

**THE USE OF COCONUT FIBRE AS STANDARD pH ENHANCER FOR DRILLING  
MUD FORMULATION**

**BY:**

**ONYIA GODSFAVOUR UGOCHUKWU**

**ENG2002629**

**DEPARTMENT OF PETROLEUM ENGINEERING,**

**FACULTY OF ENGINEERING**

**UNIVERSITY OF BENIN, BENIN CITY.**

**NIGERIA.**

**THE USE OF COCONUT FIBRE AS STANDARD pH ENHANCER FOR DRILLING  
MUD FORMULATION**

**BY:**

**ONYIA GODSFAVOUR UGOCHUKWU  
ENG2002629**

**A THESIS SUBMITTED TO  
DEPARTMENT OF PETROLEUM ENGINEERING,  
FACULTY OF ENGINEERING  
UNIVERSITY OF BENIN, BENIN CITY.  
NIGERIA.  
FEBRUARY, 2025.**

**IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF  
BACHELOR OF ENGINEERING, B.ENG IN PETROLEUM ENGINEERING.**

## **CERTIFICATION**

This is to certify that this thesis was carried out by **ONYIA GODSFAVOUR UGOCHUKWU** and it has been supervised, examined and approved in partial fulfillment of the requirements for the award of **BACHELOR OF ENGINEERING, B.ENG** In petroleum Engineering, University of Benin, Benin city.

\_\_\_\_\_  
**ENGR. N. J. ISUK**  
(Project Supervisor)

Date.....

\_\_\_\_\_  
**ENGR. (DR.) I OHENHEN**  
(Head of Department)

Date.....

\_\_\_\_\_  
**PROF. S. O ISEHUNWA**  
(External supervisor)

Date.....

## **DEDICATION**

This project is dedicated to **God almighty** for his unending love, blessing and grace he granted me and made it possible for me to complete this course and to my lovely parent **MR & MRS. OLIVER O. ONYIA**, for their love support and prayers and to all who have contributed unanimously towards the success of this project.

## **ACKNOWLEDGEMENT**

My sincere and profound gratitude goes to **God Almighty** the Ultimate who gave me the knowledge and understanding and for the redemption of our life and good health, he granted to me to complete the course and finally this project work.

The successful completion is a collective effort to this effect I wish to whole heartedly express my profound gratitude to those who contributed to the success of this work.

Special thanks goes to my parents **MR & MRS. OLIVER O. ONYIA**, who in the course of stay in the university encouraged and supported me financially and morally throughout the period of me writing this project, I love you and God bless you abundantly.

I am in particularly grateful to my project supervisors **ENGR. NSISONG JOHNNY ITSUK** for his diligence and advise to make the project a success.

My sincere thanks go to my Head of Department **ENGR. (DR.) I OHENHEN** for his fatherly advises he give us during lectures and meeting.

]

## TABLE OF CONTENTS

Cover Page	-	-	-	-	-	-	-	-	-	i
Title Page	-	-	-	-	-	-	-	-	-	ii
Certification	-	-	-	-	-	-	-	-	-	iii
Dedication	-	-	-	-	-	-	-	-	-	iv
Acknowledgements	-	-	-	-	-	-	-	-	-	v
Table of Contents	-	-	-	-	-	-	-	-	-	vi

### Chapter One

- 1.0 Introduction
- 1.1 Background to the Study
- 1.2 Statement of the Problem
- 1.3 Aim of the Study
- 1.4 Objectives of the Study
- 1.5 Research Questions
- 1.6 Justification/Significance of the Study
- 1.7 Scope of the Study
- 1.8 Limitations
- 1.9 Operational Definitions of Key Terms
- 1.10 Organization of the Study

### Chapter Two: Literature Review

- 2.0 Introduction
- 2.1 Concept of Coconut Fiber
- 2.2 Drilling Fluid Fundamentals & pH Importance

2.3 Conventional pH Control vs. Biomass Alternatives

2.4 Coconut-Derived Additives in Drilling Muds

2.5 Coconut Palm Tree

### **Chapter Three: Materials and Methods**

3.1 Introduction

3.2 Equipment and Apparatus Used

3.3 Preparation of the Mud Sample

3.4 Preparation of Molar Concentration Solution from Coconut Fiber

3.5 Laboratory Test

3.5.1 Measuring pH of Drilling Fluids

3.5.2 Determination of Rheological Properties

### **Chapter Four: Results and Discussion**

4.1 Results

4.2 Discussion

### **Chapter Five: Conclusions and Recommendations**

5.1 Conclusion

5.2 Recommendations

References

## ABSTRACT

In the present-day oil and gas industry, the chemicals commonly employed as pH controllers in drilling operations are largely imported at exorbitant costs. These high costs contribute significantly to the overall drilling expenditure and create ripple effects on the national economy. Hence, there is a pressing need to identify and develop locally available substitutes that are both cost-effective and environmentally friendly. This study focuses on investigating the suitability of burnt coconut fibre, a readily available agricultural by-product in Nigeria, as a pH enhancer in drilling mud formulations.

The research methodology involved the preparation of water-based mud samples treated with different concentrations of coconut fibre solution, alongside conventional additives such as sodium hydroxide (NaOH) for comparison. Laboratory analyses were conducted to determine pH variation, rheological properties, and mud density under controlled conditions. The performance of the coconut fibre was evaluated based on its ability to increase and stabilize mud alkalinity while maintaining desirable drilling fluid characteristics.

The results revealed that burnt coconut fibre imparted a significant pH value of approximately 13.0 in the drilling mud, which is comparable to the 13.8 obtained with sodium hydroxide. Additionally, the coconut fibre showed potential in enhancing rheological properties, such as yield point and gel strength, while also exhibiting eco-friendly and biodegradable characteristics. These findings demonstrate that coconut fibre can serve as a viable supplement to imported chemical additives, thereby reducing dependency on foreign products, lowering drilling costs, and supporting sustainable resource utilization.

## CHAPTER ONE

### 1.0 Introduction

Drilling fluids (mud) are essential to safe and efficient drilling operations. They perform multiple functions including transporting cuttings to surface, controlling formation pressures, cooling and lubricating the drill bit, and maintaining borehole stability. The chemical environment of a water-based drilling fluid — particularly its pH — strongly affects clay dispersion, additive performance, corrosion rates, and the solubility/stability of contaminants and chemical conditioners. Controlling and maintaining an appropriate pH is therefore a core part of drilling-fluid formulation and field maintenance.

### 1.1 Background to the Study

Conventional pH control in water-based muds commonly relies on chemical additives such as caustic soda (NaOH), soda ash (Na<sub>2</sub>CO<sub>3</sub>) and various alkaline salts. These imported or industrial chemicals may be costly, hazardous to handle, and sometimes ecologically problematic when discharged. In many producing regions, there is growing interest in locally available, low-cost and environmentally friendlier materials that can supplement or replace conventional additives. Recent research has investigated the use of biomass-derived materials — including lignocellulosic fractions, activated carbons, and natural fibres — as functional additives in drilling fluids (for pH modification, fluid-loss control, rheology modification, and lost-circulation mitigation). Studies have demonstrated that coconut-based materials (coir, fibre, shell, burnt fibre, activated carbon from fibre) can influence alkalinity, rheology and filtration characteristics of water-based muds and may serve as sustainable substitutes for some imported additives.

Coconut fibre specifically — in raw, burned (char), or processed forms — has been evaluated for several drilling applications: as lost-circulation material (LCM), as fluid-loss control, and more recently as a pH and rheology enhancer. Laboratory studies and field investigations report that addition of treated coconut fibre can raise mud alkalinity and alter rheological/filtration behaviour in ways that may be beneficial, depending on concentration and pre-treatment. This positions coconut fibre as a promising local additive for regions where coconut biomass is abundant.

## **1.2 Statement of the Problem**

Despite the potential advantages, there is limited standardised information on how coconut fibre (in its various processed forms) performs as a *standard* pH enhancer across a range of mud recipes and operational conditions. Questions remain regarding: the most effective preparation method (e.g., burning, activation, carbonisation), optimal dosing, effects on rheology and filtration, interaction with common mud chemicals (bentonite, barite, polymers), thermal stability, and environmental impacts. Without structured evaluation and formulation guidelines, operators lack confidence to substitute or supplement conventional pH chemicals with coconut-based additives.

## **1.3 Aim of the Study**

To investigate the effectiveness of coconut fibre as a standard pH enhancer in water-based drilling mud formulations and to determine its effects on mud physicochemical and rheological properties.

#### **1.4 Objectives of the Study**

1. To prepare and characterise coconut fibre in selected forms (e.g., raw, burnt/charred, activated) for use as drilling-mud additives.
2. To evaluate the effect of coconut fibre addition on the pH of standard water-based mud formulations.
3. To determine the influence of coconut fibre on rheological properties (plastic viscosity, yield point, gel strengths) and filtration loss.
4. To compare performance against conventional pH-adjusting chemicals (e.g., NaOH) and established additives.
5. To assess environmental and operational implications (e.g., biodegradability, corrosion tendency, solids management).

#### **1.5 Research Questions**

1. Which form of coconut fibre (raw, burnt, activated) is most effective at increasing/maintaining the pH of water-based drilling mud?
2. What dosage ranges of coconut fibre produce acceptable pH levels for drilling operations?
3. How does coconut fibre addition affect rheology, gel strength and fluid loss of bentonite-based muds?
4. Can coconut fibre replace part or all of conventional alkaline pH controllers without compromising mud performance?
5. What are the environmental and handling implications of using coconut fibre in drilling operations?

## **1.6 Justification/Significance of the Study**

Substituting or supplementing imported inorganic alkalis with locally sourced coconut fibre could reduce operational cost, lower handling hazards, and promote environmentally friendlier drilling practices. Demonstrating a reliable, documented methodology for using coconut fibre as a pH enhancer would support operators in coconut-producing regions to adopt sustainable additives, promote local supply chains (value-addition to agricultural waste), and potentially reduce environmental footprint of drilling operations. Prior studies have suggested positive pH and rheology effects from coconut-derived materials; this study aims to produce systematic formulation guidance and performance comparisons.

## **1.7 Scope of the Study**

This study focuses on laboratory formulation and testing of water-based drilling muds (bentonite base) amended with coconut fibre prepared by commonly available treatment routes. Tests will include pH measurement, rheology (using API rotational viscometer methods), filtration (API filter press), and basic solids/chemical characterization. Field trials are outside the scope but may be recommended as follow-up work.

## **1.8 Limitations**

Results obtained in laboratory conditions may not capture all complexities of field operations (temperature, contamination, continuous circulation).

Variability in coconut fiber properties (source, age, processing) may affect repeatability; efforts will be made to characterize feedstock.

Some advanced characterization (e.g., detailed surface chemistry, long-term biodegradation in formation) may require specialized equipment beyond the present study.

## 1.9 Operational Definitions of Key Terms

**Drilling mud (drilling fluid):** A fluid circulated in a borehole during drilling to transport cuttings, control pressure, cool and lubricate.

**pH enhancer / pH controller:** Any additive intended to raise and stabilize the alkalinity (pH) of the drilling fluid.

**Coconut fiber (coir):** Natural fibrous material extracted from the fiber of coconut; may be used raw, burnt/charred, or processed (e.g., activated carbon).

**Rheology:** Study of flow — in drilling muds typically represented by plastic viscosity, yield point, and gel strength.

**Fluid loss (filtration):** Volume of filtrate lost through a filter medium under set pressure and time, indicative of the mud's tendency to leak into formation.

## 1.10 Organization of the Study

This work is organized as follows: Chapter One (Introduction and study framework); Chapter Two (Review of related literature on drilling fluids, pH control, and coconut-based additives); Chapter Three (Materials and Methods — sample preparation, mud formulation, test methods); Chapter Four (Results and Discussion); Chapter Five (Conclusions, Recommendations and suggestions for further work)

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.0 Introduction**

A literature review is essential in academic research as it situates the study within the context of existing knowledge, highlights gaps, and justifies the need for the current work. In the petroleum industry, particularly in drilling operations, controlling the pH of drilling fluids is critical because it ensures efficient drilling performance, reduces operational risks, and enhances safety. Therefore, this review focuses on coconut fibre as a potential eco-friendly pH enhancer and its application in drilling mud formulations.

This presents the review of related literature on the use of coconut fibre as standard pH enhancer for drilling mud formulation. Views and opinions of other authors are presented as follows..

#### **2.1 Concept of Coconut Fibre**

Historically, coconut fibre has been used for centuries in maritime applications due to its durability and resistance to saltwater degradation. It has also been employed in agriculture for soil stabilization and in construction for reinforcing plasters and composites. Comparing coconut fibre with other natural fibres such as jute, sisal, hemp, and banana fibre reveals its unique advantage of high lignin content, which makes it more durable than many other lignocellulosic fibres. Coconut fibre, also known as coir, is a natural lignocellulosic fibre obtained from the mesocarp (husk) of the coconut (*Cocos nucifera* L.). It consists primarily of cellulose, hemicellulose, and lignin, giving it high durability, resistance to microbial degradation, and a coarse texture. Coconut fibre is widely used in the production of ropes, mats, brushes, mattresses, erosion control products, and as reinforcement in composite materials due to its high tensile strength and saltwater resistance (John & Thomas, 2008; van Dam et al., 2004).

Coir fibres are categorized into two main types based on their extraction stage:

- Brown fibre – extracted from mature coconuts, thick, strong, and resistant to abrasion.
- White fibre – extracted from immature coconuts, finer and more flexible.

Coconut fibre is considered an eco-friendly and renewable material because it is biodegradable and derived from a waste product of coconut processing (Satyanarayana et al., 2007).

### **Origin and Structure**

Coconut fibre, scientifically called coir, is obtained from the mesocarp (the fibrous husk) of the coconut fruit (*Cocos nucifera* L.), a tropical palm species belonging to the family *Arecaceae*. The mesocarp contains a network of lignocellulosic fibres embedded in a matrix of pith, which protects the coconut seed.

### **Composition**

Comparatively, the high lignin content of coconut fibre distinguishes it from other natural fibres, making it more suitable for applications requiring resistance to biodegradation and saltwater. In drilling mud applications, the cellulose provides flexibility, while lignin enhances durability under harsh subsurface conditions.

Chemically, coconut fibre is made up of:

- **Cellulose** (~32–43%) – gives flexibility and contributes to tensile strength.
- **Hemicellulose** (~0.15–0.25%) – supports the cellulose structure.
- **Lignin** (~40–45%) – provides rigidity, stiffness, and resistance to microbial degradation.
- Small amounts of pectin, waxes, and ash.

The high lignin content makes coir one of the most durable natural fibres and highly resistant to saltwater, unlike many other plant-based fibres (John & Thomas, 2008).

## **Types of Coconut Fibre**

**Brown fibre:** extracted from fully mature coconuts; thick, strong, and coarse; used in ropes, brushes, mattresses, mats, and erosion control nets.

**White fibre:** extracted from immature coconuts; smoother, finer, and more flexible; used in yarns, ropes, and fishing nets.

## **Extraction Process**

The fibre is separated through a process called retting, where the husk is soaked in water (traditionally in lagoons or pits) to soften and loosen the fibres. After retting, mechanical or manual defibering separates the fibres from the pith.

## **Physical and Mechanical Properties**

**Density:** 1.15–1.46 g/cm<sup>3</sup>

**Tensile strength:** ~131–175 MPa

**Elongation at break:** 15–40%

Moisture absorption: high due to hydrophilic nature.

**Abrasion resistance:** excellent.

## **Uses and Applications**

**Textile & Rope making:** due to high tensile strength.

**Brushes and mats:** because of stiffness.

**Mattresses and cushions:** due to elasticity and resilience.

**Erosion control:** coir mats prevent soil loss in slope protection.

**Composite materials:** reinforcement in polymer matrices for eco-friendly products.

**Agriculture:** coir pith as a soil conditioner and growing medium.

### **Environmental Significance**

Coconut fibre is renewable, biodegradable, and often a by-product of coconut processing, making it an eco-friendly alternative to synthetic fibres. Its use also helps reduce agricultural waste and supports rural economies in coconut-producing regions (Satyanarayana et al., 2007).

## **2.2 Drilling Fluid Fundamentals & pH Importance**

Drilling fluids are broadly classified into water-based, oil-based, and synthetic-based muds, each with specific pH control requirements. For instance, water-based muds typically maintain a pH between 8.5 and 10.5, while oil-based muds require slightly different conditions. Poor pH control may lead to corrosion of drill strings, dispersion of clays, wellbore instability, and ultimately higher drilling costs.

Drilling fluids must maintain an alkaline pH to mitigate corrosion, inhibit clay swelling, and ensure optimal performance of viscosity-control additives. Alkalinity in water-based muds relies on ions like  $\text{OH}^-$ ,  $\text{HCO}_3^-$ , and  $\text{CO}_3^{2-}$ ; accurate pH measurement typically uses calibrated meters.

## **2.3 Conventional pH Control vs. Biomass Alternatives**

Biomass alternatives to conventional pH enhancers include plantain peel ash, rice husk ash, palm kernel shell, and groundnut shell ash. These materials are abundant in many oil-producing regions and offer cost-effective, environmentally sustainable

solutions. Studies have shown that these biomass sources contain alkaline oxides that contribute to pH enhancement.

Standard pH enhancers (e.g., NaOH, Na<sub>2</sub>CO<sub>3</sub>) are effective but imported, costly, and potentially environmentally hazardous. Growing interest in biomass-based alternatives has led to evaluation of local, sustainable substitutes such as coconut-derived materials.

#### **2.4 Coconut-Derived Additives in Drilling Muds**

Several studies have compared coconut-based additives with conventional ones. For instance, coconut shell ash has been shown to enhance mud rheology and filtration properties. Coir pith has been explored as a filtration control agent, while coconut oil derivatives have been tested as lubricants in drilling fluids.

**Activated carbon from coconut fibre** raised mud pH to 13.0 versus 13.5 from NaOH, while achieving cost savings (\$6.18 vs. \$7.15 per barrel)

**Coconut fibre (coir)**, when dried, ground and oven-treated, increased pH from 9.0 to approximately 9.2–9.5, also improving rheology and fluid-loss characteristics; an optimal yield point ( $\approx 20$  lb/100 ft<sup>2</sup>) was achieved at  $\sim 3.5$  g fibre dosing

**Coconut fibre ash**, when paired with bentonite, enhanced mud properties; an effective dosage ranged from  $\sim 6$  g to 15 g per sample

**Powdered coconut fibre** (varied mesh sizes) improved pH, gel strength, and filtration control; finer mesh (10–40  $\mu$ m) showed better overall performance.

## 2.5 Coconut Palm Tree

Globally, coconut production exceeds 60 million tonnes annually, with the Philippines, Indonesia, and India leading producers. In Nigeria, coconut farming is gaining momentum, particularly in coastal states like Lagos, Ogun, and Akwa Ibom. This ensures the local availability of coconut husks and fibres for industrial applications such as drilling mud formulation. The integration of coconut by-products into petroleum engineering practices not only adds value but also aligns with sustainable development goals.

The coconut tree (*Cocos nucifera*) is a member of the palm tree family (*Arecaceae*) and the only living species of the genus *Cocos* (Pearsall, 1999). The term "coconut" (or the archaic "cocoanut") can refer to the whole coconut palm, the seed, or the fruit, which botanically is a drupe, not a nut. The term is derived from the 16th-century Portuguese and Spanish word *coco* meaning "head" or "skull" after the three indentations on the coconut shell that resemble facial features (Pearsall, 1999).

Coconuts are known for their versatility of uses, ranging from food to cosmetics (Elzebroek and Koop, 2008). The inner flesh of the mature seed forms a regular part of the diets of many people in the tropics and subtropics. Coconuts are distinct from other fruits because their endosperm contains a large quantity of clear liquid, called "coconut milk" in the literature, and when immature, may be harvested for their potable "coconut water", also called "coconut juice" (Elzebroek and Koop, 2008).

Mature, ripe coconuts can be used as edible seeds, or processed for oil and plant milk from the flesh, charcoal from the hard shell, and coir from the fibrous fibre. Dried coconut flesh is called copra, and the oil and milk derived from it are commonly used in cooking – frying in particular – as well as in soaps and cosmetics. The hard shells, fibrous fibres and long pinnate leaves can be used as material to make a variety of products for furnishing and decorating. The coconut also has cultural and

religious significance in certain societies, particularly in India, where it is used in Hindu rituals (Rosengarten, 2004).

Coconut palm is one of the most important crops of the tropics. The slender, leaning, ringed trunk of the tree rises to a height of up to 25 m (80 feet) from a swollen base and is surmounted by a graceful crown of giant, featherlike leaves. Mature fruits, ovoid or ellipsoid in shape, 300–450 mm (12–18 inches) in length, and 150–200 mm in diameter, have a thick, fibrous fibre surrounding the familiar single-seeded nut of commerce. A hard shell encloses the insignificant embryo with its abundant endosperm, composed of both meat and liquid (Grimwood et al; 2005).

Coconut fruits float readily and have been dispersed widely by ocean currents and by humans throughout the tropics; they probably originated somewhere in Indo-Malaya. Marco Polo was among the first Europeans to describe coconuts.

Coconut palms flourish best close to the sea on low-lying areas a few feet above high water where there is circulating groundwater and an ample rainfall. Most of the world's coconuts are produced on small native plantations. Propagation is by unfibred ripe nuts. These are laid on their sides close together in nursery beds and almost covered with soil. After 4 to 10 months the seedlings are transplanted to the field, where they are spaced at distances of 8–10 m. Palms usually start bearing after 5 to 6 years. Full bearing is obtained in 15 years. Fruits require a year to ripen; the annual yield per tree may reach 100, but 50 is considered good. Yields continue profitably until trees are about 50 years old.

The harvested coconut yields copra (q.v.), the dried extracted kernel, or meat, from which coconut oil, the world's ranking vegetable oil, is expressed. The Philippines and Indonesia lead in copra production, and throughout the South Pacific copra is one of the most important export products. The meat may also be grated and

mixed with water to make coconut milk, used in cooking and as a substitute for cow's milk.

Although the coconut finds its greatest commercial utilization in the industrial countries of the Western world, its usefulness in its native areas of culture is even greater. Indonesians claim that coconuts have as many uses as there are days in a year. Besides the edible kernels and the drink obtained from green nuts, the fibre yields coir (q.v.), a fibre highly resistant to salt water and used in the manufacture of ropes, mats, baskets, brushes, and brooms.

Other useful products derived from the coconut palm include toddy, palm cabbage, and construction materials. Toddy, a beverage drunk fresh, fermented, or distilled, is produced from the sweetish sap yielded by the young flower stalks when wounded or cut; toddy is also a source of sugar and alcohol. Palm cabbage, the delicate young bud cut from the top of the tree, is, like the buds from other palms, eaten as a salad vegetable. Mature palm leaves are used in thatching and weaving baskets. The fibrous, decay-resistant tree trunk is incorporated into the construction of huts; it is also exported as a cabinet wood called porcupine wood.

## **CHAPTER THREE**

### **MATERIALS AND METHODS**

#### **3.1 Introduction**

A sound methodology is the backbone of any scientific research as it provides the framework through which data are collected, analyzed, and validated. The materials chosen for this study—coconut fibre, bentonite, caustic soda (NaOH), and distilled water—are not arbitrary. Coconut fibre was selected due to its availability, eco-friendliness, and promising results in previous studies as a pH enhancer. Bentonite was chosen as the base clay because of its widespread use in drilling fluids. Distilled water ensured purity, avoiding contamination that might alter results.

The local sourcing of coconut fibre further highlights the potential for cost-effective and sustainable drilling fluid additives in Nigeria's petroleum industry. This section details the materials, equipment, preparation methods, and testing procedures adopted for the study to ensure accuracy, reproducibility, and reliability.

For the purpose of this work, the materials required in this research are; coconut fibre (fibre), bentonite clay, caustic soda (NaOH) as reagent and distilled water. The coconut fibre was sourced locally.

#### **3.2 Equipment and Apparatus Used**

**Table 3.1: Equipment and Specifications**

<b>Equipment</b>	<b>Specification/Role</b>
Mud Mixer	Multi-beach, used for homogenizing mud samples
Measuring Cylinder	500 ml, accuracy $\pm 0.5$ ml
Spatula	Stainless steel, used for stirring and transfer
Weighing Balance	Digital, accuracy $\pm 0.01$ g
Mud Balance	Standard OFITE type, for mud density measurement
Filter Paper	Whatman No. 42, for separating fibre residue
Beaker	250 ml and 500 ml, for solution preparation

**Safety Precautions:**

- Use of gloves, lab coats, and protective eyewear.
- Proper handling of caustic soda due to its corrosive nature.
- Adequate ventilation during burning of coconut fibre.
- Proper disposal of chemical waste in compliance with laboratory standards

**3.3 Preparation of the Mud Sample**

The mud samples were prepared at three concentrations—high, medium, and low—to simulate different field conditions encountered in drilling operations. The concentrations were chosen to reflect industry practices where mud density is adjusted based on formation pressure and drilling requirements.

1. The clay samples - high concentration (24.5g of clay) mud,
2. medium concentration (21.0g of clay) mud and
3. low concentration (17g of clay) mud were prepared accordingly with the addition of 350ml of water.

Formula for mud preparation:

$$\text{Mud concentration (g/ml)} = \text{Mass of clay (g)} / \text{Volume of water (ml)}$$

The water used was distilled and confirmed to be neutral (pH  $\approx$  7). The mud mixer was operated at 11,500 rpm for 5 minutes to ensure homogeneity. All prepared mud samples were stored in airtight containers to prevent contamination prior to testing.



Fig. 1: Agitation Process of Water Base mud using Mud Mixer

### 3.4 Preparation of Molar Concentration Solution from Coconut Fibre

1. Collection of coconut fibre from source (Ughelli, Delta State, Nigeria).
2. The fibre was sun dried in the open field for 7 days.
3. The dried fibres were burnt in a gas kiln and weighed using an electronic weighing balance as recommended by (Menzel, 2013).
4. 10g of the coconut fibre was dissolved in 100ml of distilled water and sieved with filter paper to obtain a molar solution.
5. Sample A was treated with caustic soda, Sample B treated with coconut fibre while Sample C was treated with bentonite. The samples are shown Fig. 2.



Fig. 2: Molar solution Prepared for the analysis

### 3.5 Laboratory Test

#### 3.5.1 Measuring pH of Drilling Fluids

The principle of pH measurement is based on detecting hydrogen ion activity in a solution. In this study, pH paper strips were used for simplicity, although it is acknowledged that digital pH meters offer greater precision

1. To the first mud sample, 1.0 mol. molar concentration of caustic soda was added into the controlled volume of 0.5, 1.0, 1.5 up to 7.0ml. The pH was determined by dipping a pH paper strips which is removed and compared the standard color change readings and were recorded at different intervals.
2. The same procedure was repeated for the second sample except that 2mol molar concentration of caustic soda was used.
3. To the third sample, burnt coconut fibre filtrate was added at a controlled volume of 0.5, 1.0, 1.5 up to 7.0ml and the pH was also measured as stated above.
4. The mud density was measured using a mud balance.

### **3.5.2 Determination of Rheological Properties**

The rheological properties measured include viscosity, plastic viscosity, yield point, and gel strength. These properties are essential in drilling because:

Viscosity determines fluid flow resistance.

Plastic Viscosity (PV) reflects the contribution of solid particles to fluid flow.

Yield Point (YP) indicates the ability of the mud to carry drilled cuttings.

Gel Strength represents the suspension capability of mud when circulation stops.

A Fann VG viscometer was used for measurements.

Formulas Used:

$$\text{Plastic Viscosity (PV)} = \theta 600 - \theta 300$$

$$\text{Yield Point (YP)} = \theta 300 - \text{PV}$$

## CHAPTER FOUR

### RESULTS AND DISCUSSION

pH of blank mud = 9.5

pH of Burnt coconut fibre (BCF) filtrate = 13.0

Mud Temperature = 27°C

**Table 1: Results of the pH of Molar Concentration of Burnt Coconut Fibre in water**

<b>VOLUME (ml)</b>	<b>2.0 mol. Molar concentration of NaOH (causticsoda) in 350ml of water</b>	<b>pH of Molar Concentration of Burnt Coconut Fibre (BCF)+350ml of water</b>
0.5	7.5	7.3
1.0	8.0	7.5
1.5	8.5	8.0
2.0	9.0	8.0
2.5	9.0	8.0
3.0	9.5	8.5
3.5	10.0	9.0
4.0	10.5	9.5
4.5	11.0	10.0
5.0	11.5	11.0
5.5	12.0	11.5
6.0	12.8	12.0
6.5	13.5	12.0
7.0	13.5	12.2

**Table 2: Results of the pH of Molar Concentration of NaOH + Drilling Mud and Molar Solution of Burnt Coconut Fibre in Drilling Mud**

<b>VOLUME (ml)</b>	<b>2.0 mol molar concentration of NaOH (causticsoda)+ Drilling Mud, SAMPLE A</b>	<b>pH of Molar Concentration of Burnt Coconut Husk (BCF) filtrate + Drilling Mud, SAMPLE B</b>
0.5	11	10.0
1.0	11	10.3
1.5	12	10.5
2.0	12	10.5
2.5	12.5	11.0
3.0	12.5	11.0
3.5	12.5	11.5
4.0	13.0	12.0
4.5	13.5	12.5
5.0	13.5	12.5
5.5	13.5	13.0
6.0	13.8	13.0
6.5	13.8	13.2
7.0	13.8	13.5

**Table 3: Result of Final Rheological Properties of drilling mud samples**

<b>Type of Mud</b>	<b>Viscosity Reading</b>		<b>Gel Strength</b>		<b>Rheological Properties</b>			<b>Mud Weight (ppg)</b>
	600rpm	300rpm	10esc	10mins.	Plastic Viscosity	Apparent Viscosity	Yield Point	
SampleA	40	30	25	33	10	20	20	8.65
SampleB	41	30	18	25	11	21.5	19	8.67

**Table 4: Readings of the Rheological properties of Mud containing Burnt Coconut Fibre**

<b>Volume (ml)</b>	<b>Viscosity Readings</b>		<b>Rheological Properties</b>		
	300rpm	600rpm	Plastic Viscosity	Apparent Viscosity	Yield Point
0.5	31	41	10	20.5	21
1.0	31	41	10	20.5	21
1.5	31	41	10	20.5	21
2.0	31	41	10	20.5	21
2.5	30	41	11	20.5	19
3.0	30	40	10	20	20
3.5	30	40	10	20	20
4.0	30	40	10	20	20
4.5	29	39	9	19.5	21
5.0	29	39	10	19.5	19

5.5	29	39	10	19.5	19
6.0	29	38	9	19	20
6.5	28	38	10	19	18
7.0	28	38	10	18	18

**Table 5: Results of the mud parameters obtained at the experiment**

Mud parameters	Mud Compositions	
	SAMPLEA	SAMPLEB
Mud Weight (ppg)	8.7=1.040g/cm <sup>3</sup>	9.2=1.1g/cm <sup>3</sup>
Marsh Viscosity (seconds)	37	37
Plastic Viscosity (cp)	6	7
Apparent Viscosity	11	13.5
Yield Point (lb/100ft <sup>2</sup> )	10	13
Gel Strength (lb/100ft <sup>2</sup> )	10s=8 10min=18	10sec=17 10min=32
Gel Strength, Shearometer (lb/100ft <sup>2</sup> )	10sec=4.71 0min=5.7	10sec=8.2 10min=5.3
pH	8.5	8.5

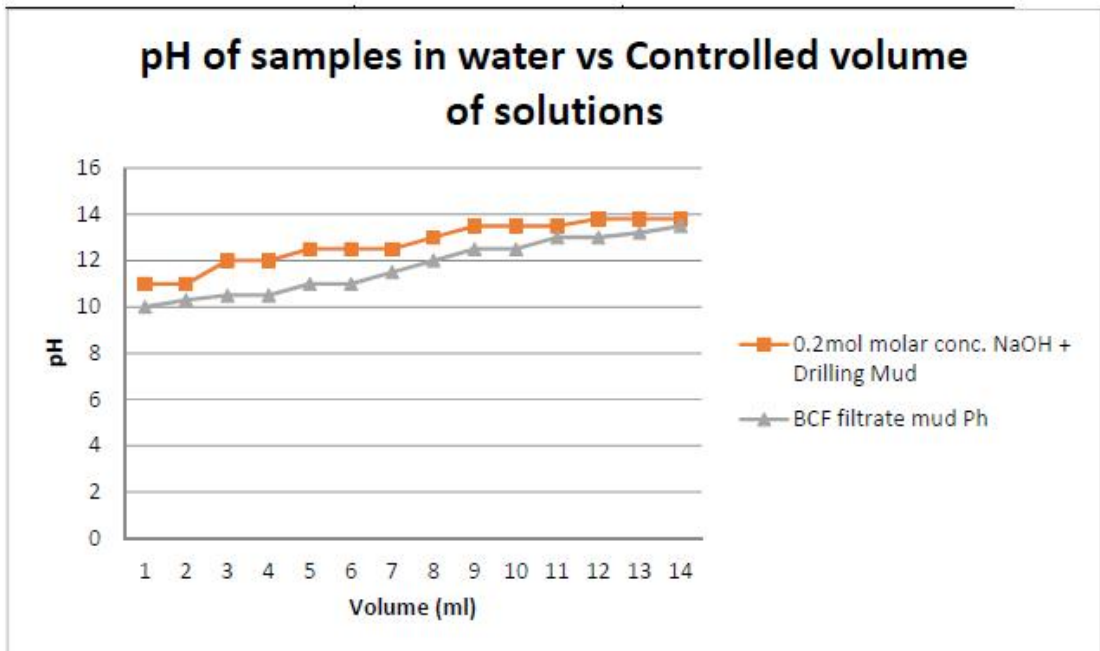


Fig. 3: A chart showing the pH of burnt coconut fibre filtrates in water

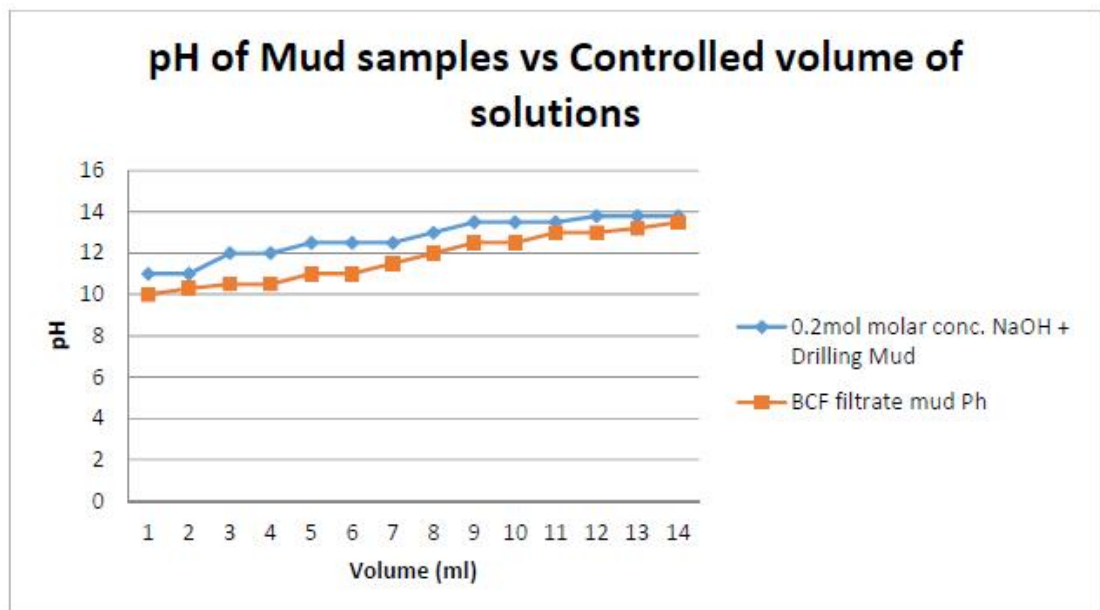


Fig. 4: A chart showing the comparison of pH of Sodium hydroxide (NaOH) with Burnt Coconut Fibre filtrates in drilling mud

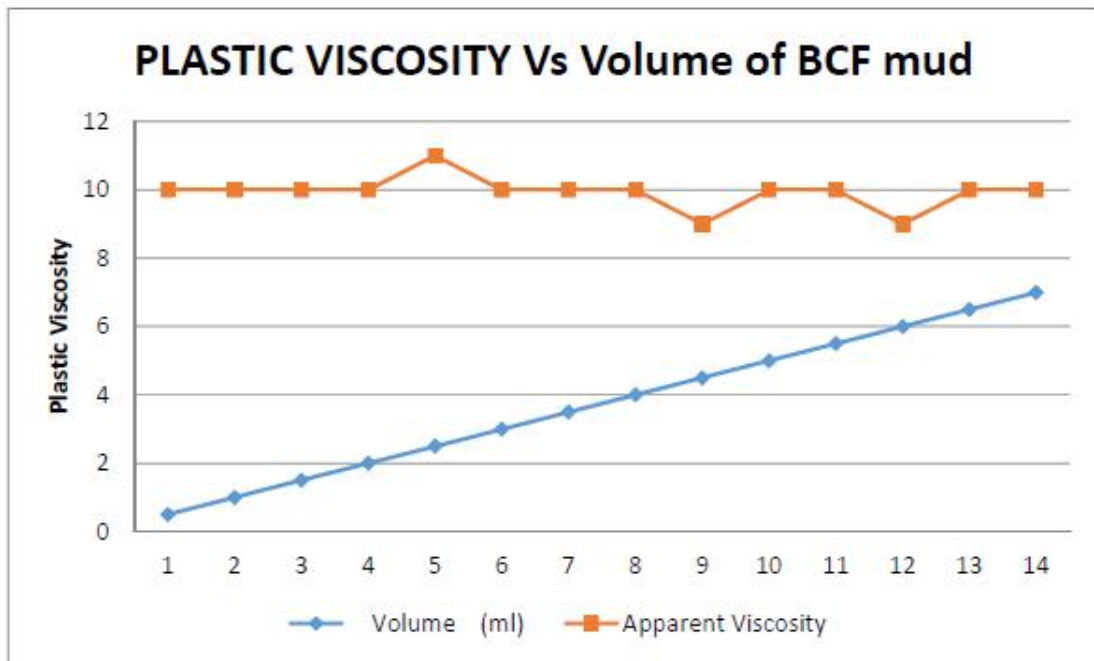


Fig. 5: A chart showing comparison between plastic viscosities of Burnt Coconut Fibre Mud

### Cost/Benefit Justification

This section gives a comparative analysis of the tested local additives and foreign additives to justify its economic prospects since the pH impartation is appreciable.

#### A. For Local Additives (Coconut Fibre)

During the experiment, coconut fibre was extracted from three coconut fruit which cost two hundred Naira (₦200.00). The coconut extract yielded 10grams of caustic soda (NaOH) from which 1.5grams gave the desired pH unit for one laboratory barrel of drilling mud.

$$1 \text{ gram} = 0.0022$$

$$\text{Thus, } 1.5 \text{ gram} = 1.5 \times 0.0022 \text{ lb}$$

$$= 0.0033 \text{ lb}$$

If 10 grams cost ₦200.00 then 1.5 grams will cost ₦15

₦15 = \$0.075

## B. Drilling Mud Economics

The economic analysis performed for Fresh Water Dispersed Drilling Fluid and Fresh Water Dispersed Drilling Fluid using Burnt Coconut fibre are presented in Table 4.5 and Table 4.6 respectively.

**Table 6: Fresh Water Dispersed Drilling Fluid**

<b>Component</b>	<b>Volume pounds (lbs)</b>	<b>Cost Unit (\$)</b>	<b>Cost Components (\$)</b>
Bentonite	25.0	0.07	1.75
Chrome Lignosulfonate	6.0	0.50	3.00
Lignite	4.0	0.30	1.20
Caustic Soda (NaOH)	4.0	0.40	1.60
Water	1.0bbl	-	-
<b>Total cost (1bbl)</b>			<b>7.15</b>

**Table 7: Fresh Water Dispersed Drilling Fluid using Burnt Coconut fibre**

<b>Component</b>	<b>Volume pounds (lbs)</b>	<b>Cost Unit (\$)</b>	<b>Cost Components (\$)</b>
Bentonite	25.0	0.07	1.75
Chrome Lignosulfonate	6.0	0.50	3.00
Lignite	4.0	0.30	1.20
Local Additives	3.0	0.075	0.225
Water	1.0bbl	-	-
<b>Total cost (1bbl)</b>			<b>6.175</b>

## Discussion

From Fig. 1, it was observed that the pH of water which was 7.0 was increased with the addition of 2.0 molar concentration of NaOH to 13.5. Moreover, further

addition of the solution did not have any effect on the pH. Also, Fig. 2, showed that the local material (i.e. the burnt coconut fibre) increased the pH of the drilling mud from 9.5 to 13.0. However, when foreign standard sodium hydroxide was used as mud pH modifier, the mud pH increased from 9.5 to 13.8. Nevertheless, it was also established from Table 4.0 and Table 4.1 that the mud pH increased significantly from 11.0 to 13.5 on addition of varying volume of 0.2mol of NaOH as compared with the pH of the mud which increased significantly from 10.0 to 12.5 in the case of the burnt coconut fibre. Nonetheless, from the Table 2 and Fig. 4, it was established that there was no significant change in plastic viscosity of the drilling mud samples containing burnt coconut fibre solution. Also, from the economic analysis, the cost of formulating laboratory barrel of drilling mud using the foreign pH additive was \$7.15, while the cost of same volume using local additive (coconut fibre) was \$6.175, the use of local additives would save a minimum of \$0.975.

## CHAPTER FIVE

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusion

From the result analysis, it was established that the local additives (coconut husk) had great effect on the mud pH significantly. The burnt coconut husk imparted a pH of 13.0. This pH value is comparable to the standard imported foreign pH additives like Sodium Hydroxide (NaOH) that imparted 13.8. It can be concluded that the foreign additives such as Sodium Hydroxide (NaOH) imparted 0.8 pH unit more than the local burnt coconut husk. From the economic justification, the use of these local additives would save a minimum of \$ 0.975 per barrel of drilling mud formulated.

#### 5.2 Recommendations

1. Adopt locally available coconut fibre or fibre ash as partial or full substitutes for conventional pH enhancers in WBM systems.
2. Standardize preparation and dosing methods (e.g., milling to 10–40  $\mu\text{m}$ ; 3.5 g dosing), tailored to performance goals.
3. Conduct field trials under real drilling conditions (e.g., elevated temperatures, high contamination).
4. Explore mixed-use approaches, combining coconut fibre with traditional additives to balance performance and cost.

## REFERENCES

- Agbabi, O. Praise (2025). powdered coconut fibre (10–40  $\mu$ m) improves pH, gel strength, filter cake
- Dune & Vipene (2024). coconut fibre improves pH and rheology (pH 9.2–9.5; optimal 3.5 g)
- Elzebroek, A.T.G. and Koop, W. (2008). *Guide to Cultivated Plants*. CABI. pp. 186–192
- Grimwood, Brian E., F. Ashman, D.A.V. Dendy, C.G. Jarman, E.C.S. Little, and W.H. Timmins. (2005). *Coconut Palm Products – Their processing in developing countries*. Rome: FAO. pp. 3–4.
- John, M. J., & Thomas, S. (2008). Biofibres and biocomposites. *Carbohydrate Polymers*, 71(3), 343–364.
- Menzel, D. (2013). “A New Weighting Material for Drilling Fluids Based on Synthetic Iron Oxide”, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 4517-MS.
- Okologume & Asaboro (2019): activated carbon raises pH (~13) and reduces cost per barrel
- Pearsall, J. (1999). *Coconut*. Concise Oxford Dictionary (10th ed.). Oxford: Clarendon Press.
- Rosengarten, F. (2004). *The Book of Edible Nuts*. Dover Publications. pp. 65–93
- Satyanarayana, K. G., Guimarães, J. L., & Wypych, F. (2007). Studies on lignocellulosic fibers of Brazil. Part I: Source, production, morphology, properties and applications. *Composites Part A: Applied Science and Manufacturing*, 38(7), 1694–1709.
- van Dam, J. E. G., van den Oever, M. J. A., Keijsers, E. R. P., van der Putten, J. C., & Anink, D. (2004). Process for production of high density/high performance binderless boards from whole coconut husk: Part 1: Lignin as intrinsic thermosetting binder resin. *Industrial Crops and Products*, 19(3), 207–216.
- Zairil Aznin & Misdan (2024). coconut fibre ash enhances bentonite mud; optimal 6–15 g