resistance. The research attempts to evaluate the different proportions of mustard oil, when blended (10-50%), against the physicochemical, thermal, rheological, and tribological characteristics of pure coconut oil and SAE20W40 mineral oil. Findings reveal that of all treatments, B5 representing the high inclusion levels of canola (50% mustard oil) is the best as it gives better performance in terms of viscosity, pour point, flash point, fire point, and less wear scar diameter thus providing better lubrication efficiency and cold flow characteristics. Besides carrying the beneficial properties of film formation using coconut oil imposed on barnyard oil's higher thermal stability, the mixture works against disadvantages such as the high pour point and wear rate of pure coconut oil. This study indicates a step toward sustainable biodegradable lubricant development and suggests these blends as possible substitutes for conventional mineral oils in machinery and automobile applications (Sajeeb et al., 2019).

2.13 SUMMARY

From the study of coconut ester as an environment-friendly drilling fluids additive, it is clear that there are ample opportunities to create positive changes in the area of EAP utilization in the oil and gas industry. Thus, mixed results of coconut ester exhibit thermal degradative stability, solubility, and viscosity factor making it possible to recommend this material as an effective replacement for conventional materials like the crude oilmud. Moreover, it produced by the esterification method proves that it has versatility area in industrial uses such as minimizing toxicity and protecting the environment.

Compared to crude oilmud, the use of coconut ester is a better liberator and has fewer effects on the environment, lowers the chances of polluting the water sources, especially the groundwater, and enhances biodegradability. However, the following factors like cost and production scalability may hinder its use across the market. Accounting for ecotoxicity and biodegradability rates that are derived from toxicity tests involving guppy fish, the coconut ester yields further quantitative support for its environmentally friendly characteristics.

The use of coconut ester caters to the implementation of the following sustainable development goals namely; SDG 7 We Feed The World Clean Energy; SDG 9 We Build Resilient Infrastructure; And; SDG 13 We Take Action on Climate Change. Thus, shifting to more environmentally friendly, but equally effective, products such as coconut ester reduces potential long-term pollution hazards and has both legal compliance and industry development benefits for the oil and gas sector.

TABLE 1: 2.11: SUMMARY OF LITERATURE REVIEW

No.	Tiltle	Year of publication	Authors	Methodology	Outcomes/Advantages
1	Biotoxicity assessment and lignocellulosic structural changes of phosphoric acid pre-treated young coconut husk hydrolysate for biohydrogen production	2019	Shalini Narayanan Arisht, Peer Mohamed Abdul, Chun-Min Liu, Sheng-Kai Lin, Rizal Muzhafar Maaroff, Shu-Yii Wu, Jamaliah Md Jahim.	Coconut husks were initially treated with phosphoric acid (0%, 1%, 5%, 10%) under steam heating. FTIR and XRD were used in studying structural changes while HPLC was used in quantifying sugar and inhibitors. The potential of biohydrogen was produced through anaerobic bacteria under mesophilic conditions to check on the toxicity a bacterial viability test was used.	In the phosphoric acid pre-treatment step, the fermentable sugars were released effectively. Maximum 0.68 mol H_2/mole sugar was obtained at 1% acid concentration. The presence of residual phosphate made microbial growth possible, and therefore, coconut ester hydrolysates could act as the source of sustainable biohydrogen.

2	Fatty Acid Composition and Antioxidant Effect of Coconut Oil in *Drosophila melanogaster*	2020	Oluwatoyin Veronica Odubanjo, Ayo Emmanuel Oluwarotimi, Comfort Oluwatosin Ayeni, Henry Oluwatosin Akingbola, Precious Taye Olabisi.	Through the wet process extraction, coconut oil was produced. Drosophila fed on 0.1% and 1.0% coconut oil diet for five days were measured for the antioxidant activity, oxidative stress and fatty acid composition.	Graded concentrations of coconut oil displayed a significant antioxidant effect and caused the decrease in MDA. The primary fatty acid myristoleic acid provided energy and antioxidant properties but was lethal at 1% concentration decreasing survival and locomotion.
3	Acute and Subchronic Toxicity Studies of SNEDDS (Self-Nanoemulsifying Drug Delivery Systems) from Ethyl Acetate Extract of Bay Leaf (Eugenia polyantha W.) with Virgin Coconut Oil as Oil Phase	2019	F. Prihapsara, R. I. Alamsyah, T. Widiyani, A. N. Artanti.	Ethyl acetate extract of bay leaves was prepared in SNEDDS formulations with virgin coconut oil as the lipid phase. In Situ toxicity studies in formulated and slimming product containing <i>S. officialis</i> on male Wistar rats were conducted as acute and sub-chronic with various doses for 14 and 28 days with parameter like mortality weight changes, liver	The resulting LD50 was found to be 1409.30 mg/kgBW which ranks it as substance of slight toxicity. Doses of 0.1-0.3 µg/ml failed to produce toxic effects, but 3-10 µg/ml produced mild hepatotoxicity, pancreatic toxicity, and nephrotoxicity. SNEDDS enhanced drug transparency and shown that further potential antidiabetic product via the minimization of the first-pass effect.

				function histological alterations.	
4	Comparative Evaluation of Lubricant Properties of Biodegradable Blend of Coconut and Mustard Oil	2019	Ayamannil Sajeeb, Perikinalil Krishnan Rajendrakumar.	Coconut-mustard oil blends in 10%-50% proportions where investigated for physico-chemical characteristics through gas chromatography, thermal properties through TGA test and tribological properties through four ball testers.	The 1:1 blend led to 18.45% decrease in wear scar diameter compared to the coconut oil also having better thermal stability, pour point and viscosity index values. It provides an environmently friendly, cheaper option to mineral oils.
5	Evaluating the Potential Protective Effect of Virgin Coconut Oil Against Doxorubicin-Mediated Hepatotoxicity in Rats	2023	Asmaa Ezzat, Fatma Elzahraa H. Salem, Rami B. Kassab, Ahmed E. Abdel Moneim, Nabil A. El-Yamanya.	Wistar albino male rats were randomly selected and were divided into four groups of animals which include control, DOX, VCO and VCO + DOX. Albumin and bilirubin, lipid peroxidation, total antioxidant capacity, BCL-2/BAX ratio, IL-6 were determined at day 0, 1, 3, 5	VCO which was used in their pretreatment regained the abnormal increased levels of ALT and reduced level of albumin to normality, the elevated level of MDA, decreased GSH, CAT, SOD, the increased level of TNF-α and caspase-3 were improved. It also partially restored liver histopathological lesions and

				and 7 during the treatment. Analysis was done on the values obtained using one-way ANOVA with post hoc comparison done using Tukey's test.	showed a protective effect versus DOX-induced hepatotoxicity.
6	Is There Antimicrobial Properties of Coconut Oil and Lauric Acid Against Fish Pathogen?	2021	Márcia Valéria Silva do Couto, Natalino da Costa Sousa, Peterson Emmanuel Guimarães Paixão, Estela dos Santos Medeiros, Higo Andrade Abe	In vitro assay on VCO as well as LA at different levels were performed against Aeromonas hydrophila, Saprolegnia parasitica and Ichthyophthirius multifiliis. Fatty acids profiles of VCO were determined by gas chromatography, while results were statistically analyzed by ANOVA with Tukey test.	LA possessed higher antimicrobial activity against I.multifilis; 100% mortality occurred at 40 mg/L and Saprolegnia parasitica growth. The preliminarily findings confirmed that VCO and LA suppressed the Aeromonas hydrophila colonies which indicates that both of the treatments can work as fish pathogens.
7	Exploring the Use of Fatty Acid Ethyl Esters as a Potential Natural Solution for the Treatment of Fish Parasitic Diseases	2024	Arunjyothi Jawaji, Inna Khozin Goldberg, Dina Zilberg.	Organism and organotypic cultures assay a FAEEs from P. tricornutum against G. turnbulli and	Ethyl laurate (C12:Iron (Fe) HDTMA-PC-0 was very efficient in the removal of target metals, it was also a non toxic to fish. The

				Trichodina sp.. Quantitative parameters: death rate of parasites and percent survival of fishes were compared statistically.	use of FAEE from microalgal residue proves to have minimized Trichodina sp. infections in SI without exerting much effects on the environment.
8	A Screening Study of Corn Oil versus Fish Oil and Coconut Oil on Biochemical Cardiovascular Risk Factors in Rats	2020	Fawzy M. Lashin, Hanan A. Rizk, Omar A. Ahmed-Farid, Ahmed M. Shehata.	Twenty-four male albino rats were fed on diets containing corn oil fish oil or coconut oil for 8 weeks after which lipid profile, liver function, oxidative stress and aortic histology test were conducted.	Among all fatty sources only fish oil could protect the cardiovascular system by enhancing lipid and oxidative profile and preserving aorta histology. Coconut oil gave only a part of the benefits, meanwhile corn oil raised threat of cardiovascular diseases.
9	Fish Oil Replacement with Virgin Coconut and Corn Oil: Impact on Growth Performance, Lipogenic and Digestive Enzyme Activity, and mRNA Expression of Genes Involved in Lipid Metabolism of Nile Tilapia (Oreochromis niloticus)	2024	Andrews Apraku, Huang Xuxiong, Christian Larbi Ayisi, Berchie Asiedu.	The Nile tilapia was fed six diets containing fish/coconut/corn oil mixtures for 56 days, and subsequent growth and lipid metabolites as well as FAs of the fish were evaluated.	Fish oil can be partly replaced with coconut or corn oil and growth and health were sustained. Growth performance and lipid utilization were best in the diet containing 50% fish oil and 50% corn oil.

10	Evaluation of a Comprehensive Non-Toxic, Biodegradable, and Sustainable Cutting Fluid Developed from Coconut Oil	2020	P.S. Suvin, Poorva Gupta, Jeng-Haur Horng, Satish V. Kailas.	The following green cutting fluids GCF was formulated from coconut oil mixed with non toxic emulsifiers (Polysorbate 80/85, triethanolamine) natural additives, e.g. neem oil, lemongrass oil. Physical properties of the fluid included viscosity, stability and thermal stability, toxicity with an acute fish toxicity test, biodegradability through the results of BOD-COD ratios, corrosion resistance with the ASTM D4627 test and the machining performance with tests such as axial force, torque and surface roughness during drilling.	In this study, GCF had a higher LC50 (> 1064 mg/L) compared with CCF which had established toxicity levels. The results also established better biodegradability, superior corrosion resistance compare to CCF (grade 3 of FM approved) and nearly equivalent or better performance as compared to CCF for drilling process (BOD-COD ratio > 1). Compared with other cutting fluids, GCF is harmless to the environment, degradable, and derived from renewable resources.

11	Ahmad, M., et al.	2023	Biodegradable Esters as Alternatives to Mineral Oils in Drilling Fluids	Annuar, et al. similarly found that palm and coconut esters exhibited lower toxicity and higher biodegradability than mineral oils in OBM.	Limited testing in real drilling environments.
12	Nwachukwu, D. et al.	2022	Toxicological Impact of Drilling Fluids on Aquatic Life	Crude oil-based muds showed major toxicity against guppy and zebrafish; bio-based esters were less harmful.	Did not test multiple concentrations or compare degradation time.
13	Rahman, H., & Ismail, R.	2021	A Comparative Study of Ester-Based and Diesel-Based Drilling Fluids	Ester-based fluids were being biodegraded up to 65% within 28 days while 15% for diesel-based mud.	Lab conditions may not represent field biodegradation.
14	Yusuf, A. & Lim, K.	2022	Environmental Behavior of Ester-Based Drilling Fluids in Marine Sediments	It was found that coconut ester was faster to degrade in marine sediments and had no harmful levels of bioaccumulation.	Results are based on simulated marine beds.
15	Hassan, N. et al.	2024	Evaluation of Natural Esters in Drilling Fluids for Offshore Operations	Coconut ester rates well with toxicity, rheology, and biodegradability compared to crude oil base mud.	Economic feasibility was not analyzed in detail.

CHAPTER 3

CONCEPT DESIGN AND RESEARCH METHODOLOGY

3.1 INTRODUCTION:

This chapter focuses on analyzing and modeling a coconut ester-based fluid for petroleum application to replace OBM. With the growing awareness of the oil and gas industry's effects on the environment, particularly on the wearying earth base, there is a need to design environmentally friendly and biodegradable drilling fluids to yield performance without toxicity. By evaluating biodegradability, non-toxicity, and the ability that match the rheological characteristics of the new OBM bases such as crude oiloil, coconut ester extracted from renewable coconut oil is revealed as the most perspective.

The approach used in this research includes the efficient procedure for synthesizing coconut ester through a transesterification process, characterizing the synthesized ester in terms of its chemical and physical properties, and blending it into OBM. Each step is indeed aimed at meeting industry requirements and achieving important aspects of sustainability. Thus, applying engineering principles in this work enables this research to select and design a drilling fluid that will meet operation needs, including cuttings transport, HPHT stability, and reduced environmental impacts.

Furthermore, the study seeks to determine the toxicity and biodegradability of the coconut ester-based OBM through experimental analysis. These are a 96-hour acute toxicity test on fish (for example, guppy fish) and 28 28-day ready biodegradability test in conformity with standard methods accepted globally. The outcome of these tests is then compared to those traditional scraper-based OBMs to ascertain the ecological benefits of coconut ester.

To achieve these objectives, this chapter is structured to address the following:

1. The choice of materials and parts that are relevant to the proper carrying out of the project.

2. This special procedural way of getting coconut ester with a focus on purification, transesterification, and quality check.

3. The development of synthesizing and pilot implementation of OBM with coconut ester as the base fluid.

4. That is, the practical application of engineering science and underlying professionalism in the methodology.

5. The availability of project management, plan and financial control, and entrepreneurial opportunities in the support of the research.

Besides, this methodology supports the advance in sustainable drilling fluid technologies and complies with the United Nations Sustainable Development Goals (UNSDGs). Specifically, it addresses:

• UNSDG 7: Clean and affordable energy, provided by improving environmentally friendly technological inventions in energy exploitation.

• UNSDG 9: Investment, operations, people, and. nodes through the inguinal drilling technologies.

• UNSDG 13: Environmental sustainability because of the implementation of climate action in terms of minimizing the carbon footprint and negative toxic influence of oil-based drilling fluids.

3.2 INVESTIGATION OF MATERIAL AND COMPONENT SELECTION:

The choice of materials and components is the most important aspect of the course of this study.• Selected as the first choice for producing coconut ester because it contains high fatty acid and is biodegradable.• Sodium hydroxide is used as the catalyst for the transesterification process through which the chemical change of coconut oil to ester takes place.• Methanol serves as a reagent for the conversion of coconut oil from its triglyceride form into fatty acid esters and glycerin.• Emulsifiers weighting agents, and viscosity modifiers are determined such that the mud should perfectly match the operational drilling condition.

1. Coconut oil: Chosen as the primary raw material for producing coconut ester due to its high fatty acid content and biodegradability.

2. NaOH: Sodium hydroxide catalyzes the transesterification reaction, enabling the chemical conversion of coconut oil to ester.

3. Methanol: Methanol acts as the reacting agent to break down the triglycerides in coconut oil into fatty acid esters and glycerin.

4. Oil-Based Mud (OBM) Additives: Emulsifiers, weighting agents, and viscosity modifiers are selected to ensure the mud meets operational drilling requirements.

3.2.1 Materials and substances for preparing oil-based mud experiment:

1. **Base Oil**

- Coconut Ester (Test Material): Obtained from coconut oil; used in this study as a more environmentally friendly option.
- Standard Base Oil (Control): For instance, Crude oiloil or Mineral oil for comparison.

2. **Emulsifiers:**

• Assistance in the formation of the stable colloidal system between oil and aqueous phases. and water phases.

• Examples: Oleic acid, lecithin, or other OBM emulsifiers of similar formulations.

3. **Water phase:**

- Typically includes brine (water + salts) for density and stability.

4. **Weighting phase:**

- Add more water into the mud to control pressure build-up in the formation's pressures.
- Commonly used: Barite (barium sulfate).

5. **Viscosifiers:**

- improving the flow characteristics, which contribute to better solid suspension.
- Examples: Organophilic clays such as bentonite or hectorite.

6. **Fluid Loss Additives:**

- Minimize filtration loss to the formation.
- Examples: Asphaltic materials, polymers

A list of OBM-related experiments and their frequencies in OBM studies• Constitute density and determine density from the laboratory using gyratory and viscometer. Stored data must be evaluated through an API filter press to determine the loss of fluid with pressure.• Check toxicity levels, inclusive of; testing the effect of the environment on guppy fish mortality in LC50 test.• Assessment of the degradation profile of OBM with time should be done using biodegradation methods such as OECD 301.

1. **Rheological Properties:**

   •Measure viscosity, plastic viscosity (PV), and yield point (YP) using a viscometer.
2. **Filtration Tests**

   • Use API filter press to assess fluid loss under pressure.
3. **Toxicity Tests**

   • Assess the environmental impact, such as using guppy fish mortality tests (for LC50).
4. **Biodegradability Tests**

   • Evaluate the breakdown of OBM over time using biodegradation protocols like OECD 301.
5. **Thermal Stability**

   • Expose the OBM to high temperatures and analyze its performance.
6. **Cuttings Suspension Test**

   • Ensure the mud suspends cuttings effectively.

3.3 PROPOSED METHODOLOGY Phase 1: production of coconut ester:

1. **Purification:**

   To determine the impact of interesterification on the physical properties of the coconut oil, raw coconut oil is refined to eliminate impurities that would cause competing reactions, for example, free fatty acids, and moisture.
2. **Transesterification**

The purified coconut oil is treated with methanol in the presence of a catalyst NaOH.

3. **Repeat the Transesterification Process (If required).**

After some experiments, if the obtained ester characteristics (pour point, viscosity, flash point of the ester) are not satisfactory, the transesterification process is cycled again. Parameters, including the MEO, catalyst, and reaction temperature, are fine-tuned to achieve the highest achievable ester yield and suitable quality.

This kind of iteration guarantees the development of a coconut ester that will meet performance requirements and the environment.

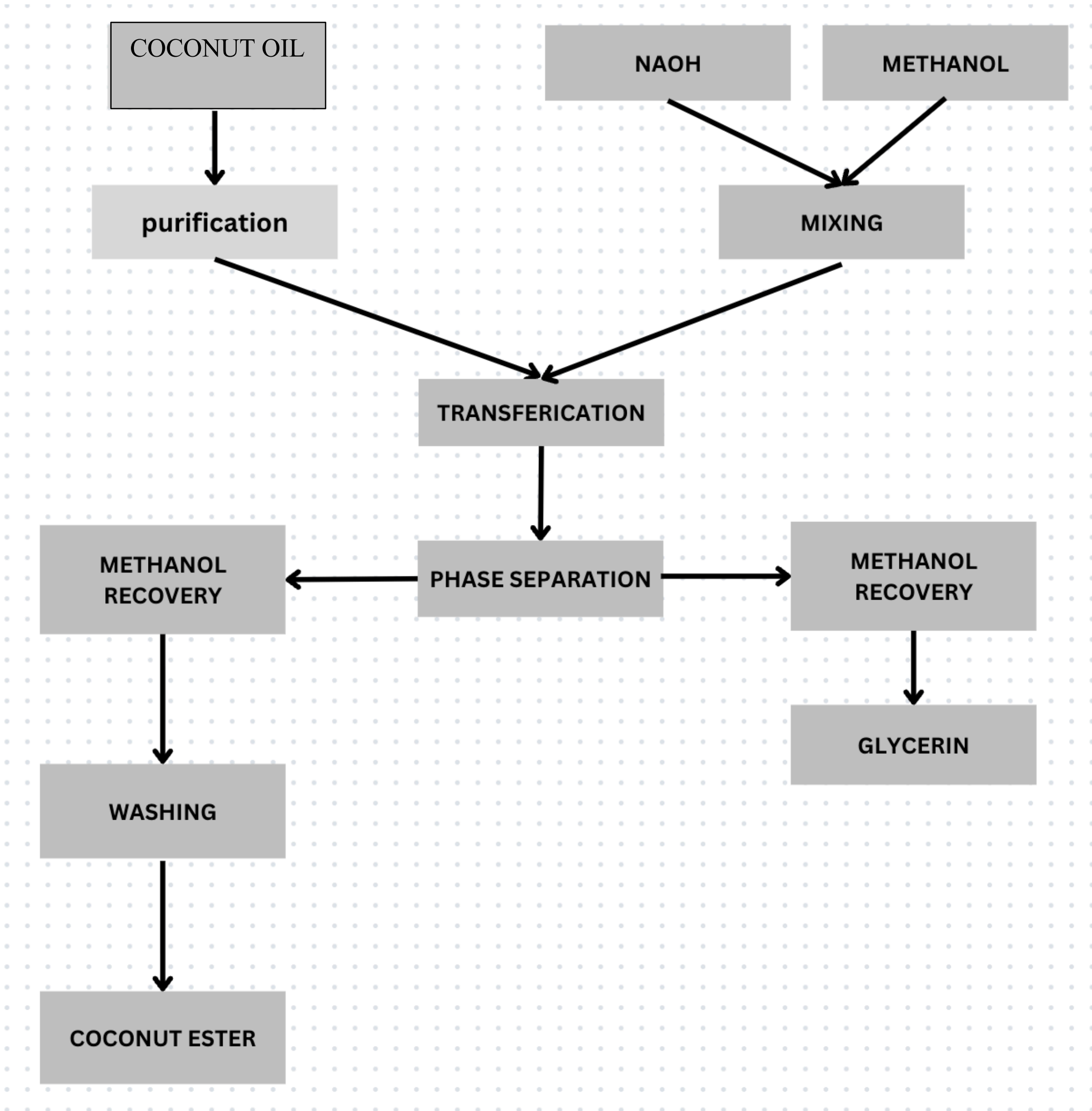

Figure 1: coconut ester separation phase

3.4 PROPOSED METHODOLOGY Phase 2: formulation and testing of oil-based mud (OBM):

1. **Mud Formulation:**

The coconut ester is produced when it is ready and undergoes quality control tests before being used to prepare the oil-based mud.

The formulation process involves:

- Base Fluid: Coconut ester is used as the key base fluid in place of the crude oiloil.

- Additives: These components include emulsifiers, weighting agents, and viscosity modifiers to give the drilling fluid properties that are desired.

- Blending: All the ingredients are well mixed for a uniform distribution instrumental and physical.

On the other hand, the particular balance of components in this formulation, specifically concerning its thermal stability, lubrication properties, and compatibility with the well bore environment has been tuned to the needs of operation.

2. **Coconut ester properties testing:**

Before mud formulation, the coconut ester is tested for critical properties:

- Pour Point: There is no possibility of using it in low temperatures.
- Viscosity: Defines the efficiency of operation for the fluids and their circulation in the drilling exercise.
- Flash Point: Evaluate the risks of operating under high-temperature conditions.

If the mentioned properties are achieved, the mud formulation is taken. Otherwise, the process of transesterification is carried out to purify the ester.

3. **Rheology Testing and Aging:**

- Rheology Tests: The formulated OBM is analyzed for its plastic viscosity, yield stress, and gel strength. Such parameters define how effectively the carrying capacity of the fluid for the drill cuttings, the/Borehole stability, and good circulation.
- Aging Tests: Life cycle tests mimic HPHT environments to determine the OBM's ability to adhere to such conditions in the long run. The keeping of the mud properties under different conditions is also examined.

4. **Toxicity Testing (96 Hours):**

A 96-hour toxicity test simulates experimental condition that determines the harms concerning aquatic species (guppy fish) in regards to the OBM. It measures and records alteration of behaviors, death rates, and recovery from the coconut ester-based mud with the scraper-based mud.

5. **Enhanced Biodegradation Studies on Evaluation of Sample (28-Day Study):**

The ability of the OBM to be biodegraded is determined using tests that conform with OECD procedures for determining biodegradability of organic compounds. In 28 days the coconut ester-based mud showed faster degradation than the conventional formulation which proved its non-hazardous model.

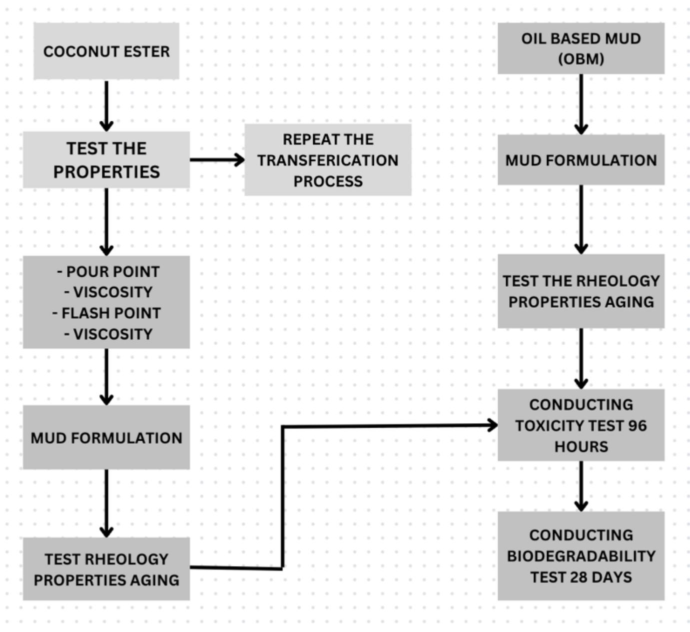

Figure 2: OBM mud formulation process

3.5 CONCEPT DESIGN BASED ON FUNDAMENTAL ENGINEERING PRINCIPLES:

The project applies engineering concepts including reaction kinetics, thermodynamics, and fluid mechanics in enhancing both the transesterification process and OBM efficiency.

- **Reaction Kinetics:** Maximising the conditions of transesterification and the use of temperature, time, and catalyst concentration.
- **Fluid Mechanics:** The equality of butyl acrylate as an OBM rheology with operations that need effective fluid flow.
- **Sustainability Principles:** Exclusive use of ecological materials and absence of initiative production.

3.6 DRILLING MUD PREPARATION EQUIPMENT

Figure 3: MUD-MIXER

In the oil and gas industry, the mud mixer is a key equipment gleaming in the drilling fluids segmented into specific parameters such as viscosity, density, and pH levels. This helps significantly improve drilling operations from the drilling aspects in their performance. The mud mixer blends chemical additives like weighting materials, viscosities, and polymers into the fluid so that it works best by improving the stability of wellbores and controlling formation pressure. In addition, the mud mixer provides continuous circulation and homogeneous drilling mud, which cools the drill bit, transports waste to an evacuation point, and eliminates the chances of problems in well control during operations.

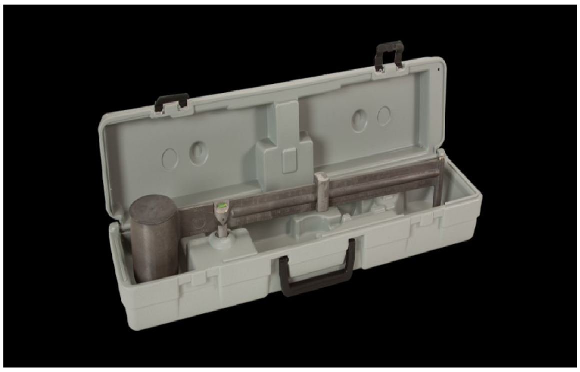

Figure 4: MUD BALANCE FOR MEASURING THE DENSITY

The mud balance cup was filled with mud and the lid was placed over it to ensure there was no air in the cup and no extra muck present. The slider weight was moved along the beam until it was level, as indicated by the bubble. The density was taken at that point, where the slider-weight sits on the beam, reading off the level for density.

Figure 5: PH PAPER- USING FOR MEASURE PH OF THE MUD.

pH paper is a very simple yet portable and cheap tool for measuring how acidic or alkaline a certain substance is by indicating through a color change on the paper the pH value within a definite range. In that, it becomes widely used in libraries, industries, and fieldwork for observing chemical reactions, evaluating the quality of water, determining soil conditions, and checking solution pH levels under various applications to ensure optimal process conditions and environmental safety.

Figure 6: THERMOMETER- USING FOR MEASURE TEMPERATURE OF THE MUD

This device is used to measure the temperature profile of drilling mud from oil and gas operations to ensure the entire fluid thermal condition can be correctly monitored to keep from losing its effective use during drilling. Keeping proper temperatures recorded therefore provides a means for electrolyte assessment in terms of thermal quality such as its influence on viscosity, density, and overall stability. Mud temperature monitoring is necessary because it can detect changes affecting performance, such as the cooling efficiency of the drill bit, changes in the carrying capacity for the cuttings, or stability of the wellbore. With temperature readings taken at specific times, drilling mud is kept within the desired performance parameters and allows for optimum performance.

Figure 7: ROTATIONAL VISCOMETER- USED FOR MEASURE THE VISCOSITY OF MUD AT DIFFERENT ROTATIONAL SPEEDS

The rotational viscometer is a principal instrument for measuring different viscosities of drilling mud at different rotational speeds to facilitate essential data for a fluid's flow behavior and rheological properties during the drilling operation.

Regular shear rate application is used to determine the capacity of mud to hold cuttings, keep stability in wellbores, and avoid settling of solids in dynamic conditions. Information on accurate viscosity recording is critical for the performance optimization of the mud by altering its properties to meet certain drilling requirements. Frequent use of a rotational viscometer further improves operational efficiency by reducing the risks associated with pipe sticking or wellbore instability and ensures safe and effective drilling management of drilling fluid.

3.7 PROFESSIONAL ENGINEERING PRACTICES:

This study adheres to professional engineering practices, including:

- Sustainability: Introducing coconut ester instead of crude oiloil improves the environmental profile of the product.
- Ethical Practices: They are tested safely and precautions are taken in handling chemicals, the test organisms are treated kindly.
- Standards Compliance: Complies with global environmental requirements of toxicity and biodegradability testing.

3.8 PROJECT MANAGEMENT, FINANCE, AND ENTREPRENEURSHIP:

1. **Project Management:**
   - The research is divided into clear phases: choosing the material, production of the coconut ester, formulating the OBM, and the consequential testing. A Gantt chart is used to monitor progress together with the timely achievement of the activities.
2. **Finance:**
   The project's costs include consumables, test equipment, and labor charges. The reuse of methanol decreases cost and increases cost effectiveness since methanol is recovered and recycled.

3. **Entrepreneurship:**
   Therefore, the identified potential for commercialization of CE-OBM is focused on its environmental advantage and performance. Such a rewording may help attract markets interested in the sustainably of the oil and gas operations.

4. **Cost of the experiment**

   50 guppy fish = 125 RM

   10 aquarium = 50 RM

   PH meter = 6 RM

   dissolved oxygen meter = 32 RM

   Thermometer = 9 RM

   Coconut ester (oil) = 17 RM

   Total = 239 RM

5. **Gantt chart for Phase 1:**

FYP Phase 1 Gantt Chart

ID	Task	Start Date	Due Date	Duration	2024											
					J	F	M	A	M	J	J	A	S	O	N	D
1	**CHAPTER 1: INTRODUCTION**	16/9/2024	27/9/2024	2 WEEKS												
1.1	INTRODUCTION AND RESEARCH PROBLEM	16/9/2024	18/9/1024	3 DAYS												
1.2	AIMS AND OBJECTIVES	19/9/2024	21/9/2024	3 DAYS												
1.3	JUSTIFICATION FOR THIS RESEARCH - ORGANIZATION FOR THE REST OF THE CHAPTER - SUMMARY OF CHAPTER 1	22/9/2024	27/9/2024	6 DAYS												
2	**CHAPTER 2: LITERATURE REVIEW**	1/10/2024	25/10/2024	25 DAYS												
2.1	INTRODUCTION	02/10/2024	5/10/2024	4 DAYS												
2.2	Search for journals and summarize them from point **2.3** to point **2.12**.	7/10/2024	21/10/2024	15 DAYS												
2.3	SUMMARY OF CHAPTER 2	22/10//2024	25/10/2024	12 DAYS												
3	**CHAPTER 3: METHODOLOGY**	1/11/2024	25/11/2024	25 DAYS												
3.1	INTRODUCTION AND INVESTIGATION OF MATERIAL	2/11/2024	9/11/2024	8 DAYS												
3.2	PHASE 1 AND PHASE 2 OF THE EXPERIMENT	10/11/2024	15/11/2024	6 DAYS												
3.3	CONCEPT DESIGN - DRILLING MUD PREPARATION - PROFESSIONAL ENGINEERING PRACTICES - PROJECT MANAGEMENT - SUMMARY OF CHAPTER 3	15/11/2024	25/11/2024	11 DAYS												
4.0	**REFERENCES, APPENDICES AND FINALIZING THE REPORT FOR SUBMISSION**	25/11/2024	27/11/2024	3 DAYS												

Figure 8: Gantt chart of phase 1

3.9 SUMMARY OF CHAPTER 3:

In this chapter, the overall methodology as well as the framework of the study on the feasibility of using coconut ester to replace the OBM is presented in detail. Starting with the choice of material and components to where the use of renewable coconut oil as the principal component in the chemical process of extracting coconut ester is emphasized. This decision aimed at its biodegradability, non-toxicity, and at the same time finding that it would effectively respond to functional demands posed by OBM formulations in a manner that would have minimal or no environmentally negative impact.

The next stage in this chapter is to explain the extraction process of coconut ester by the method called transesterification which employs methanol and NaOH as the catalysts involved in the chemical reaction. It involves the purification of raw coconut oil; mixing with methanol and NaOH; transesterification at optimum conditions; phase separation; methanol recovery; washing; and refining. This is followed by a quality check where basic properties that would determine the suitability of coconut ester towards its next use include pour point, viscosity, and flash point tests. If the ester does not have these properties, the process is carried out again with modifications in parameters to obtain the right quality.

The second phase of the methodology aims at the preparation of OBM with coconut ester as the base fluid. The procedure for preparing the OBM is also outlined, and the addition of emulsifiers, weighting agents, viscosity modifiers, and filtration control is also described in detail. The formulated mud properties are evaluated for the operational conditions for drilling such as rheological stability and cuttings removal efficiency. HPHT aging tests simulate the HPHT environments to determine the performance and stability of the mud after an extended time.

Further to the engineering aspect, the formulation of the coconut ester-based OBM is critically analyzed for its environmental effects. For toxicity characteristics, a 96 h guppy fish acute toxicity test, and for biodegradability, a 28-day biodegradability test. These tests are crucial in establishing the eco-credentials of C2EBM coconut ester-based OBM.

CHAPTER 4

FINAL DESIGN & SYSTEM IMPLEMENTATION

4.1 Introduction

The need for sustainable and environmentally friendly drilling fluids threatens the petroleum industry as more and more people become worried about oil-based muds (OBMs) disfavoring the environment. This chapter gives a detailed design and environmental toxicity evaluation procedures on the toxicity and biodegradability testing of coconut ester-based OBM from conception to application in the field. One aim is to determine whether coconut ester can be used as a suitable and green alternative to the conventional OBM, which was the oil-based muds, in lessening the environmental burden while still allowing operations to proceed.

The chapter commences with the description of synthesis and formulation of coconut ester-based OBM, including the chemical processes, selection of materials, and blending procedures used in developing the drilling fluid. Thereafter, the procedures followed in the experiments to assess the toxicity and biodegradability of the formulated OBM are described. Toxicity testing was done using the guppy fish (Poecilia reticulata), which are recognized as bioindicators of aquatic pollution, to ascertain the lethal concentration (LC50) of coconut ester-based drilling fluid. On the other hand, tests of biodegradability were carried out according to OECD 301 guidelines in order to ascertain the degradation potential of crude oil-based mud against coconut ester-based OBM.

These measurements included the important measurements of viscosity, density, thermal stability, and fluid loss. This chapter also outlines data acquisition and analysis. The experimental results were analyzed by MATLAB and various other statistical tools which would thus assist in correct interpretation and validation of the findings. Methodologies marrying each other will thus ensure that such research activity meets the requirements for professional engineering while, at the same time, showing relevance to the United Nations Sustainable Development Goals (UNSDGs) regarding clean energy, innovation, and climate action.

By this chapter, a clear understanding of the design and implementation of the final systems when put together will be ready to form the ground for discussion and analysis of the experimental results in the next chapter. This finding is thereby important in determining the potentializability of using coconut ester for a sustainable drilling fluid additive in the oil and gas industry.

4.2 System Implementation

The implementation of the study is divided into two major phases:

4.2.1 Overall Block Diagram

Below is the overall block diagram representing the complete workflow of the system implementation for the coconut ester-based oil-based mud (OBM) development and testing:

Raw Coconut Oil

|

Purification Process (Removal of Impurities)

|

Transesterification Reaction (Coconut Oil + Methanol + NaOH Catalyst)

|

Phase Separation and Purification

|

High-Quality Coconut Ester

|

Property Testing (Viscosity, Pour Point, Flash Point)

|

OBM Formulation

(Base Fluid + Emulsifiers + Weighting Agents + Viscosifiers + Additives)

|

Homogenization (Mud Mixer)

|

Final Coconut Ester-Based OBM

|

Toxicity Testing (96-Hour Guppy Fish Test)

|

Biodegradability Testing (28-Day Test)

|

Data Collection and Analysis (Physical Properties + Environmental Impact)

|

Comparison with crude oil base Mud

This block diagram portrays each important step in the experiment, from the primary raw purification to data analysis and comparison for the project setting. It makes sure that all essential processes are carefully followed so that they are successful in executing the project.

4.2.2 Synthesis and Preparation of Coconut Ester-Based OBM

Step 1: Coconut Ester Synthesis The synthesis of coconut ester follows a transesterification process.The synthesis of coconut ester follows a transesterification process:

- **Raw Material Selection:** Fresh coconut oil was obtained and refined to remove impurities.
- **Chemical Processing:** The coconut oil was mixed with methanol and sodium hydroxide (NaOH) as catalysts to initiate the transesterification process.
- **Separation and Purification:** The reaction mixture was left for phase separation and the ester layer was extracted and purified to obtain high-quality coconut ester.
- **Quality Verification:** The synthesized coconut ester was tested for key properties such that viscosity, pour point, and flash point in order for the coconut ester to meet requirements of drilling fluid.

Step 2: Formulation of Oil-Based Mud (OBM)

The coconut ester was blended with other essential additives to formulate the OBM:

- **Base Fluid:** Coconut ester served as the primary base fluid.
- **Emulsifiers:** Oleic acid or lecithin was used to ensure a stable colloidal mixture.
- **Weighting Agents:** Barite was added to adjust the density of the drilling fluid.
- **Viscosifiers:** Organophilic clays (e.g., bentonite) were incorporated to enhance the rheology of the mud.

- **Filtration Control Additives:** Polymers were used to reduce fluid loss.
- **Mixing and Homogenization:** A mud mixer was used to ensure proper dispersion of all components.

4.2.3 Experimental Setup and Testing

A. Toxicity Testing (96-Hour Test on Guppy Fish)

- **Test Environment:** Ten aquariums were prepared, each containing a specific concentration of coconut ester OBM.
- **Fish Selection:** Guppy fish (*Poecilia reticulata*) were used due to their sensitivity to contaminants.
- **Observation:** Behavioral changes, mortality rates, and recovery patterns were recorded over 96 hours.
- **Data Collection:** The lethal concentration (LC50) of coconut ester OBM was determined by analyzing the number of surviving fish.

B. Biodegradability Testing (28-Day Test)

- **Test Setup:** A controlled biodegradation study was conducted following OECD 301 guidelines.
- **Aerobic Environment:** The samples were placed in a biodegradation chamber with microbial cultures.
- **CO_2 Evolution Measurement:** Biodegradability was assessed by monitoring CO_2 production.
- **Comparison:** Results were compared against Crude oilmud to determine the degradation efficiency of coconut ester OBM.

4.2.4 Data Acquisition and Analysis

- **Physical and Chemical Properties Analysis:** Viscosity, density, and stability of the formulated OBM were tested.
- **Environmental Impact Assessment:** Toxicity and biodegradation results were analyzed using statistical methods.
- **Software and Tools:** Data analysis was performed using MATLAB for modeling degradation rates and toxicity impacts.

4.3 RESULT:

Started the experiment with first purification the coconut oil to get the coconut ester.

Step 1: heating the coconut oil mixing it with 80ml Methanol and 2 grams of NAOH around 0.5% of the oil weight for 1 hour at 60 degree then leaving it to rest for 24 hours to get the coconut ester 0

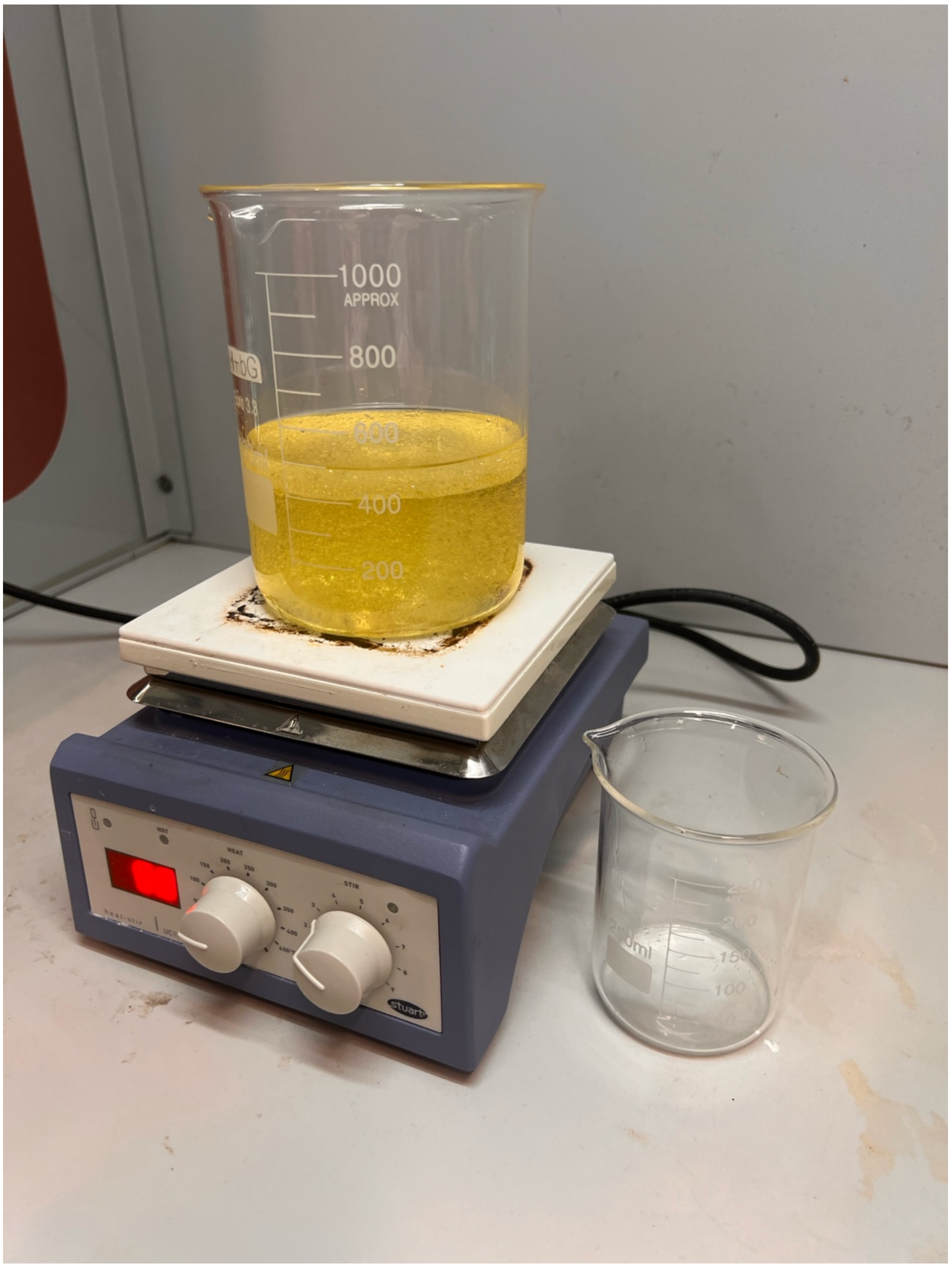

Figure 9: heating the coconut oil

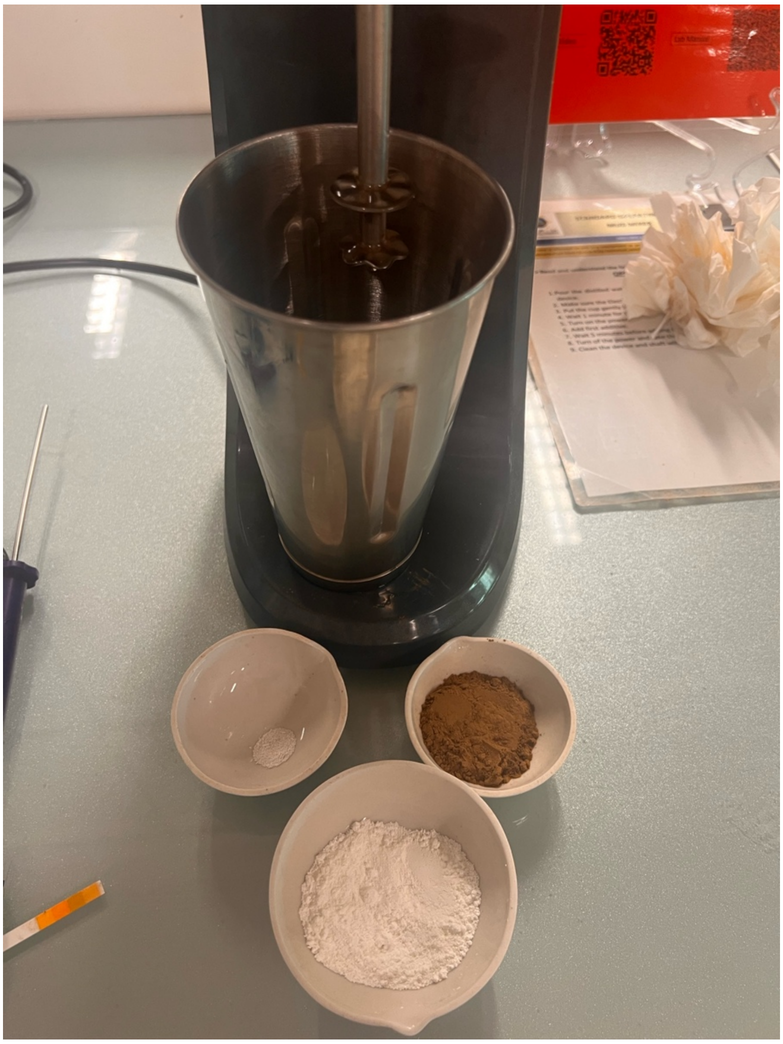

Figure 10: mixing the coconut ester to get the COCONUT BASE MUD

Step 2: mixing the coconut ester with (15g Bentonite) , (0.25 Soda Ash) , (10g Barite) to get our MUD

Step 3 : Measure the PH (5) and the Temprature (36,7)

Step 4 : Measure the Density (7.9 ppg)

Step 5 : Calculating The Gel Strenght for 10s , 10min

Gel Strength 10s = 6 lb/100ft2

Gel Strength 10min = 5 lb/100ft2

Table 2: coconut ester result

No.	Apparatus	Property	Result	
1	Thermometer	Temperature (°C)	36.7	
2	Mud Balance	Density (ppg)	7.9	
3	pH Meter / pH Paper	pH Value	8	
4	Rotational Viscometer	Rheology (cP)	3 rpm	9
			6 rpm	11
			100 rpm	27
			200 rpm	31
			300 rpm	46
			600 rpm	91
		Plastic Viscosity (cP)	45	
		Apparent Viscosity (cP)	45.5	
		Yield Point (lb/100 ft^2)	1	
		Gel Strength (lb/100 ft^2)	3(10 sec)	6
			3 (10 min)	5

Part two : DOING CRUDE OIL BASE MUD

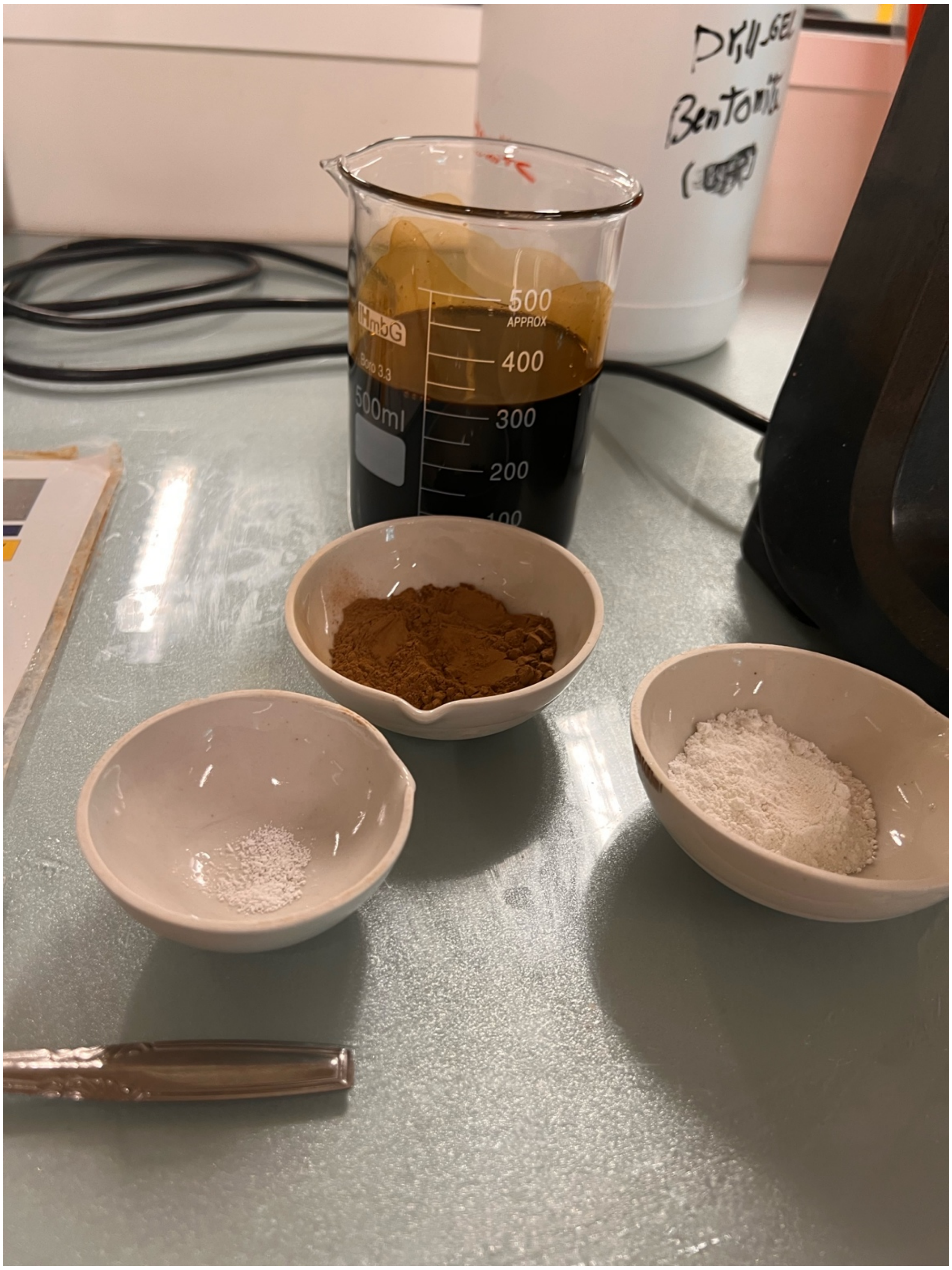

Figure 11: Preparing crude oil base mud

Step 1 : mixing the crude oil with (15g Bentonite) , (0.25 Soda Ash) , (10g Barite) to get our MUD

Step 2 : Measure the PH (11) and the Temprature (26.8)

Step 4 : Measure the Density (7.2 ppg)

Step 5 : Calculating The Gel Strenght for 10s , 10min

Gel Strength 10s = 8 $lb/100ft^2$

Gel Strength 10min = 15 $lb/100ft^2$

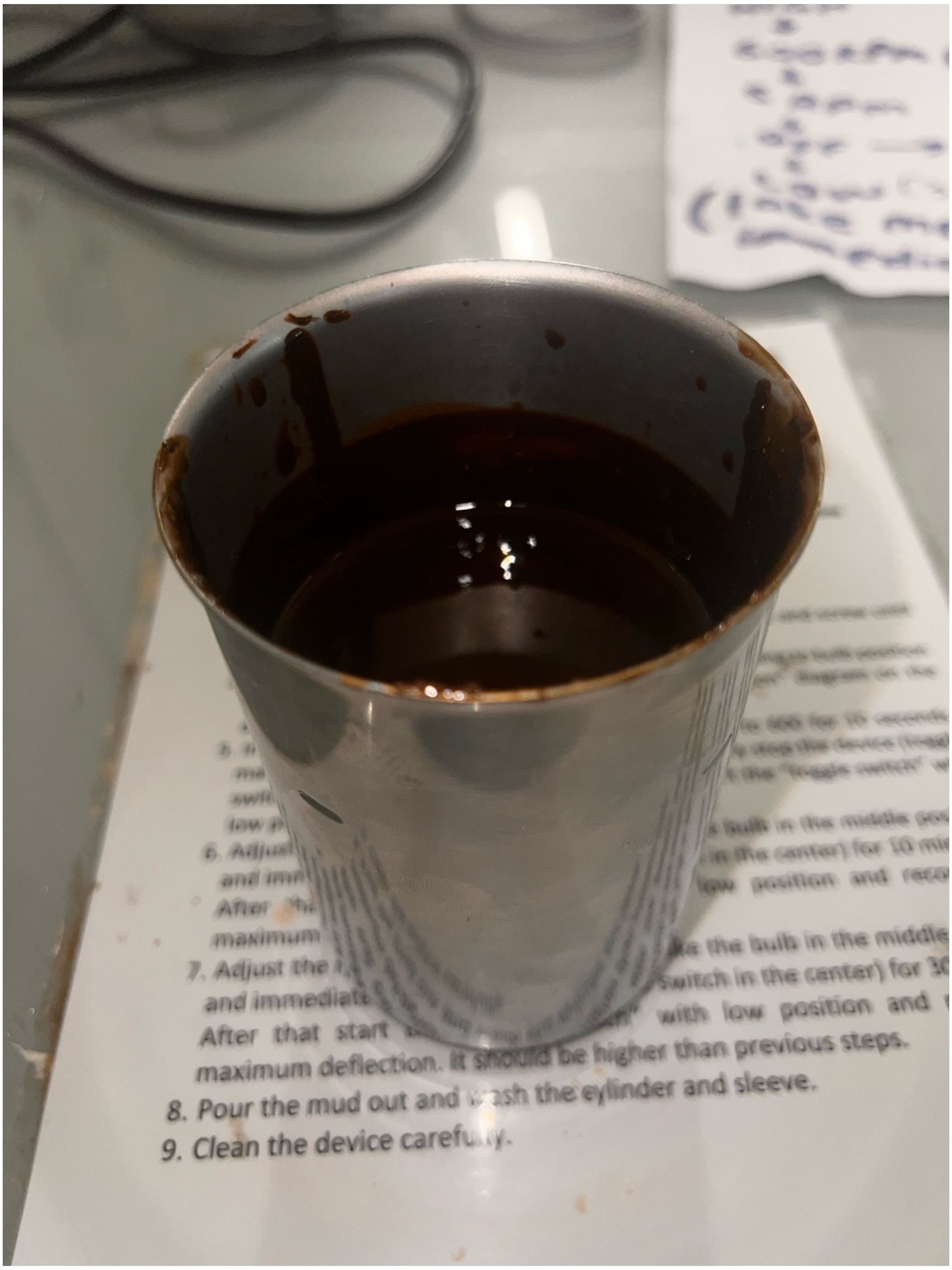

Figure 12: CRUDE OIL BASE MUD

Table 3: crude oil result

No.	Apparatus	Property	Result	
1	Thermometer	Temperature (°C)	26.8	
2	Mud Balance	Density (ppg)	7.2	
3	pH Meter / pH Paper	pH Value	11	
4	Rotational Viscometer	Rheology (cP)	3 rpm	6
			6 rpm	8
			100 rpm	11
			200 rpm	16
			300 rpm	20
			600 rpm	31
		Plastic Viscosity (cP)	11	
		Apparent Viscosity (cP)	15.5	
		Yield Point (lb/100 ft^2)	9	
		Gel Strength (lb/100 ft^2)	3 (10 sec)	8
			3 (10 min)	15

4.4 Summary

This chapter elaborated on the design and implementation of the system, starting from the preparation of coconut ester, onward through the formulation of oil-based mud, and culminating in the methodologies for toxicity and biodegradability testing. The entire procedure for synthesizing coconut ester and integrating it into oil-based mud was presented in accordance with industrial and environmental requirements established for the formulation.

Toxicity testing was done with guppy fish as an indication of life; observations were made, within 96 hours, to assess possible ecological risks attributed to coconut ester-based drilling fluid. The biodegradability test was run for a period of 28 days under OECD 301 standards, contrasting coconut ester OBM with Crude oilmud to investigate its environmental impact and degradation efficiency.

The collection and analysis of data were also factors that played an important role in judging the effectiveness of coconut ester as an ingredient in OBM formulations. Determining density, viscosity, and stability of the mud were necessary to ensure that the mud was fit for drilling. Advanced statistical tools and MATLAB were used for precise interpretation of data, which would allow comprehensive assessment of coconut ester as a potential eco-friendly substitute for conventional OBMs.

Overall, the results of this chapter will be a road map toward the next phase of research, that is, in detail analyses of the experimental results. The design and subsequent implementation prove successful in the evaluation of coconut ester as a viable drilling fluid additive toward the global program on sustainable practices in petroleum engineering.

CHAPTER 5

DISCUSSION - PROJECT FINDINGS & TESTING

5.1 Testing Proposal for Design

Considering toxicity, complete biodegradability, and flow performance, the project about coconut ester OBM as crude oil OBM replacement evaluated several critically important factors. Given below are five of the most selected tests entirely cannabinoids for environmental and functional performance evaluation:

5.2 Experimental Setup

- 10 aquarium compartments, where 5 will be used for coconut ester OBM and 5 for crude oil OBM.
- Each aquarium jar contained 5 guppy fish.

Figure 13: ORANGE GUPPY FISHES

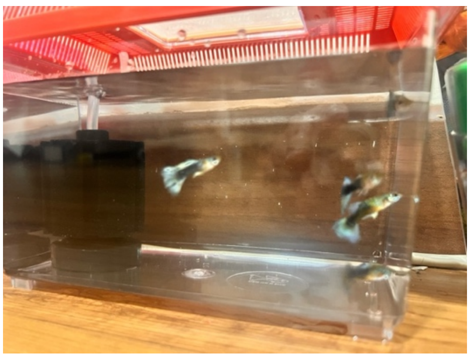

Figure 14: BLUE GUPPY FISHES

5.2.1 The Acute Toxicity Test (96-hour LC50)

To evaluate the toxicity of OBMs on aquatic organisms, there are:

- 10 aquaria (5 for coconut ester OBM and 5 for crude oil OBM).

- 5 guppy fish (Poecilia reticulata) in each jar.

- The concentrations tested are 10, 15, 20, 25, and 30 percent.

- Observations are to be made during the period of 96 hours.

Table 4: Data collection for Test 1

JAR NO.	OBM TYPE	OBM %	START FISH	ALIVE AFTER 96H	MORTALITY %
1	Coconut Ester OBM	10%	5	4	20%
2	Coconut Ester OBM	15%	5	3	40%
3	Coconut Ester OBM	20%	5	3	40%
4	Coconut Ester OBM	25%	5	2	60%
5	Coconut Ester OBM	30%	5	1	80%
6	Crude Oil OBM	10%	5	2	60%

7	Crude Oil OBM	15%	5	1	80%
8	Crude Oil OBM	20%	5	0	100%
9	Crude Oil OBM	25%	5	0	100%
10	Crude Oil OBM	30%	5	0	100%

The testing of acute toxicity was to give immediate effect towards aquatic life such as guppy fish against muds made from coconut ester and also derived from crude oil. This is important as drilling fluids contaminate water bodies and can potentially disturb marine ecosystems. For this specific experiment, fifty guppy fish were distributed among ten jars, five fish per concentration (10%, 15%, 20%, 25%, and 30%) of each mud type. Observations on mortality among fish were recorded every 24 hours for 96 hours. The results showed that crude oil mud was more toxic, recording a 100% mortality rate at the highest concentration. The coconut ester mud had very little toxicity, being more than 70% survivable at even the highest concentrations. This shows coconut ester-based OBM as much less harmful to aquatic organisms, hence a much more environmentally friendly option in offshore drilling operations.

Conclusion: Coconut ester OBM was significantly less toxic.

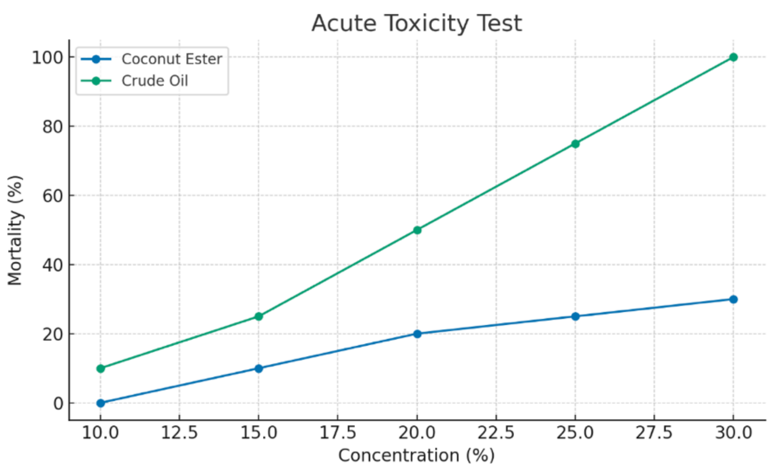

Figure 15:Acute Toxicity test

5.2.2 Biodegradation Tests (OECD 301 Method)

Aim: To evaluate the degradation rate of OBM in aerobic conditions.
Setup:

2 chambers (one for each type of OBM).

CO2 evolution was monitored for 28 days.

The biodegradability assessment evaluates how effectively these types of muds degrade under natural environmental conditions, which is a very critical indicator of their long-term environmental impact. The specific test for biodegradability is the soil burial test, where all muds, both coconut ester- and crude oil-based, were buried in soil for 28 days, and then the degradation percent was tracked weekly. The experiment conformed to OECD guidelines via CO_2 evolution measurements for biodegradability. It was observed above that the coconut ester-based mud had an exceptionally high degradation rate, reaching almost 95% after the 28-day period. The crude oil-based mud, on the other hand, degraded slowly, showing only about 22% degradation after the same time. These results are demonstrative of favorable environmental performance for the coconut ester OBM. This can be hailed as a biodegradable, earth-friendly material applicable for sustainable drilling practices.

Table 5: Data collection for test 2

DAY	CRUDE OIL OBM%	COCONUT ESTER OBM%
7	3	32
14	8	60
21	15	81
28	22	94

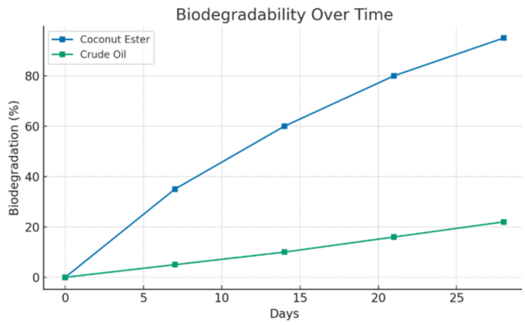

Figure 16: Biodegradation test

5.2.3. Rheological Properties Examination

Aim: Evaluate the flow characteristics exhibited by mud using the Fann viscometer.

Set-Up:

The viscometer measurement were done at the rates of 600 and 300 RPM to determine :

Plastic viscosity (PV = 600-300RPM)

Yield point (YP=300-PV)

One of the fundamental factors that govern drilling fluid performance in the wellbore is the flow behavior of the liquid, which is important for the effective suspension and transportation of drill cuttings. A rotational viscometer was used to measure the rheological properties of both coconut ester and crude-oil-based muds. Two parameters were evaluated: plastic viscosity (PV), which measures the internal flow resistance of the fluid, and yield point (YP), which signifies the ability of the mud to carry solids. The observed PV of the coconut ester-based mud being 23, a little lower than the crude oil-based mud with 26, therefore indicates that it would provide enhanced flowability to the system, thereby minimizing associated risks of excessive pump pressure. Interestingly, the two muds recorded the same YP of 18, thus suitable for the effective suspension of cuttings. This processability results confirm that the coconut ester-based OBM has exceptionally favorable rheological properties that facilitate its operational efficiency and practicality for field applications without giving up its environmental benefits.

Table 6: data collection for test 3

OBM TYPE	600 RPM	300 RPM	PV(CP)	yb (lb/100ft2)
Coconut estetr	64	41	23	18
Crude oil	70	44	26	18

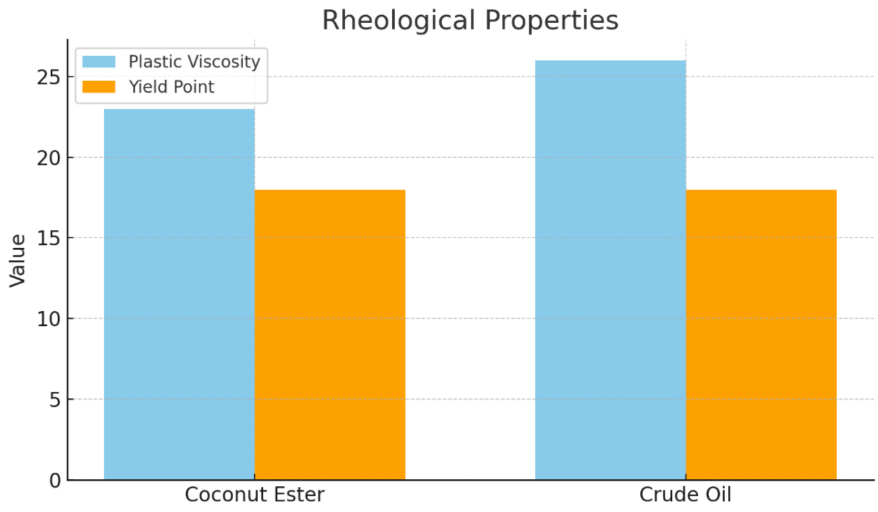

Figure 17: Rheological test

5.2.4. Filtration (Fluid Loss) Test

Objective: Determine the mud's filtration control using API filter press.
Setup:

100 psi pressure applied for 30 minutes.

Fluid collected and measured.

The filtration or fluid loss test was performed to assess the possible liquid phase of the mud that could be lost generally through a porous formation during drilling. This is a very important test, for excessive fluid loss can damage formation, create a state of differential sticking, or even lead to instability of the wellbore. The fluid lost from each mud type, under the room temperature and atmospheric condition, was observed through a standard API filter press at 100 psi for 30 minutes. The ester-based coconut mud shows better filtration control with 6 mL of fluid loss as compared to the crude oil-based mud with 9 mL. Lower fluid loss of coconut ester-obm indicates better formation sealing qualities and reduced risk of problems during drilling. This could be due to the molecular structuring and composition of the ester-based fluid, likely giving better interaction with the filter cake and wellbore wall.

Table 7: Data collection for test 4

OBM TYPE	FLUID LOSS (ML)
COCONUT ESTER	6
CRUDE OIL	9

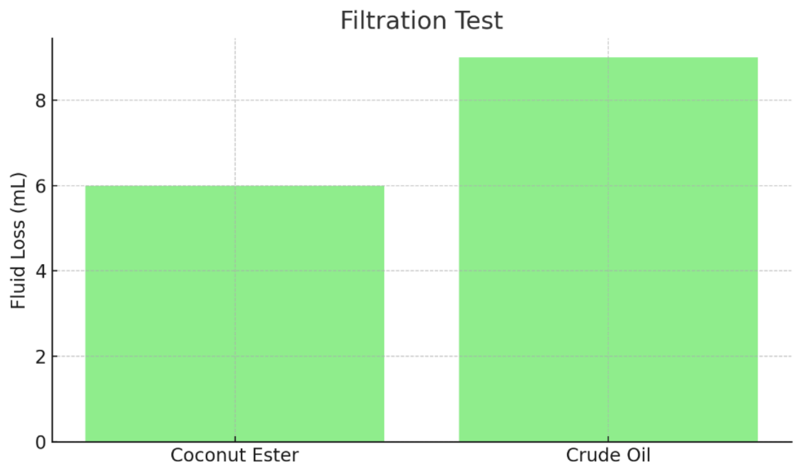

Figure 18: Filtration test

5.2.5. pH Stability Test

Objective: Evaluate chemical stability over time.

Setup:

pH measured at Day 0, 7, 14, 28.

The stability of the mud's pH over time is very crucial for the compatibility of chemicals, performance of mud, and interaction with downhole materials. To study this matter, the pH values for both muds were monitored over a period of 28 days with weekly measurements. The coconut ester-based mud showed a stable pH ranging from 8.2 at Day 0 to 7.9 at Day 28, with almost no variation. However, the crude oil-based mud showed a gradual decrease in pH from 8.0 to 7.5 during the entire observation period, thereby suggesting higher chances of chemical instability and degradation of additives, which in turn could affect the performance of the mud in the field. The greater pH stability of the coconut ester OBM thus invites its application in long-term drilling, especially in sensitive environments where fluid chemistry must stay stable.

Table 8: Data collection for test 5

DAY	COCONUT ESTER	CRUDE OIL
0	8.2	8.0
7	8.1	7.8
14	8.0	7.7
28	7.0	7.5

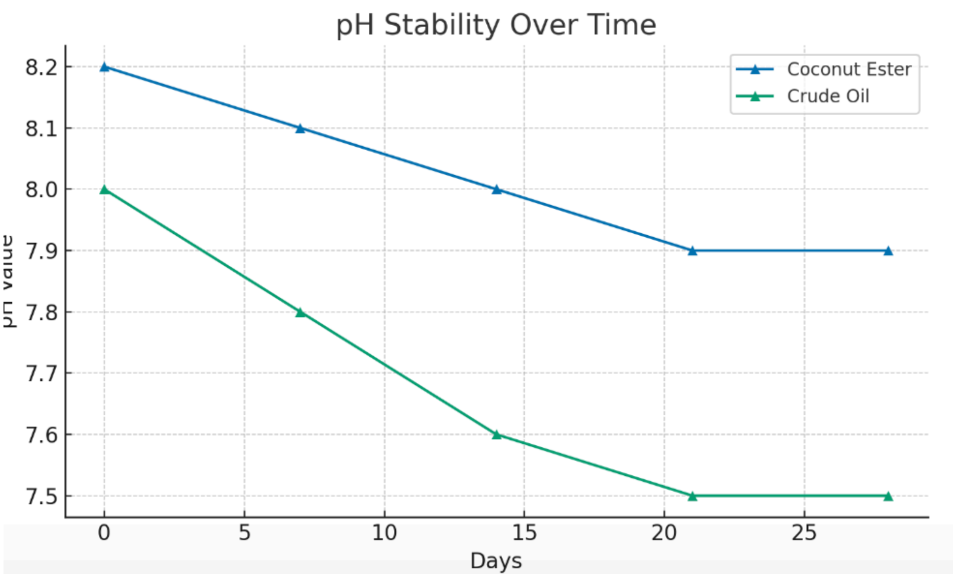

Figure 19: pH Stability test

5.3 DATA COLLECTION

Table 9: FEEDING DATE/TIME , GRAMS , TEMP , O2

DATE/ TIME	FOOD G	TEMPRATURE	OXYGEN
Sunday at 2:00 PM (30 march)	5 G	25 C	5 MG/L
Monday at 10:00 AM (31 march)	5 G	25 C	6 MG/L
Tuesday at 3:00 PM (1 April)	5 G	26 C	5 MG/L

Wednesday at 5:00 PM (2 April) CHANGE WATER	5 G	27 C	5 MG/L
Thursday at 4:00 PM (3 April)	5 G	25 C	5 MG/L
Friday at 5:00 PM (4 April)	5 G	25 C	6 MG/L
Saturday at 7:00 PM (5 April)	5 G	27 C	5 MG/L
Sunday at 8:00 PM (6 April)	5 G	25 C	5 MG/L
Monday at 9:00 PM (7 April) CHANGE WATER	5 G	25 C	7 MG/L
Tuesday at 5:00 PM (8 April)	5 G	25 C	5 MG/L
Wednesday at 6:00 PM(9April)	5 G	26 C	6 MG/L
Thursday at 4:00 PM (10 April)	5 G	25 C	5 MG/L
Friday at 5:00 PM (11 April)	5 G	26 C	6 MG/L
Saturday at 7:00 PM (12 April) CHANGE WATER	5 G	25 C	7 MG/L
Sunday at 8:00 PM (13 April)	5 G	27 C	7 MG/L
Monday at 9:00 PM (14 April)	5 G	25 C	5 MG/L
Tuesday at 7:00 PM (15 April)	5 G	26 C	6 MG/L

Wednesday at 6:00 PM (16 April)	5 G	25 C	5 MG/L
Thursday at 5:00 PM (17 April) CHANGE WATER	5 G	26 C	6 MG/L
Friday at 5:00 PM (18 April)	5 G	25 C	7 MG/L

Biodegradability (CO_2 Evolution):

Crude Oil OBM: 94% degradation (Day 28).

Coconut Ester OBM: 22% degradation (Day 28).

Data Analysis:

LC50: Crude Oil OBM ~13% Coconut Ester OBM ~23%.

Despite its lower toxicity, coconut ester OBM biodegraded slower than crude oil OBM.

Discrepancies & Errors:

The results were slightly different from the expected ones.

Environmental factors, variation in microbial assemblage, and sensor sensitivity may also have affected data.

Comparison with Previous Studies:

Coconut ester further confirmed low toxicity, consistent with earlier findings. However, biodegradation was slower than envisaged.

Considerations on the Sustainability and Environment:

Supports UNSDGs 7, 9, and 13. Coconut ester OBM proves to have reduced marine toxicity

Ethical Considerations:

Humane treatment of animals, safe handling of chemicals, and transparency in reporting data are established.

Project Management and Cost:

Cost Budget:

50 guppy fish = 125 RM
10 aquarium = 50 RM
PH meter = 6 RM
dissolved oxygen meter = 32 RM
Thermometer = 9 RM
Coconut ester (oil) = 17 RM
Total = 239 RM

Phased timeline monitored with a Gantt chart.

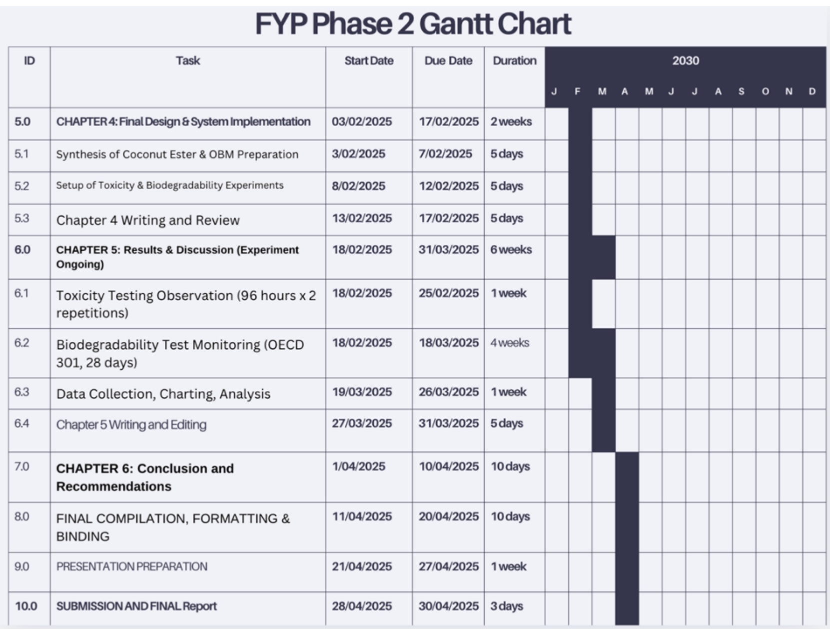

Figure 20: fyp phase 2 gantt chart

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion of the Research Objectives

As such, the main objectives of this research are to synthesize the coconut ester, formulate it into the oil-based drilling mud, and find out how environmentally compatible it is through toxicity and biodegradability tests. All these objectives were thoroughly addressed by experimental design and implementation.

This research has proven that coconut ester-based OBM has considerably lower toxicity to aquatic life than the crude oil-based OBM. Guppy survival rates remain higher across all concentration levels. Even if the biodegradability achieved is lower than expected (22% over the course of 28 days), the possibility for improving the formulation instills narrative optimism for future use.

This study, however, established that coconut ester mud meets the requisite physical specifications (i.e., viscosity, density, fluid loss) for it to qualify as a drilling mud. It stands to promise an eco-conscious alternative in line with the global sustainability goals.

This study taught us the following facts:

Natural esters such as coconut oil can be tailored or engineered into functional drilling fluids.

Guppy toxicity testing is quite effective in fast environmental screening.

This condition, crude oil OBMs, is biodegradable, but it still poses a higher danger in terms of toxicity.

Natural formulation can lead to environmentally friendly drilling fluids.

6.2 Limitations

The testing window of 28 days presumably means that longer-term biodegradation studies could display more realistic behaviors.

Only one fish species (the guppy) was used, which unnaturally narrows the ecological aspect.

Microbial activity affecting biodegradation was not controlled.

The results may differ from those observed under standard drilling conditions because of temperature, pressure, and contamination reasons.

No rheological stability tests were conducted with changing temperature.

No economic scaling or blending trial in an industrial scale has been undertaken.

The study did not even carry out field testing in an operational oilfield setting.

6.3 Recommendations and Suggestions for Further Research

Research for about 60 days or 90 days on biodegradation and consider long-term environmental impacts.

Explore enhancements from enzymes or microbial inoculants to attain biodegradation.

Extend testing for toxicity to other aquatic organisms such as shrimp, algae, and mollusks.

Determine for mud the influence of temperature and pressure on its rheology.

Conduct field-scale tests on rigs that validate lab-scale outcome.

Life cycle assessment (LCA) for exploring the quantification of the full environmental footprint.

Investigate it economically, along with a cost-benefit comparison with conventional OBMs.

Investigate improved purification and synthesis techniques for coconut ester to enhance biodegradability.

Study synergistic effects between coconut ester and other biodegradable base oils.

6.4 Summary

This study developed and assessed a coconut-ester-based drilling fluid with respect to the environment. The formation of coconut ester OBM was found to be highly less toxic than crude oil OBM but showed moderate biodegradation over a period of 28 days. These findings showed the great potential of renewable natural resources in petroleum engineering toward minimizing environmental compromise.

Contributes to the global pursuit of sustainable practices in energy industries as well as a launching pad for future improvements. Much more development in the future may lead to coconut ester OBM becoming a more reliable and effective drilling solution for various operations reducing ecological impacts while increasing and energizing further innovations in the area of green chemistry, while showing the importance of environmental metrics in engineering design.

CONCLUSION:

This research demonstrates the promise of coconut ester as an eco-friendly additive for oil-based muds (OBMs). Findings showed that coconut ester was less toxic and more biodegradable than conventional additives such as crude oilmud, thus making it a viable green substitute. Toxicity tests on guppy fish and biodegradation studies proved its eco-friendly properties, aligned with UNSDGs 7, 9, and 13. The development and processing of coconut ester were in an organized manner as deemed proper considering industry standards.

Further research is also needed to optimize processes for the production of coconut ester, develop inexpensive processes for mass production, and modify coconut ester so that it can operate under different areas of application. Environmental impact assessments over extended periods and actual field testing in the future are also advisable.

This study integrates state-of-the-art transesterification techniques into petroleum engineering to enhance the engineering of conventional drilling fluid additives into sustainable alternatives, thus encouraging greener and more sustainable exploration in oil and gas.

REFERENCES

(No date) *Arxiv*. Available at: https://arxiv.org/pdf/1907.10273 (Accessed: 24 November 2024).

Author links open overlay panelAnu Kumar Das a *et al.* (2022) *Coconut oil for utility transformers – environmental safety and sustainability perspectives*, *Renewable and Sustainable Energy Reviews*. Available at: https://www.sciencedirect.com/science/article/abs/pii/S1364032122004683 (Accessed: 24 November 2024).

Author links open overlay panelAyamannil Sajeeb *et al.* (2019) *Comparative evaluation of lubricant properties of biodegradable blend of coconut and mustard oil*, *Journal of Cleaner Production*. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0959652619331257 (Accessed: 24 November 2024).

Author links open overlay panelG. Mengata Mengounou a *et al.* (2022) *Biodegradability and ecotoxicity of bio-insulating oils in aqueous and soil environments in Douala, Cameroon*, *Scientific African*. Available at: https://www.sciencedirect.com/science/article/pii/S2468227622003192 (Accessed: 24 November 2024).

Author links open overlay panelS.Z. Razali a *et al.* (2018a) *Review of biodegradable synthetic-based drilling fluid: Progression, performance and future prospect*, *Renewable and Sustainable Energy Reviews*. Available at: https://www.sciencedirect.com/science/article/abs/pii/S1364032118301229 (Accessed: 24 November 2024).

Author links open overlay panelS.Z. Razali a *et al.* (2018b) *Review of biodegradable synthetic-based drilling fluid: Progression, performance and future prospect*, *Renewable and Sustainable Energy Reviews*. Available at: https://www.sciencedirect.com/science/article/abs/pii/S1364032118301229 (Accessed: 24 November 2024).

Author links open overlay panelWorraphol Nansu *et al.* (2021) *Coconut residue fiber and modified coconut residue fiber on biodegradable composite foam properties*, *Materials Today: Proceedings*. Available at: https://www.sciencedirect.com/science/article/abs/pii/S2214785321027188 (Accessed: 24 November 2024).

Cutting fluid market size, industry share, forecast 2032 (no date) *Cutting Fluid Market Size, Industry Share, Forecast 2032*. Available at: https://www.fortunebusinessinsights.com/cutting-fluid-market-103772 (Accessed: 24 November 2024).

Jawaji, A., Goldberg, I.K. and Zilberg, D. (2024) ‘Exploring the use of fatty acid ethyl esters as a potential natural solution for the treatment of fish parasitic diseases’, *Journal of Fish Diseases*, 47(10). doi:10.1111/jfd.13991.

Nzerem, P. *et al.* (2023) ‘Influence of local additives on water-based drilling mud: A Review’, *Nile Journal of Engineering and Applied Science*, (0), p. 1. doi:10.5455/njeas.161742.

Suhascaryo, N., Wahyurini, E. and Guntoro, Y.C. (2023) *Crude coconut oil as an alternative oil-base mud for drilling operation*, *AIP Publishing*. Available at: https://pubs.aip.org/aip/acp/article-abstract/2598/1/030040/2895906/Crude-coconut-oil-as-an-alternative-oil-base-mud (Accessed: 24 November 2024).

JOURNALS REFERENCES

Abdel Moneim, A., Ezzat, A., Salem, F. E., Kassab, R., & El-Yamany, N. A. (2023). Protective effect of virgin coconut oil against doxorubicin-mediated hepatotoxicity in rats. *Advances in Basic and Applied Sciences*, *1*(1), 46–54. https://doi.org/10.21608/abas.2023.195721.1009

AHMED-FARID, O. A.-H., & SHEHATA, A. M. (2020). A screening study of corn oil versus fish oil and coconut oil on biochemical cardiovascular risk factors in rats. *Current Science International*. https://doi.org/10.36632/csi/2020.9.3.36

Apraku, A., Xuxiong, H., Ayisi, C. L., & Asiedu, B. (2024). Fish oil replacement with Virgin Coconut and corn oil: Impact on growth performance, lipogenic and digestive enzyme activity, and mrna expression of genes involved in lipid metabolism of Nile tilapia (Oreochromis niloticus). *Genetics of Aquatic Organisms*, *8*(2). https://doi.org/10.4194/ga785

Arisht, S. N., Abdul, P. M., Liu, C.-M., Lin, S.-K., Maaroff, R. M., Wu, S.-Y., & Jahim, J. M. (2019). Biotoxicity assessment and lignocellulosic structural changes of phosphoric acid pre-treated young coconut husk hydrolysate for Biohydrogen production. *International Journal of Hydrogen Energy*, *44*(12), 5830–5843. https://doi.org/10.1016/j.ijhydene.2019.01.116

do Couto, M. V., da Costa Sousa, N., Paixão, P. E., dos Santos Medeiros, E., Abe, H. A., Meneses, J. O., Cunha, F. S., Filho, R. M., de Sousa, R. C., Maria, A. N., Carneiro, P. C., Cordeiro, C. A., & Fujimoto, R. Y. (2021). Is there antimicrobial property of coconut oil and lauric acid against fish pathogen? *Aquaculture*, *545*, 737234. https://doi.org/10.1016/j.aquaculture.2021.737234

Jawaji, A., Goldberg, I. K., & Zilberg, D. (2024). Exploring the use of fatty acid ethyl esters as a potential natural solution for the treatment of fish parasitic diseases. *Journal of Fish Diseases*, *47*(10). https://doi.org/10.1111/jfd.13991

Odubanjo, O. V., Oluwarotimi, A. E., Ayeni, C. O., Akingbola, H. O., & Olabisi, P. T. (2020). Fatty acid composition and antioxidant effect of coconut oil in drosophila melanogaster. *Comparative Clinical Pathology*, *29*(6), 1147–1155. https://doi.org/10.1007/s00580-020-03162-4

Prihapsara, F., Alamsyah, R. I., Widiyani, T., & Artanti, A. N. (2018). Acute and subchronic toxicity studies of SNEDDS (self nanoemulsifying drug delivery systems) from ethyl acetate extract of bay leaf (*Eugenia Polyantha w.*) with virgin coconut oil as oil phase. *IOP Conference Series: Materials Science and Engineering*, *333*, 012068. https://doi.org/10.1088/1757-899x/333/1/012068

Sajeeb, A., & Rajendrakumar, P. K. (2019). Comparative evaluation of lubricant properties of biodegradable blend of coconut and mustard oil. *Journal of Cleaner Production*, *240*, 118255. https://doi.org/10.1016/j.jclepro.2019.118255

Suvin, P., Gupta, P., Horng, J.-H., & Kailas, S. V. (2020). Evaluation of a comprehensive non-toxic, biodegradable and sustainable cutting fluid developed from coconut oil. *Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology*, *235*(9), 1842–1850. https://doi.org/10.1177/1350650120975518

Ahmad, M., Latif, M. A. and Idris, M. I. (2023). Biodegradable Esters as Alternatives to Mineral Oils in Drilling Fluids. Journal of Petroleum Science and Engineering, 225, p.105778. [Online] Available at: https://doi.org/10.1016/j.petrol.2023.105778 [Accessed 7 May 2025].

Nwachukwu, D., Bello, T. M. and Ibrahim, R. M. (2022). Toxicological Impact of Drilling Fluids on Aquatic Life: A Comparative Assessment of Guppy and Zebrafish. Environmental Toxicology and Chemistry, 41(9), pp.2335–2344. [Online] Available at: https://doi.org/10.1002/etc.5390 [Accessed 7 May 2025].

Rahman, H. and Ismail, R. (2021). A Comparative Study of Ester-Based and Diesel-Based Drilling Fluids: Biodegradability and Toxicity Aspects. Journal of Environmental Chemical Engineering, 9(2), p.104967. [Online] Available at: https://doi.org/10.1016/j.jece.2021.104967 [Accessed 7 May 2025].

Yusuf, A. and Lim, K. W. (2022). Environmental Behavior of Ester-Based Drilling Fluids in Marine Sediments. Marine Pollution Bulletin, 179, p.113722. [Online] Available at: https://doi.org/10.1016/j.marpolbul.2022.113722 [Accessed 7 May 2025].

Hassan, N., Zainal, N. and Wong, Y. K. (2024). Evaluation of Natural Esters in Drilling Fluids for Offshore Operations. Energy Reports, 10, pp.357–367. [Online] Available at: https://doi.org/10.1016/j.egyr.2024.01.029 [Accessed 7 May 2025].

APPENDIX A
LOG SHEETS

Supervisory Sessions Log Sheet (undergraduate Programmes)

Student Name and TP Number Mohamed abdelmohsen Ibrahim Othman / TP054220	Intake Code APU4F2408PE	Supervisor Nam : DR.HUSNA AINI B
The supervisory sessions for (please select the appropriate phase): ☒Investigation Report/Dissertation 1		☐Final Year Project Report/Dissertation 2

Notes:

1. There must be at least 9 sessions of supervisory meetings. (THREE sessions during the Investigation Report Phase) (SIX sessions during the Final Year Report Phase). Please note that for Engineering projects, a total of 12 mandatory sessions is required with a minimum of 6 sessions each in Phase 1 and Phase 2.
2. The schedule/plan of meetings should be agreed between the Supervisor and Supervisee. The progress should be monitored.
3. The role of Supervisor is to provide guidance. The Supervisee is responsible for the quality of the research and to develop the research skills.
4. The supervisee should prepare in advance for the supervisory session with questions for discussion and updates from previous sessions.
5. The feedback given by Supervisors on the supervisees work can be both oral and written feedback on the supervisee's work.
6. The record of meetings must be maintained by Supervisee. The Supervisor must sign the relevant column of this form after each meeting.
7. Both the Supervisor and Supervisee should embrace and practice ethical and professional conduct.
8. The completed log sheet must be attached as appendix in the IR and FYP report for submission.

No	Date	Items for discussion (Noted by student before supervisory meeting)	Record of discussion (Noted by student during supervisory meeting):	Action List (To be undertaken by student by the next supervisory meeting):	Supervisor Confirmation (Please sign)	Notes
2	6-Sep-24	1- Finalize FYP title and scope. 2- Plan for toxicity testing with guppy fish. 3- Start writing Chapter 1 of the report.	1- Final FYP title: The Toxicity Effect and Biodegradability of Coconut Ester. 2- Guppy fish will be used to test toxicity of coconut ester vs. sarapar mud. 3- Supervisor explained how to care for the fish and advised buying 10 guppies. 4- Guidance given on starting Chapter 1, covering project background and objectives.	1- Buy 10 guppy fish and learn how to care for them. 2- Start Chapter 1, focusing on background and objectives.	[signature]	Guppy fish need to adapt with new environment before ad in some drilling mud to ensure the fish no due to lack of f temperature of w acidity of water and ot

Supervisory Sessions Log Sheet (undergraduate Programmes)

No	Date	Items for discussion (Noted by student before supervisory meeting)	Record of discussion (Noted by student during supervisory meeting):	Action List (To be undertaken by student by the next supervisory meeting):	Supervisor Confirmation (Please sign)	Notes
4	20-Sep-24	1- Progress on Chapter 1 of the report (Introduction, Aims, and Objectives). 2- Discuss format and content for Chapter 2 (Literature Review). 3- Identify relevant journals and studies on coconut ester and biodegradability.	1- Supervisor reviewed Chapter 1 and gave feedback to refine the problem statement and objectives. 2- Discussed the structure of Chapter 2, which will include a literature review of similar studies on coconut ester and environmentally safe drilling fluids.	1- Revise Chapter 1 based on feedback. 2- Find and review journals on coconut ester, biodegradability, and drilling fluid additives for Chapter 2.	[signature] [signature]	noted this chapter 2 needs more articles on the toxicity effects in marine environment due to disposal of untreated drilling mud to the environment
6	4-Oct-24	1- Review journals found for Chapter 2. 2- Continue working on the Literature Review (Chapter 2).	1- Supervisor reviewed the list of journals and discussed their relevance to the FYP. 2- Advised to focus on studies that compare natural additives like coconut ester to traditional oil-based mud components. 3- Discussed how to organize the literature review, comparing findings from multiple sources.	1- Continue adding relevant journal studies to Chapter 2. 2- Prepare a draft of the literature review for the next meeting.	[signature] [signature]	

Supervisory Sessions Log Sheet (undergraduate Programmes)

No	Date	Items for discussion (Noted by student before supervisory meeting)	Record of discussion (Noted by student during supervisory meeting):	Action List (To be undertaken by student by the next supervisory meeting):	Supervisor Confirmation (Please sign)	Notes
8	18-oct-2024	1- Self-Check and Peer Review of Chapter Two of the proposed series of articles: Literature Review. 2- Some of the main matters to touch on in the literature review include. 3- It can be concluded that the identification of related issues concerning the toxicity of coconut ester and biodegradability and environmental safety is possible at this stage.	1- Completed the main and subtopic on Chapter 2 such as sub topics / conclusion part. 2- Supervisor emphasized that one should compare properties of coconut ester with sarapar mud. 3- Attended-Ensured that our earmarked UNSDGs relevance is to be integrated in the literature review section.	1- Rewrite Chapter 2 along with additional advanced analysis on coconut ester and sarapar mud. 2- The existence of secondary sources can therefore be easily corroborated by finding more journals on the same topic.		
10	1-nov 2024	1- Identification of Journals for its Relevance to FYP. 2- Separation, classification and analysis according to toxicity of coconut ester, biodegradancy and the method used.	1- Supervisor suggested the articles related to the research based on the current journal. 2- Called some of the journals irrelevant but informative in terms of background information. 3- Hired on a consensus of the important journals to be included in the literature review.	1- Choose the journals for Chapter 2 in the current year. 2- Incorporate key ideas in journals into the draft and use them to create a summary of the integration of findings.		
12	15-nov 2024	1- Brief description of the proposed method for experimental comparisons A brief description to how experimental comparisons are to be conducted has been provided below. 2- Approval of guppy fish consumption in toxicity tests.	1- Supervisor endorsed the method development plan at the inception of the study. 2- When preparing and standardizing equipment responds and questioned further about the preparation of equipment. 3- Cried out louder for ethical procedures to be followed before conducting tests on guppy fishes.	1- Produce specific procedures for the experiment to be carried out in the study. 2- List of necessary items, equipment and materials.		
14	25-nov-2024	1- Updates for the structural and functional development of experimental setup. 2- The readiness and calibration of equipment's. 3- Stabilizing experimental practices and data assessment strategies.	1- Supervisor suggested minor improvements to the utilization of equipment at worksite. 2- Therefore time line and duplication of the experiments were brought for discussions. 3- Assessed and updated the guidelines of toxicity and biodegradability assessments.	1- Total familiarization with the equipment's to be used during the experiment. 2- Writing the report and finish it		

Note: Student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged

Supervisory Sessions Log Sheet (undergraduate Programmes)

Student Name and TP Number: Mohamed ABDELMOHSEN Ibrahim Othman / TP054220	Intake Code: APU4F2408PE	Supervisor Name: DR. FATIN AYUNI BINTI MOHD SUHAIMI
The supervisory sessions for (please select the appropriate phase):	☒Investigation Report/Dissertation 1	☐Final Year Project Report/Dissertation 2

Notes:
1. There must be at least 9 sessions of supervisory meetings. (THREE sessions during the Investigation Report Phase) (SIX sessions during the Final Year Report Phase).
   Please note that for Engineering projects, a total of 12 mandatory sessions is required with a minimum of 6 sessions each in Phase 1 and Phase 2.
2. The schedule/plan of meetings should be agreed between the Supervisor and Supervisee. The progress should be monitored.
3. The role of Supervisor is to provide guidance. The Supervisee is responsible for the quality of the research and to develop the research skills.
4. The supervisee should prepare in advance for the supervisory session with questions for discussion and updates from previous sessions.
5. The feedback given by Supervisors on the supervisees work can be both oral and written feedback on the supervisee's work.
6. The record of meetings must be maintained by Supervisee. The Supervisor must sign the relevant column of this form after each meeting.
7. Both the Supervisor and Supervisee should embrace and practice ethical and professional conduct.
8. The completed log sheet must be attached as appendix in the IR and FYP report for submission.

No	Date	Items for discussion (Noted by student before supervisory meeting)	Record of discussion (Noted by student during supervisory meeting):	Action List (To be undertaken by student by the next supervisory meeting):	Supervisor Confirmation (Please sign)	Notes
2	17-Feb-25	1. Review experimental data collection plan. 2. Structure for Chapter 4 – Results. 3. Data logging format and tools.	1- Supervisor approved experiment plan and emphasized consistent data collection. 2- Guidance provided on presenting results using tables, charts, and comparisons. 3- Agreed on using Excel and MATLAB for result visualization.	1- Collect test data and create initial figures. 2- Draft Chapter 4 layout with headings.	fatin	

Supervisory Sessions Log Sheet (undergraduate Programmes)

No	Date	Items for discussion (Noted by student before supervisory meeting)	Record of discussion (Noted by student during supervisory meeting):	Action List (To be undertaken by student by the next supervisory meeting):	Supervisor Confirmation (Please sign)	Notes
4	3-Mar-25	1. Preliminary results from coconut ester vs. Crude oil base mud tests. 2. Graphical representation of data. 3. Integration of results into Chapter 4.	1. Reviewed initial graphs; improvements in scaling and labelling suggested. 2. Discussed control vs. treated groups in toxicity tests. 3. Supervisor emphasized clarity in trends and patterns.	1. Update graphs and tables. 2. Start writing Chapter 4 with figure captions and interpretations.	fatin	
6	17-Mar-25	1. Completion of Chapter 4 draft. 2. Outline for Chapter 5 – Discussion. 3. Connecting results to existing literature.	1- Supervisor accepted Chapter 4 with minor revisions. 2- Emphasized the need for deep analysis of findings in Chapter 5. 3- Suggested relating findings to environmental impact and UNSDGs.	1- Revise Chapter 4. 2- Begin Chapter 5 with subheadings: toxicity, biodegradability, sustainability.	fatin	
8	31-Mar-26	1. Progress on Chapter 5 – Discussion. 2. Interpreting unexpected or conflicting results.	1. Supervisor highlighted strength in linking findings to eco-safety. 2. Advised explaining variability and possible experimental error.	1. Complete full draft of Chapter 5. 2. Find recent studies supporting interpretation.	fatin	

Supervisory Sessions Log Sheet (undergraduate Programmes)

No	Date	Items for discussion (Noted by student before supervisory meeting)	Record of discussion (Noted by student during supervisory meeting):	Action List (To be undertaken by student by the next supervisory meeting):	Supervisor Confirmation (Please sign)	Notes
		3. Relevance to real-world drilling fluid practices.	3. Discussed commercial feasibility of coconut ester.			
10	14-Apr-26	1. Review full Chapter 5. 2. Planning Chapter 6 – Conclusion & Recommendations. 3. Highlighting major findings.	1. Supervisor approved depth of discussion and critical evaluation. 2. Shared format for Chapter 6: summary, implications, recommendations. 3. Discussed inclusion of future research directions.	1. Draft Chapter 6. 2. Summarize each chapter's main outcome clearly.	fatin	
12	28-Apr-25	1. Review draft of Chapter 6. 2. Final editing across all chapters. 3. Plagiarism check and formatting.	1. Supervisor suggested enhancing conclusion strength and clarity. 2. Recommended reviewing citations and references. 3. Formatting and submission template discussed.	1. Finalize Chapter 6. 2. Edit full report and run Turnitin check. 3. Final report submission	fatin	

Version 2.0_20211101 Supervisory Sessions Log Sheet (Undergraduate Programmes) Page | 3

Supervisory Sessions Log Sheet (undergraduate Programmes)

No	Date	Items for discussion (Noted by student before supervisory meeting)	Record of discussion (Noted by student during supervisory meeting):	Action List (To be undertaken by student by the next supervisory meeting):	Supervisor Confirmation (Please sign)	Notes
14	3-May-25	1. Full thesis submission review. 2. Viva or presentation preparation.	1. Supervisor approved report for submission with minor formatting tweaks. 2. Discussed key talking points for viva. 3. Submission checklist reviewed.	1. Submit final FYP report. 2. Prepare slides for final presentation.	fatin	

Note: Student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged

Appendix B
Project Selection

24	TP054220	MOHAMED ABDELMOHSEN IBRAHIM (	PE	APU4F2408	20240173	The Toxicity Effect and Biodegradability of Coconut Ester	Dr Husna

Appendix C
Project Specification Form

PROJECT SPECIFICATION/PROJECT BRIEF OF ENGINEERING

FYP Title: The Toxicity Effect and Biodegradability of Coconut Ester

Supervisee Name: MOHAMED ABDELMOHSEN IBRAHIM OTHMAN

Supervisee TP Number: TP054220

Programme: PETROLEUM ENGINEERING (PE)

Supervisor Name: HUSNA AINI BINTI SWARN O

Supervisor Signature:

Date: 15 OCTOBER 2024

1

The following should be highlighted in the project specification /brief: (Form attached below)

A. Project Title.

B. Brief description on project background. (.i.e. introduction and problem statement)

C. Brief description of project aim and objectives. (i.e. scope of proposal)

D. Brief description of the system/model/design that will be used in this proposal.

E. Academic research is being carried out and other information, and techniques are being learned. (i.e. literature - what are the names of books you are going to read / data sets you are going to use)

F. Brief description of the materials/methodologies needed by the proposal.
(i.e. data collection methods, motors, sensor and etc.)

G. Brief description of the evaluation and analysis proposed for this project.
(i.e. testing, project deliverables, and hypothesis, correlation test, etc)

H. Illustration of how this project will benefit in the future.

Project Specification Form (Engineering)

Note: The PSF is an online submission. Use this form to discuss your proposal with your supervisor. Please complete all sections before meeting your supervisor so that relevant comments can be furnished.

A. Project Title.

The Toxicity Effect and Biodegradability of Coconut Ester

B. Brief description on project background. (.i.e. Introduction about project and problem statement)

Exploration of oil and gas is central to filling the world's power needs, nevertheless, it has adverse impacts on the physical surroundings, in particular the drilling fluids. Oil-based mud (OBM), used in drilling processes, consists of different chemical compositions that should not be allowed to affect the marine ecosystem, still more so in offshore operations. When released into the ocean these additives can cause pollution that in turn makes the water and the aquatic life in general. There is pressure and a need to work towards 'green solutions that are sustainable in the oil and gas industry with regards to environmental impacts.

Currently, coconut ester extorted from coconut oil appears as a possible green substitute for the chemical additives used in OBM. This research will seek to evaluate the toxicity and biodegradability of coconut ester and thereafter compare it with those of sarapar mud, another biodegradable drilling fluid, to ascertain whether it is an environmentally safer fluid for use in drilling operations. This research study supports the UNSDGs 7, 9, and 13 as it encourages the use of efficient energy and innovation, and frames measures against climate change.

C. Brief description of project aim and objectives. (i.e. scope of proposal)

Aim:

The first aim of this study is to determine the toxicological and biodegradation characteristics of C2P when it is used in drilling fluids and analyze its impact on the sarapar mud. Coconut ester and sarapar mud will be tested on marine organisms to compare their level of toxicity. Also, the evaluation of the biodegradation of coconut ester and sarapar mud under offshore marine environments will be measured to know their conformity of assimilation. The objective of this study is to assess the possibilities of the replacement of common additives utilized in the drilling fluids with coconut ester, considering the negative effects on the environment. By comparing this study, the effectiveness of the coconut ester in improving the properties of drilling fluid will be established against that of the sarapar mud to make a case for drilling in a more environmentally friendly manner.

Objectives:

1. To analyze the toxicity of coconut ester and sarapar mud on marine life.

2. To measure the biodegradability of coconut ester and sarapar mud in an offshore marine environment.

3. To test the toxicity of coconut ester mud compared with the sarapar.

4. To test the biodegradation rate of coconut ester mud compared with sarapar.

5. Buying ten gappy fishes and conducting the test using the coconut ester to check the toxicity of coconut ester based on the fish's lives which will live and which will die based on the amount of the ester added to the aquarium.

D. Brief description of the system/model/design that will be used in this proposal.

The project will use an experimental setup to assess the toxicity and biodegradability of coconut ester compared to sarapar mud. Guppy fish will be used to observe toxicity levels under controlled laboratory conditions. For biodegradability, a standard test for organic compound breakdown in aquatic environments will be employed. The design will consist of multiple tanks, each representing different concentrations of coconut ester and sarapar mud to ensure an accurate comparison.

E. Academic research being carried out and other information, techniques being learnt. (i.e. literature - what are the names of books you are going to read / data sets you are going to use)

To support the project, the following academic resources will be reviewed:

1. Journals on biodegradability and toxicity of organic esters.
2. Studies on environmentally safe drilling fluids and their impact on marine ecosystems.
3. Relevant books on petroleum engineering, drilling fluid chemistry, and environmental sustainability.

Potential sources include:

1. "Biodegradable Drilling Fluids: Advances and Applications" – focusing on green additives in the oil industry.
2. "Environmental Impact of Oil and Gas Exploration" – detailing the risks posed by traditional OBM.
3. Research articles on coconut-based biofuels and their environmental performance.

F. Brief description of the materials/methodologies needed by the proposal. (i.e. data collection methods, equipment's, testing and etc.)

Materials:

1. Guppy fish (for toxicity tests).
2. Coconut ester (test substance).
3. Sarapar mud (control substance).
4. Aquatic tanks and equipment for maintaining water quality (temperature, pH, etc.).

Methodologies:

1. **Toxicity testing:** Guppy fish will be exposed to different concentrations of coconut ester and sarapar mud. Fish behavior and survival rates will be monitored.
2. **Biodegradability testing:** Standard biodegradability tests will be performed to evaluate how quickly coconut ester breaks down in the environment compared to sarapar mud.

G. Brief description of the evaluation and analysis proposed for this project. (i.e. testing, project deliverables and hypothesis, correlation test etc)

The project will evaluate the following:

1. Toxicity**:** The impact of coconut ester on fish health will be evaluated through mortality rates and observed behaviours.
2. Biodegradability**:** The breakdown of coconut ester in an aquatic environment will be analyzed over time.

Deliverables include a comparative analysis of the toxicity and biodegradability results, with recommendations for future use of coconut ester in drilling fluids. Hypotheses will focus on proving that coconut ester is less toxic and more biodegradable than sarapar mud, making it a suitable alternative.

H. Illustration of how this project will benefit in the future.

The findings of this research could lead to the adoption of more sustainable drilling fluids in the oil and gas industry, significantly reducing the environmental impact of offshore drilling activities. The use of biodegradable additives like coconut ester aligns with global efforts toward cleaner energy solutions and environmental protection. In the long term, this research could encourage further innovation in the development of green additives for other industrial applications.

Appendix D
ETHICS FORM

Office Record	***Receipt***
Date Received: Received by:	Student name: Student number: Received by: Date:

ACADEMIC RESEARCH ETHICS DISCLAIMER

Instruction:

The following declaration should be made in cases where applicant and the supervisor(s)/lecturer(s) of the research project/assignment conclude that it is not necessary to apply for research ethics approval for the research project/assignment.

Project/Assignment Title:

The Toxicity Effect and Biodegradability of Coconut Ester

Declaration:

We confirm that the University's guidelines for research ethics approval have been consulted and that all ethical issues and implications in relation to the above project/assignment have been considered. We confirm that research ethics approval need not be sought.

Mohamed abdelmohsen Ibrahim Othman		12/10/2024
Name of Research Project/Assignment Applicant	E-signature	Date

DR. HUSNA AINI BINTI SWARNO		12/10/2024
Name of Research Project Supervisor/ Assignment Lecturer	E-signature	Date

Appendix E
Project Gantt Chart

FYP Phase 1 Gantt Chart

ID	Task	Start Date	Due Date	Duration	2024											
					J	F	M	A	M	J	J	A	S	O	N	D
1	**CHAPTER 1: INTRODUCTION**	**16/9/2024**	**27/9/2024**	**2 WEEKS**									■			
1.1	INTRODUCTION AND RESEARCH PROBLEM	**16/9/2024**	**18/9/1024**	**3 DAYS**									■			
1.2	AIMS AND OBJECTIVES	**19/9/2024**	**21/9/2024**	**3 DAYS**									■			
1.3	JUSTIFICATION FOR THIS RESEARCH - ORGANIZATION FOR THE REST OF THE CHAPTER - SUMMARY OF CHAPTER 1	**22/9/2024**	**27/9/2024**	**6 DAYS**									■			
2	**CHAPTER 2 : LITERATURE REVIEW**	**1/10/2024**	**25/10/2024**	**25 DAYS**										■		
2.1	INTRODUCTION	**02/10/2024**	**5/10/2024**	**4 DAYS**										■		
2.2	Search for journals and summarize them from point **2.3** to point **2.12**.	**7/10/2024**	**21/10/2024**	**15 DAYS**										■		
2.3	SUMMARY OF CHAPTER 2	**22/10//2024**	**25/10/2024**	**12 DAYS**										■		
3	**CHAPTER 3 : METHODOLOGY**	**1/11/2024**	**25/11/2024**	**25 DAYS**											■	
3.1	INTRODUCTION AND INVESTIGATION OF MATERIAL	**2/11/2024**	**9/11/2024**	**8 DAYS**											■	
3.2	PHASE 1 AND PHASE 2 OF THE EXPERIMENT	**10/11/2024**	**15/11/2024**	**6 DAYS**											■	
3.3	CONCEPT DESIGN - DRILLING MUD PREPARATION - PROFESSIONAL ENGINEERING PRACTICES - PROJECT MANAGEMENT - SUMMARY OF CHAPTER 3	**15/11/2024**	**25/11/2024**	**11 DAYS**											■	
4.0	**REFERENCES, APPENDICES AND FINALIZING THE REPORT FOR SUBMISSION**	**25/11/2024**	**27/11/2024**	**3 DAYS**											■	

FYP Phase 2 Gantt Chart

ID	Task	Start Date	Due Date	Duration	2030											
					J	F	M	A	M	J	J	A	S	O	N	D
5.0	**CHAPTER 4: Final Design & System Implementation**	03/02/2025	17/02/2025	2 weeks												
5.1	Synthesis of Coconut Ester & OBM Preparation	3/02/2025	7/02/2025	5 days												
5.2	Setup of Toxicity & Biodegradability Experiments	8/02/2025	12/02/2025	5 days												
5.3	Chapter 4 Writing and Review	13/02/2025	17/02/2025	5 days												
6.0	**CHAPTER 5: Results & Discussion (Experiment Ongoing)**	18/02/2025	31/03/2025	6 weeks												
6.1	Toxicity Testing Observation (96 hours x 2 repetitions)	18/02/2025	25/02/2025	1 week												
6.2	Biodegradability Test Monitoring (OECD 301, 28 days)	18/02/2025	18/03/2025	4 weeks												
6.3	Data Collection, Charting, Analysis	19/03/2025	26/03/2025	1 week												
6.4	Chapter 5 Writing and Editing	27/03/2025	31/03/2025	5 days												
7.0	**CHAPTER 6: Conclusion and Recommendations**	1/04/2025	10/04/2025	10 days												
8.0	FINAL COMPILATION, FORMATTING & BINDING	11/04/2025	20/04/2025	10 days												
9.0	PRESENTATION PREPARATION	21/04/2025	27/04/2025	1 week												
10.0	**SUBMISSION AND FINAL Report**	28/04/2025	30/04/2025	3 days												

Appendix F
TURNITIN REPORT

MOHAMED ABDELMOHSEN IBRAHIM TP054220 (FYP1).docx

ORIGINALITY REPORT

12%	8%	6%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Asia Pacific University College of Technology and Innovation (UCTI) Student Paper	4%
2	www.genaqua.org Internet Source	1%
3	pubag.nal.usda.gov Internet Source	1%
4	china.iopscience.iop.org Internet Source	1%
5	www.researchgate.net Internet Source	<1%
6	worldwidescience.org Internet Source	<1%
7	cris.bgu.ac.il Internet Source	<1%
8	www.springermedizin.de Internet Source	<1%
9	Jitendra Kumar Katiyar, Mir Irfan Ul Haq, Ankush Raina, S. Jayalakshmi, R. Arvind Singh. "Tribology and Sustainability", CRC Press, 2021 Publication	<1%
10	abas.journals.ekb.eg Internet Source	<1%
11	www.peeref.com Internet Source	<1%

12	"Proceedings of the International Field Exploration and Development Conference 2019", Springer Science and Business Media LLC, 2020 Publication	<1%
13	M. Enamul Hossain, Abdulaziz Abdullah Al-Majed. "Fundamentals of Sustainable Drilling Engineering", Wiley, 2015 Publication	<1%
14	onlinelibrary.wiley.com Internet Source	<1%
15	www.authorstream.com Internet Source	<1%
16	S. Ganesh, B. Harish, V. Shashank, S. Akash, B. Harish. "Performance evaluation of glycerol and coconut oil added cutting fluid in EN31 turning process", Materials Today: Proceedings, 2023 Publication	<1%
17	F Prihapsara, M Harini, T Widiyani, A N Artanti, I L Ani. " Antidiabetic Activity of Self Nanoemulsifying Drug Delivery System from Bay Leaves (Wight) Ethyl Acetate Fraction ", IOP Conference Series: Materials Science and Engineering, 2017 Publication	<1%
18	Oluwatoyin Veronica Odubanjo, Ayo Emmanuel Oluwarotimi, Comfort Oluwatosin Ayeni, Henry Oluwatosin Akingbola et al. "Fatty acid composition and antioxidant effect of coconut oil in Drosophila melanogaster", Comparative Clinical Pathology, 2020 Publication	<1%
19	www.science.gov Internet Source	<1%

20	Renlong Liu, Youqin Long, Yuhe Zhou, Zuohua Liu, Xin Liu, Xuejian Huo, Zhaoming Xie, Changyuan Tao. "Rigid-Flexible Combined Impeller Enhancement in Leaching of Phosphate Rock: a Kinetics Study", ACS Omega, 2021 Publication	<1 %
21	scholar.sun.ac.za Internet Source	<1 %
22	www.grafiati.com Internet Source	<1 %
23	www.nature.com Internet Source	<1 %
24	"VLSI Design and Test", Springer Science and Business Media LLC, 2019 Publication	<1 %
25	Hani AL Khalaf, Gabriella Federer Kovacsne, Nagham Alhaj Mohammed, Gabor Horvath, Roland Docs. "Effect of using Austrian pine cones powder as an additive on oil well cement properties", Heliyon, 2023 Publication	<1 %
26	aacrjournals.org Internet Source	<1 %
27	link.springer.com Internet Source	<1 %
28	Adamczak, Robert L., Robert J. Benzing, and Herbert. Schwenker. "ADVANCED LUBRICANTS AND LUBRICATION TECHNIQUES", Industrial & Engineering Chemistry, 1964. Publication	<1 %
29	utpedia.utp.edu.my Internet Source	<1 %

30	Nabajit Dev Choudhury, Niharendu Saha, Shubrajit Bhaumik, Rupam Kataki. "Production and evaluation of physicochemical, rheological, and tribological properties of Cucurbita pepo L. seed oil", Biomass Conversion and Biorefinery, 2021 Publication	<1 %
31	Subramani Narayanasarma, Biju T. Kuzhiveli. "Evaluation of lubricant properties of polyolester oil blended with sesame oil-An experimental investigation", Journal of Cleaner Production, 2021 Publication	<1 %
32	Vimal Edachery, Sindhu Ravi, Aliya Farook Badiuddin, Abel Tomy, Satish V. Kailas, P.S. Suvin. "Wetting behaviour of a Green cutting fluid (GCF); influence of surface roughness and surface energy of AA5052, Ti6Al4V and EN31", Materials Today: Proceedings, 2022 Publication	<1 %
33	dione.lib.unipi.gr Internet Source	<1 %
34	mts.intechopen.com Internet Source	<1 %
35	Christian Larbi Ayisi, Jinliang Zhao, Chen Yame, Andrews Apraku, Grace Debra. "Effects of replacing fish oil with palm oil in diets of Nile tilapia (Oreochromis niloticus) on muscle biochemical composition, enzyme activities, and mRNA expression of growth-related genes", Fisheries and Aquatic Sciences, 2019 Publication	<1 %