RIVERS STATE UNIVERSITY
PORT HARCOURT

CHEMICAL AND PETROCHEMICAL ENGINEERING: THE MONUMENTAL DISCOVERIES AND INNOVATIONS FOR NATIONAL DEVELOPMENT

AN INAUGURAL LECTURE

BY

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DEDICATION

This inaugural lecture is dedicated to Almighty God, the giver of all good things and whose mercy endures forever. He is worthy to be praised, honoured, and worshiped because all things were made by Him.

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Distinguished Ladies and Gentlemen

1. PREAMBLE

Vice-Chancellor, Sir, before I begin, permit me to express my sincere appreciation to Almighty God for His grace and mercy upon my life. I thank Him who said in Jeremiah 29:11-13 (KJV), "*For I know the thoughts that I think towards you, saith the LORD, thoughts of peace and not of evil to give you an expected end. For ye shall call upon me and ye shall go and pray unto me and I will hearken unto you. And ye shall seek me, and find me, when ye shall search for me with all your heart.*" With the good thoughts of God upon my life, all the challenges of life led me to an expected end. I finally found myself in the family of academics.

Vice-Chancellor, Sir, this is the 107th inaugural lecture of this great university and as a Professor of Chemical and Petrochemical Engineering, my contributions to the field engineering revolved around harnessing the knowledge of chemical engineering in the processing of waste materials discharged into the environment to useful products for national development. The raw materials used in these discoveries, which ordinarily are classified as wastes, were further converted into desired products for human utilization and national development. It is important to note that the more the wastes in the environment are harnessed for national development, the more the environment becomes developed and the more the people will rejoice over job creation and opportunity for employment.

2. MY RESEARCH INTERESTS

Chemical Engineering involves the basics of processes, design, and operation of plant in which materials undergo changes in their physical and chemical states. The processing of raw materials into useful products by the application of chemical, petrochemical, and biochemical engineering provides monumental opportunity for academics to make meaningful discoveries through responsible research and innovation for the benefit of members of the university community and the public.

Vice-Chancellor, Sir, as you may well know, the topic of today's inaugural lecture is Chemical and Petrochemical Engineering: The Monumental Discoveries and Innovations for National Development. The choice of this topic was guided by the significant contributions made so far in the field of Chemical, Petrochemical, and Biochemical Engineering driven by identified research gaps in these thematic areas and the need to unveil to the audience and society at large the outcomes of the application of my professional knowledge in the conversion of waste to wealth. As stated, these wastes are usually discharged into the environment, constituting great environmental burden and hazards. Typically, these wastes are agro-based materials, chemicals, and petrochemicals. Some of the agro-based materials are useful to the soil environment, whereas the chemical and petrochemical wastes are harmful to the soil and water environment.

Vice-Chancellor, Sir, the use of chemicals for treatment processes has adverse effects on soil and water. However, the application of biological treatment methods protects the environment from further degradation and enhances soil nutrients. For instance, the treatment of contaminated water may require the use of adsorbents; and most of the adsorbents are formulated from different agro-based materials mixed with clay. A recent study conducted in this area involved an admixture of different proportions of agro-based materials derived from plantain, banana, and palm oil fibre with clay soil to obtain different adsorbents, which were immersed in petroleum-contaminated media to determine the sorption potential and adsorption rate of the adsorbents over time in a batch process. Additionally, an adsorption process using a well-designed and fabricated packed-bed column with adequate instrumentation and control network was developed for monitoring the dependent variables of the treatment plant and to examine the significance of temperature on the performance of the adsorbents in terms of pollutant removal.

Vice-Chancellor, Sir, my research interests are in chemical, petrochemical, and biochemical engineering; and I am happy to say that I have made some monumental achievements and innovations in this field of research. Specifically, I have conducted research in the following areas: process plant design, modelling and simulation of process plant, unit operation, heat and mass transfer, corrosion, instrumentation, dynamics and control, reliability and risk analysis of chemical and petrochemical plants, biochemical processes, chemical and petrochemical process analysis, waste management, polymer, organic synthesis, and material engineering (among others).

2.1 What is Chemical Engineering and Who is a Chemical Engineer?

Chemical Engineering is the branch of engineering concerned with the design and operation of industrial chemical plants, according to Oxford Dictionary.

Chemical Engineering **involves the production and manufacturing of products through chemical processes**. This includes designing equipment, systems, and processes.

Chemical Engineering is an **engineering field, which deals with the study of operation and design of chemical plants as well as** methods of improving production.

Chemical Engineering is **a discipline influencing numerous areas of technology**. In broad terms, chemical engineers conceive and design processes to produce.

Chemical Engineering helps in the development of processes and the design and operation of plants in which materials undergo changes in their physical or chemical state. Applied throughout the process industries, **chemical engineering is founded on the principles of chemistry, physics, and mathematics.**

Chemical Engineers **play a pivotal role in how we all live, working across societies and industries globally to** achieve the Sustainable Development Goals.

Chemical Engineers **design processes to produce chemicals and materials that improve the quality of life**.

2.2 What is Petrochemical Engineering and Who is a Petrochemical Engineer?

In simple terms, petrochemical engineering is the field of engineering that deals with the exploration, extraction, production, processing, transportation, and storage of crude oil or natural gas.

Petrochemical engineering can also be described as a specialized field within Chemical Engineering that deals with the production and transformation of chemicals into petroleum and natural gas. The field integrates key concepts from various disciplines including chemistry, physics, economics, mathematics, and geology. It involves techniques and processes for refining petroleum and extracting chemicals from crude oil.

In addition, petrochemical engineering is a branch of engineering that deals with the process of converting natural resources such as crude oil, natural gas, or coal into useful products including plastics, fertilizers, and synthetic fibres. It involves the design, development, and optimization of processes and equipment used in the production of petrochemicals. This field is essential for various industries and plays a significant role in modern society.

In petrochemical engineering, engineers research and develop new ways to decompose oil and petroleum to produce petrochemical products.

2.3 Soap Production from Sawdust

2.3.1 Methods of Preparation and Soap Production

The production of liquid and bar soap is obtained by using a waste material from three different sawdust namely soft, semi-hard, and hard wood. Figure 1 illustrates the various steps or stages involved in soap production using sawdust.

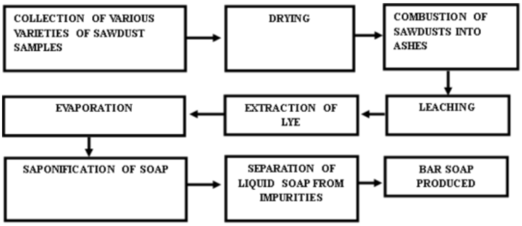

Figure 1: Block Diagram of the Steps in Soap Production

2.3.2. Collection of Dry Sawdust Samples

The first stage involves the collection of the different sawdust samples derived from soft, semi-hard, and hard wood from sawmill as demonstrated in the Plate 1.

Plate 1: Heap of Sawdust in a Sawmill Located in Port Harcourt, River State.

2.3.3 Combustion and Cooling of the Dry Sawdust

A given mass of the sawdust was introduced into the combustion chamber of the muffle furnace operated at 400°C for a period of 12 hours. The heating process enhanced the removal of moisture to obtain ash through complete combustion of the sawdust as illustrated in Plate 2.

Plate 2: Showing the Combustion of Sawdust to Whitish Ash

The ashes were recovered from the muffle furnace, transferred into a stainless-steel tray, and allowed to cool for some time before storing in an airtight container.

Plate 3: The Cooled Ash Samples Stored in Airtight Containers

2.3.4 Leaching of Sawdust Ash

1. The process involved the addition of 2 litres of distilled water to 102g of the sawdust ash in a plastic container. The mixture was then allowed to stand for 24 hours to ensure adequate leaching of the alkaline solution as illustrated in Plate 4.

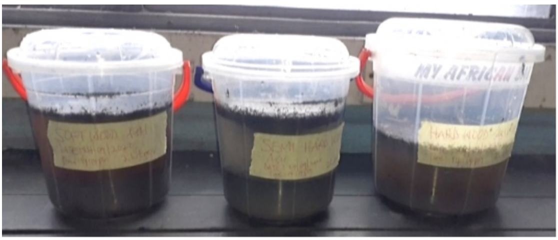

Plate 4: Leaching of Ashes from Sawdust obtained from Hard Wood, Semi-Hard Wood, and Soft Wood by Soaking in Distilled Water

2. The leached alkaline solutions were further processed by filtration whereby the ashes were separated from the alkaline solution to obtain the different lye solutions as illustrated in Plate 5.

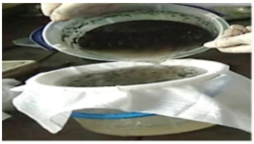
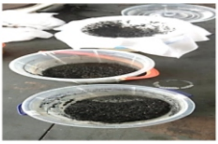
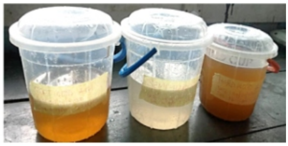

Plate 5: Filtration of the Leached Ash Samples to obtain Lye.

2.3.5 Evaporation of Extracted Potash-Lye Solution

1. The extracted potash-lye solutions from the various sources of sawdust were mixed with various quantities of distilled water to achieve different concentrations of potash-lye with each having a total volume of 200 ml as shown in Table 1.

Table 1: Extracted Potash Lye Mixed with Distilled Water

Quantity of Potash Lye (ml)	Quantity of Distilled Water (ml)	Various Mix Ratios of Potash-Lye (ml)
200	NIL	200:0
180	20	180:20
160	40	160:40
140	60	140:60
120	80	120:80
100	100	100:100

2. The various diluted Potash-Lye solutions, now having different concentrations but all of them having the same quantity of 200ml, were evaporated by boiling using an electric heater to obtain Potash-Lye with better lye strength as shown in Plate 6.

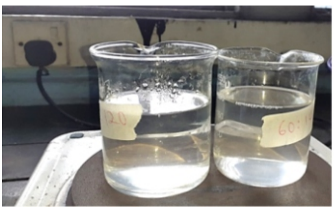
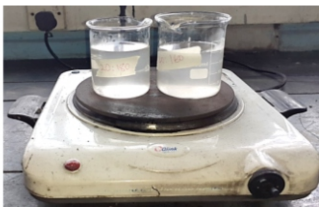

Plate 6: The Evaporation of Diluted Lye Solutions of Various Concentrations to obtain better Lye Strength.

2. The evaporated Potash-Lye were allowed to cool and stored for use.
   The produced Liquid Soaps were allowed to settle for 24 hours as demonstrated in Plate 7.

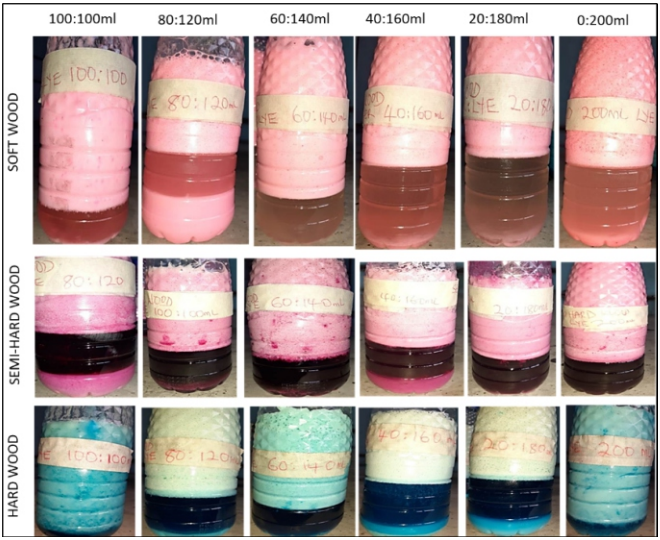

Plate 7: The Liquid Soaps Produced from Potash-Lye of different Concentrations Extracted from the Sawdust of different Varieties

After 24 hours, the liquid soaps were separated from the foams and sediments using a Separating Funnel as presented in Plate 8, which shows the mechanism used in the separation of liquid soap from the impurities. Plate 9 shows the separated and clear liquid soap samples, whereas Plate 10 shows the pictures of liquid and bar soaps made from the different sources of the sawdust samples (soft wood, semi-hard wood, and hard wood) after few weeks.

Plate 8: The Separation of Liquid Soap from Impurities using a Separating Funnel

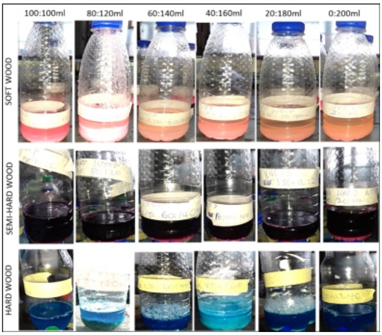

Plate 9: Separated and Clear Liquid Soap Samples

Plate 10: Picture of Liquid Soap (Top) and Bar Soap (Bottom) made from the stated starting materials after a few Weeks.

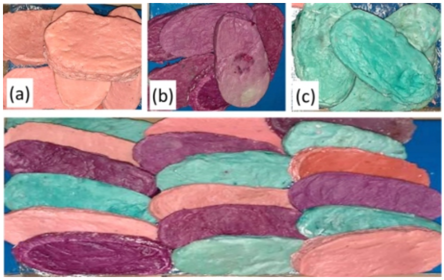

Plate 11: Picture of Bar Soaps made from the Sawdust obtained from (a) Soft Wood, (b) Semi-Hard Wood, and (c) Hard Wood after a Weeks.

2.3.6 The Effect of Mixed Ratio on Quality of Soap Produced

The effect of the mixed ratio of Potash-Lye to distilled water showed that:

- Total Alkali Content (TAC) increased with increase in distilled water volume, showing high formability.
- The pH value increased with increase in distilled water volume, showing increase in alkalinity.
- There was high penetration to remove impurities with less volume of distilled water mixed with the Lye.
- The moisture content enhanced the quality of soap produced.
- The soft-wood sawdust may increase or decrease the hardness of the soap produced.
- The soft-wood sawdust may increase or decrease the foamability heights depending on the mixed ratio.

2.3.7 Quality Indicators of the Soap Produced

The properties listed below were the quality indicators tested and compared with recommended international standard for soap production.

1. Foamability Height

2. pH
3. Dissolved Solid
4. Suspended Solid
5. Sediments
6. Foam Dispersal
7. Toxicity
8. Smoothness
9. Lather Texture
10. Solubility in water
11. Foam Capacity
12. Micro-organisms present

The result of the formability height test carried out is illustrated in Figure

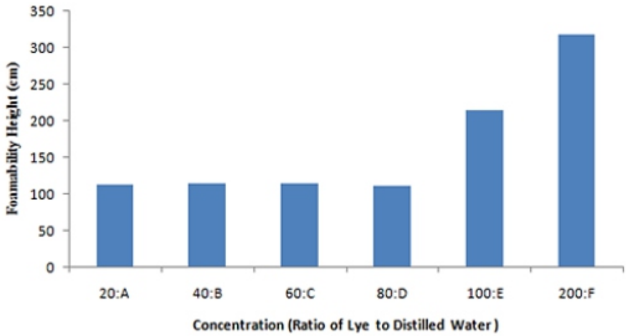

Figure 2: Effect of the Mix Ratios of Potash Lye-to-Distilled water of the Semi-Hard Wood Sawdust on the Foamability Heights of the produced Bar Soaps.

2.4 Production of Calcium Stearate Using Cow Bone and Palm Oil Extract

2.4.1 Effect of Process Conditions

Effect of Heat on Calcium Stearate: The effect of heat on calcium stearate can lead to dehydration and softness resulting from the influence of temperature above its melting point of >100°C. The calcium stearate becomes viscous within the temperature range of >160°C and soften within the temperature range of >120°C and <130°C. It is noted that within this temperature range of above 160°C, the colour of the calcium stearate changes due to the influence of heat leading to the discoloration experienced in the process. The heating of calcium stearate within the temperature of >100°C can result in about 3% moisture content reduction or weight loss, which can be attributed to water of crystallization. The process in which the calcium stearate releases water from the crystallization process is an endothermic phenomenon, which is temperature dependent. Calcium stearate is useful in the pharmaceutical, petrochemical, and food industries etc.

2.4.2 Production of Calcium Stearate from the Extraction of Calcium from Cow Bone and Stearic Acid from Palm Oil

2.4.2.1 Extraction of Calcium from Cow Bone and Stearic Acid from Palm Oil

The extraction of calcium from cow bone involves different stages as demonstrated in the flow diagram shown in Figure 3, whereas Figure 4 illustrates the flow diagram for the extraction of stearic acid from palm oil. The different stages for the extraction of calcium from cow bone are as follows:

1. Purchase of the cow bone from Abattoirs in Port Harcourt.
2. 1st washing of the cow bone.
3. 1st drying of the cow bones under the influence of atmosphere temperature.
4. Breaking of the bones.
5. 2nd washing of the bones.
6. Heating up to 80°C for fat removal.
7. 3rd washing for 2nd fat removal.
8. 2nd drying up to 80°C.
9. 3rd heating of the bone upto120°C.

10. Crushing of the bone using jaw crusher.
11. Sieving the crushed bone to get 0.8mm size.
12. Reaction process using Conc. Acid (acid digestion).
13. Neutralization of the product.
14. Separation process (decantation) (Calcium & Chaff).
15. Calcium recovery (Paste).
16. Dehydration of the paste calcium.
17. Solid calcium is formed.
18. Crushing of the solid calcium using ball mill.
19. Final product in powder form of calcium obtained.

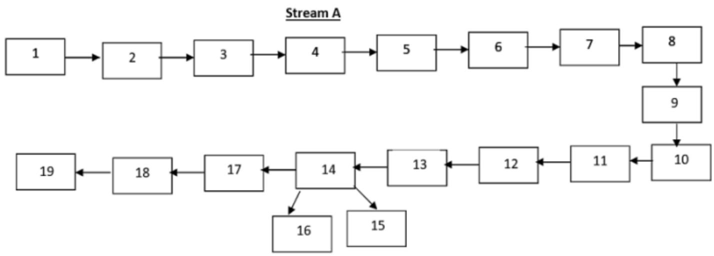

Figure 3: Flow Diagram for Extraction of Calcium from Cow Bone

The different stages for the extraction of stearic acid from palm oil are as follows:

1. Purchase of palm oil.
2. Storage of palm oil.
3. Heating (bleaching).
4. Addition of additives (base).
5. Reaction of the additives with the bleached oil.
6. Formation of Glycerin and Stearic acid.
7. Separation of the products (decantation).
8. Recovering of stearic acid (paste).
9. Dehydration of the stearic acid to solid.
10. Production of Stearate solid.

11. Crushing of solid stearate to powder form.
12. Final production (Stearate) in a container.

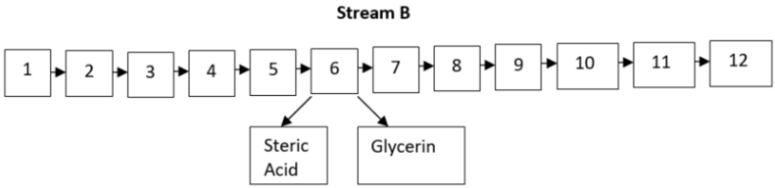

Figure 4: Flow Diagram for Extraction of Stearic Acid from Palm Oil

2.4.2.2 The Steps for Production of Calcium Stearate

The process to produce the calcium stearate involves the reaction of product of stream A and product of stream B. Stream A + Stream B, gave the calcium stearate.

Figure 5: Flow Diagram for Calcium Stearate Production

$$2C_a^{2+} + (C_{17}H_{35}COO-)_2 \rightarrow 2C_{17}H_{35}COOC_a + H_2 \uparrow$$

Plate 12 shows the cow bones. Plate 13 shows the strength reduction by hammering of the cow bones, whereas the Plate 14 demonstrates the washing of cow bones. Plate 15 illustrates the oven-drying of the cow bones. Plates 16 and 17 show the decantation the palm oil and cow bone, respectively.

Plate 12: Cow Bones

Plate 13: Hammered Cow Bones

Plate 14: Washing of Cow Bones

Plate 15: Oven Heating/Drying of Cow Bones

Plate 16: Decantation Process of Palm Oil

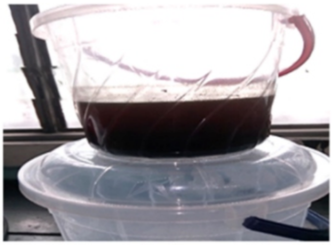

Plate 17: Decantation Process of Cow Bone

Figure 6 shows the comparison with industry standards of the pH, nitrogen, potassium, phosphate, and moisture content of the various varieties of cow bones sampled. Figure 7 shows the comparison of Pb, Ba, Mn, As, Ca, Fe, Na, K, Mg, Cd, and Cu concentrations of the produced calcium stearate with industrial standard with respect to the different varieties of the cow bone. The concentrations of magnesium, phosphorus, calcium, sodium, manganese, zinc, phosphate, iron, fatty acid, lead, barium, arsenic, and cadmium in the calcium stearate produced were also determined and compared with the industrial standard as shown in Figure 8. Figure 9 shows the comparison of N, Mg, K, Ca, Fe, Zn, PFA, iodine value, density, refractive index, saponification value, moisture content viscosity, and cloud point of the calcium stearate produced from the different varieties of cow bone compared with industrial standard. The comparison of the melting point, density, ash content, bulk density, moisture content, pH, and free fatty acid of calcium stearate produced from different varieties of the cow bone with industrial standard is shown in Figure 10. Table 2 shows the chemical names, properties, and concentrations of components of the produced calcium stearate compared with industrial standard.

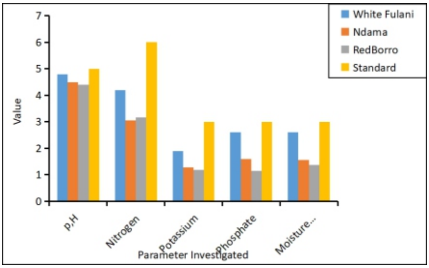

Figure 6: Comparison of pH, Nitrogen, Potassium, Phosphate, and Moisture Content versus Parameter Investigated for Different Species of Cow Bone with the Industrial Standard.

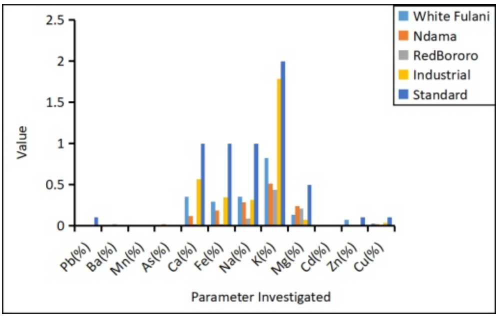

Figure 7: Comparison of Pb, Ba, Mn, As, Ca, Fe, Na, K, Mg, Cd, Zn and Cu Concentrations in the Calcium Stearate Produced from Different Species of Cow Bone with Industrial Standard.

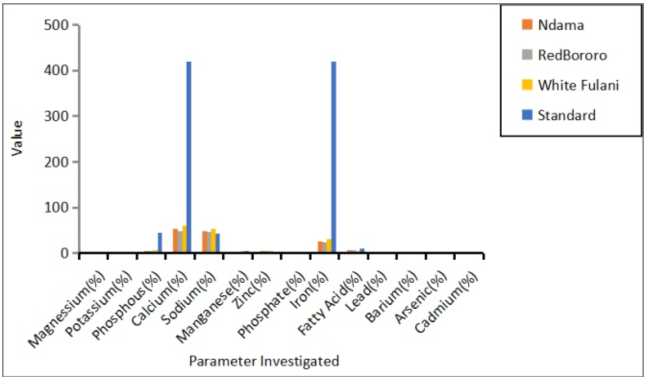

Figure 8: Comparison of Magnesium, Potassium, Phosphorus, Calcium, Sodium, Manganese, Zinc, Phosphate, Iron, Fatty Acid, Lead, Barium, Arsenic, and Cadmium Concentrations in the Calcium Stearate Produced from Different Varieties of Cow Bone with Industrial Standard.

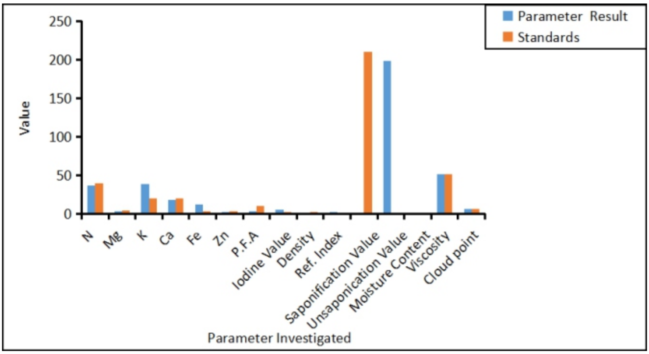

Figure 9: Comparison of N, Mg, K, Ca, Fe, Zn, P.F.A, Iodine value, Density, Ref. Index, Saponification value, Un-saponification Value, Moisture Content, Viscosity and Cloud Point in Calcium Stearate Produced from Different Varieties of Cow Bone with Industrial Standard.

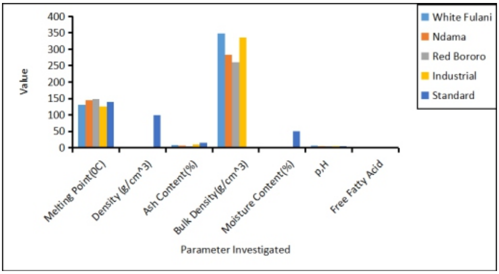

Figure 10: Comparison of Melting Point, Density, Ash Content, Bulk Density, Moisture Content, pH, and Free Fatty Acid in the Calcium Stearate Produced from Different Varieties of Cow Bone with Industrial Standard.

Table 2: Comparison of the components of Calcium Stearate Produced in this Study and the Industrial Brand

Components	Chemical Name	Concentration (ppm)	
		This Study	Industrial Brand
C_8	-	0.0197	0.0286
C_{12}	Lauric acid	0.3045	0.5935
C_{17}	Magaric acid	0.2813	0.3456
C_{14}	Myristic acid	5.4439	5.4614
C_{16}	Linoleic acid	2.6540	2.6656
C_{20}	Myristic acid	0.2187	0.4556
C_{18}	Stearic acid	48.3602	53.743

2.4.3 Areas of Usefulness

Calcium stearate can be used in the following application areas:

1. As an additive for PVC production
2. As a stabilizing agent for lead production
3. As stabilizers for organotin production
4. As a lubricant in most industrial processes
5. Useful in the window and technical profile techniques
6. Useful in the production of cable and wires
7. Useful in the production of calendared films and sheets
8. Useful in the production of plastisol
9. Useful in the production of sheets and foamed profiles

and

10. Useful in the production of pipes and fittings
11. In the pharmaceutical industry and personal care products as well as anti-tack agent and gelling agent etc.

Furthermore, calcium stearates are useful in the food production and pharmaceutical industries, they are also used as emulsifiers as well as stabilizers depending on the substance required for effectiveness of production process.

1. Calcium stearate is used as a preservative and for preventing chemicals from sticking to each other during production and transportation phases.
2. Calcium stearate is useful in preventing chemicals from sticking to the equipment during production, especially when the chemical powders are processed into tablet form. This concept is applied during the food process.
3. In the cement industry, calcium stearate is useful, in the liquid form, for preventing secondary efflorescence. The release of solvated salt into the environment may occur because of continuous exposure of cement to the atmosphere.
4. Calcium stearates are useful in the paper industry.
5. Calcium stearate is useful in the manufacturing of PVC.
6. Calcium stearate is useful in lubricating grease as product-thickening agent.

3. PRODUCTION OF LIQUID INHIBITORS FROM PLANTS FOR THE CONTROL OF METAL CORROSION

3.1 Corrosion of Metals

The deterioration of metal through an elementary process where most of the metals when in contact with water easily corrode; and the degradation of the metals is always involved in the entire process.

3.2 Factors Influencing the Corrosion Process

There are many factors that influence the corrosion process, which include (but not limited to) nature of the metal, the amount of dissolved oxygen, temperature, environment, pH, electrode potential, flow, velocity, and concentration of the corroding agent.

3.2.1 Effect of Temperature

Temperature is a critical variable in determining the corrosive nature of an aggressive metal. System temperature affects corrosion rate of metals in several ways, including:

i. Corrosion process increases in speed with rising temperature.
ii. Formation of a protective scale in acidic environments at elevated temperatures.
iii. Increasing temperature increases the aggressive nature of chloride ions in aqueous solutions by thermal activation.
iv. Increasing temperature decreases solubility of dissolved gases, which increases the pH of the environment.
v. Equilibrium constants change with temperature, which causes changes in pH.
vi. Water phase behaviour changes with temperature.

3.2.2 Effect of Oxygen

Rate of corrosion, localized attack formation is always facilitated by the oxygen in the system. The effect of oxygen when it enters any of the sour and sweet systems, as investigated by Martin, is that metal will corrode in the system in the presence of oxygen and the rate of corrosion of the metal can be attributed to the accelerated percentage of oxygen resulting from the ambient temperature and medium velocity.

3.2.3 Effect of pH

When there is an increase in the pH value of the system, it always causes a reduction in the corrosion variables, where electrochemical process is influenced, resulting in film formation of iron carbonate. When temperature is low, the only condition for formation of protective scale is that the pH must be increased to 6.

3.2.4 Influence of Velocity

The flow of fluid over a metal surface influences the corrosion rate chiefly through the effects of fluid movement on the other factors governing corrosion. In stagnant waters or waters at zero velocity, the general corrosion rate is usually low, but localized or pitting corrosion may occur. Generally, some motion in a corrosive system causes greater uniformity and results in a thinning type of corrosion rather than pitting.

3.2.5 Effect of Flow

During the corrosion process in the system, the unprotected (bare) metal surface is attached by nature of the flow regime of turbulent or laminal flow. The typical appearance of flow-shaped surfaces with shallow pits and grooves is the result of chaotic actions of near-wall turbulences.

3.3 Corrosion Control

Metal separation against corrosion agent is one of the methods of preventing deterioration of metal in the production industry. Corrosion inhibitors are used for corrosion prevention in fluid environment.

3.3.1 Application of Inhibitors

Corrosion is a destructive phenomenon that occurs when some metals are exposed to the natural environment. The reaction between air, moisture, and metal substrate gives rise to specific chemical reactions that cause the metal to convert to its more chemically-stable oxide, hydroxide, or sulfide form. In iron-based metals, such as steel, corrosion comes in the form of iron III oxides. Corrosion inhibitors can be applied either before or after conservation process. Thus, corrosion inhibitors are classified into Cathodic, Anodic, Volatile, Film, and Organic.

3.2.2 Organic Inhibitor

Organic compounds containing oxygen, nitrogen, Sulphur with multiple bonds have been classified as good corrosion inhibitors. Many organic inhibitors such as amines, aldehydes, nitro and nitroso compounds have been studied and tried as corrosion inhibitors. Organic compounds can be anodic, cathodic, and mixed types based on its reaction at the metal surface and potential. The green corrosion inhibitor chart is illustrated in Figure 11 for both natural green and synthetic green corrosion inhibitors.

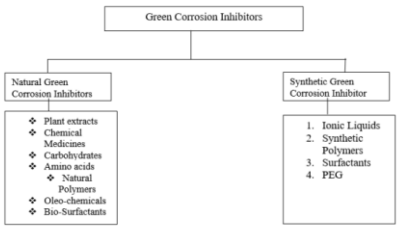

Figure 11: Green Corrosion Inhibitor Chart

3.4 Use of Plant Extracts as Corrosion Inhibitors

The hazardous nature of some anticorrosive substances is the reason emphasis is gradually shifting to alternative sources of inhibitors like natural plants. Extracts of natural plants are now known to be good sources of renewable and ecofriendly substances that can be used to produce corrosion inhibitors. Extracts from different parts of plant in earlier studies have shown that they are good and effective inhibitors of corrosion in various acid or salty environments.

3.5 Extraction of Plant Extracts

This section describes the procedures we adopted to extract and characterize organic compounds from three types of plants

Plate 18: Fresh Moringa oleifera leave (MOL)

Plate 19: Dried Coconut Coir Dust (CCD)

Plate 20: Fresh Carica papaya Leave (CPL)

i. **Reagents Preparation**

Hydrochloric acid, ethanol, acetone, and distilled water were used as reagents in the extraction process. These reagents were of analytical grades and purchased from Orient Chemical and Reagent Company located in Port Harcourt, Rivers State without further purification. While distilled water was used for the preparation of all solution, 1 mole hydrochloric acid (1.0M HCl) served as the corroding agent. The HCl was diluted with distilled water to get the 1.0M HCI. The ethanol and acetone used were in their pure states.

ii. **Extract Preparation Process**

The MOL, CCD, and CPL (obtained from a private farm in Port Harcourt, Rivers State) were air dried at a reserved area to preserve the active ingredients in the leaves. The leaves were later ground to a powdery form and 70g of it was added to 2,000 ml of distilled water. This mixture was allowed to stand for 72 hours with periodic shaking of the solution followed by filtration. The residue obtained was dried and weighed while the filtrate was used for the experiment. These procedures were repeated for each of the plant extracts.

3.6 Characterization of Plant Extracts by Gas Chromatograph-Mass Spectrometry (GC-MS)

The following equipment was used in the GC-MS analysis:

1) A 6890N Gas Chromatograph coupled to a 5975 Mass Selective Detector equipped with a 0.32-mm ID fused-silica capillary column chemically bonded with an SE-54 (DB-5 or equivalent) of 1-µm film thickness and helium gas – UHP grade as the carrier gas
2) Auto sampler vials
3) 150µL vial inserts
4) 2.5ml airtight syringe
5) 10µL auto sampler syringe
6) n-hexane
7) Anhydrous sodium sulfate
8) Plant chemicals

i. **Sample Preparation and Analysis**

About 20g and 10g of homogenized and spiked aliquots of sample were used. Anhydrous sodium sulphate was added to the sample and allowed to dry for about 30 minutes and extracted for 18 - 24 hours using methylene chloride in a Soxhlet apparatus. This was followed by evaporation of extract to dryness, and evaluation of the lipid content. Extracts for phytochemical process were subjected to a sequential methylene chloride-n-hexane (1:1) prepared specifically for these analytes, and injection of 1µL of sample into a gas chromatograph equipped with a wide-bore fused-silica capillary column. GC–MS analysis was performed using a

6890-GC coupled to a 5975 MSD. The temperature range applied in this analysis include injector at 250°C, oven initially set at 200°C held for 1 min and heated to 230°C (1.5 °C min^{-1}, then held for 10 min). The sample phytochemical characterization and identification was completed in the full scan mode with the m/z ranging from 35 to 450 g/mol.

3.7 Chemical Composition and Phytochemical Screening of Crude Extract

The extracts were subjected to preliminary phytochemical screening for various constituents and Table 3 shows the result of the screening of the three different plant extracts.

Table 3: Chemical Composition/Phytochemical Screening of Crude Extract

S/No.	Phytoconstituent	Coconut coir dust extract	*Moringa oleifera* leave extract	*Carica papaya* leave extract
1.	Flavonoids	+	+	+
2.	Carbohydrates	+	+	+
3.	Tannins	+	+	+
4.	Phenols	+	+	+
5.	Terpenoids	+	+	+
6.	Saponins	+	+	+
7.	Alkaloids	+	+	+
8.	Anthraquinones	+	+	+

3.8 Carbon Steel Specimen Preparation

For weight loss calculation and analysis, carbon steel (coupon) was purchased from a steel company in Port Harcourt and analyzed using X-ray Fluorescence (XRF) Spectroscopy to deduce its composition. The metal was mechanically cut into smaller units with dimensions of 4cm by 4cm by 0.2cm. Then, the coupons were well polished using Emery papers. The specimen was well cleaned and prepared before its application.

i. **X-ray Fluorescence** (XRF) **Spectroscopy**

The XRF Spectroscopy is one of the positive material identifications (PMI) methods that involves the application of low energy x-ray analysis in scanning and identifying the chemical compositions of the steel sample (coupon). The identification procedures involve the use of x-ray detector in the determination of the sample composition by exciting the sample atoms. Thus, the atomic composition of the coupon is excited by the x-ray that fluorescence thereby producing secondary x-rays, which are reflected to the detector. The wavelength of the reflected x-rays is useful in determining precisely the elemental composition of the sample or coupon.

3.9 Inhibitor Performance Evaluation

In the performance evaluation of the inhibitor using weight loss method, testing of the previously weighed carbon steel specimens was carried out under complete immersion of the coupon in the corroding medium (1.0M HCL), corroding medium with inhibitors (extracts) such as 1.0M HCl with MOL inhibitor, 1.0M HCl with CPL inhibitor, and 1.0M HCl with CCD inhibitor at varying concentrations. The experimental procedure was repeated for each inhibitor at concentrations of 100, 200, 300, 400, and 500mg. At room temperature, the process was conducted for 4 hours, with 24 hours monitoring for a period of 120 hours (five days). The test specimens (coupons) were removed after and cleansed using ethanol and deionized water. The resulting sample was dried using acetone while a digital analytical weighing balance was used to weigh the coupon again to evaluate the weight difference of the coupon (i.e., coupon initial weight reading minus coupon final weight reading). The difference between the original weight of the coupon and the second specimen's weight is referred as the weight loss. In addition, the coupon's final weight analysis was repeated for all samples at different concentrations of inhibitors to increase the effectiveness and reliability of the weight loss analysis. The inhibitor preparation procedures are presented in Plate 21.

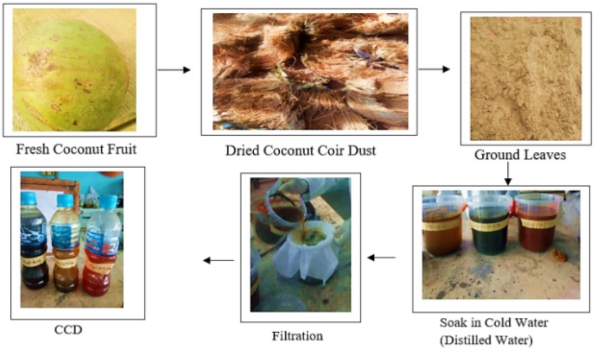

Plate 21: Inhibitor Preparation Procedures

3.10 Corrosion Inhibition Evaluation

The movement of the metal/solution interface is because of the inhibitor molecule adsorption with solution or metal contact in acidic solutions, where a productive film is formed. In this case, there is a rapid adsorption rate whereby the surface of the reactive metal is protected against acid solution. The rate of adsorption is always determined by the size of the molecules, metal surface charge, and the molecules of the inhibitor.

i. **Determination of Corrosion Rate**

Corrosion rate of metal in mmpy (millimeters per year) can be calculated experimentally using equation 1.

$$C_r = \frac{\Delta W \times K}{Adt} \tag{1}$$

where, K is conversion constant (87.600), ΔW is change in weight, A is exposed surface area, t is the time of exposure and d is metal density of coupon.

3.11 Corrosion Inhibitor Efficiency Evaluation

Using the gravimetric analysis of the carbon steel coupons in line with the previously outlined method used in determining the weight loss and corrosion rate, the values obtained were used in calculating percentage inhibition efficiency (% IE) and this can be determined using equation 2.

$$\%IE = \frac{W_o - W_1}{W_o} \times 100 \tag{2}$$

where, W_o is weight of the steel with no inhibitor, and W_1 is corrosion rate of the steel with inhibitor.

3.12 Fourier Transform Infrared (FTIR) Spectroscopy

The plant extracts were characterized by FTIR Spectroscopy, which showed infrared spectrum of MOL, CPL, and CCD in I.0M HCl solution. The FTIR spectra, the important peaks, and corresponding wavelengths identifying the type of compound in the extracts are shown in Figures 12, 13, and 14; whereas Figure 15 shows inhibition efficiency versus temperature effect on carbon steel corrosion in 1.0M HCL solution in the presence of different concentration of CCD extracts.

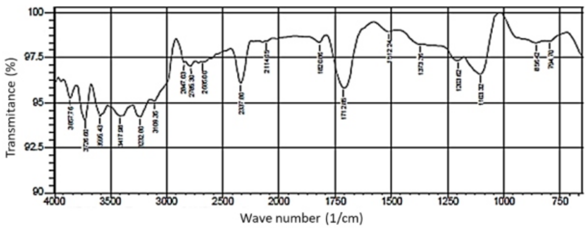

Figure 12: FTIR Spectrum of Moringa oleifera Leaf

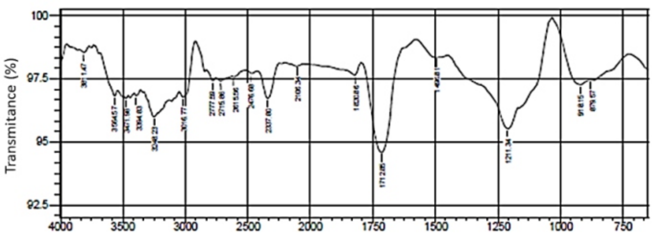

Figure 13: FTIR Spectrum for Carica papaya Leaf

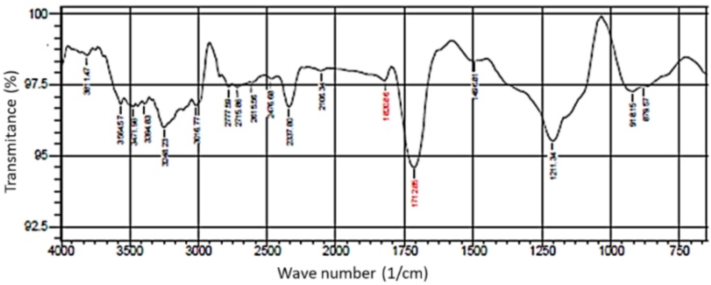

Figure 14: FTIR Spectrum of Coconut Coir Dust

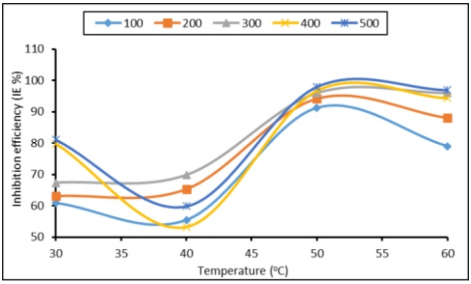

Figure 15: Inhibition Efficiency Vs. Temperature for Carbon Steel Corrosion in I.0M HCl Solution in the Presence of Different Concentrations of Coconut Coir Dust (CCD) Extracts.

4. SOME CHEMICAL AND PETROCHEMICAL PRODUCTS OBTAINED

4.1 Production of Grease Using Locally Sourced Raw Materials

The need to source materials that are environmentally friendly is necessary for purposes of safeguarding the ecosystem. Most of the materials used in the production of high-density polyethylene (HDPE) and low-density polyethylene (LDPE) are petroleum-based products. It is observed that these materials are found useful as thickening agents for synthetic oil production.

In soap production, thickening agents are significant to the process and such agents include aluminum, calcium, sodium, and lithium; and the application is found useful in the production of grease. In soap production, characteristics required include (but not limited to) alkaline hydrolysis involving fat and oil; and the process is called saponification. The reaction methods are demonstrated in equations 3 and 4.

$$\underset{\text{(Fat)}}{C_3H_5}\text{—}(OOCR)_3 + \underset{\text{(sodium hydroxide)}}{3NaOH} \longrightarrow \underset{\text{(Soap)}}{3NaOOCR} + \underset{\text{(glycerol)}}{C_3H_5OH} \quad (3)$$

$$\underset{\text{(Fat)}}{C_3H_5(OOCR)_3} + \underset{\text{(potassium Hydroxide)}}{3KOH} \longrightarrow \underset{\text{(soap)}}{3KOOCR} + \underset{\text{(glycerol)}}{C_3H_5OH} \quad (4)$$

4.1.1 Different Types of Lubricating Greases and their Functions

Currently, there are several types of lubricating greases, but their basic structure is similar. The characteristics of these lubricants include:

i. Enhance reduction in friction, especially on metal-to-metal contact
ii. Enhance cooling system, especially in heat generating processes
iii. Possess the ability of absorbing as well as dissipating heat
iv. Possess the characteristics and function of sealant as well as enhance combustion in gas tight chamber.

Presently, the demand for grease by the automobile industries has tremendously increased. Modern grease is designed to last longer, work better under extreme conditions and is also expected to provide adequate protection against rust, water, and dust.

Good lubricating grease possesses the following characteristics:

i. High boiling point
ii. Low freezing point

iii. High viscosity index

iv. Thermal stability

v. Corrosion prevention

vi. High resistance to oxidation

4.1.2 Types of Grease

Currently, the following are the different types of grease available in the market

i. WBG – Wheel Bearing Grease
ii. UJG – Universal Joint Grease
iii. CG – Chassis Grease
iv. ELI – Extended Lubrication Interval
v. MG – Multipurpose Grease
vi. EPG – Extreme Pressure Grease
vii. SG – Spindle Grease

4.1.3 Conceptual Steps for Grease Production

The conceptual steps involved in grease production are listed and illustrated in Figure 16 for the three different samples used for this investigation, which include *Pisifera*, *Dura*, and *Tenera.*

1. Sample Collection
2. Removal of impurity such sands
3. Initial air-drying
4. Second oven-drying involving heating and burning
5. Crushing/grinding into powdery form and sieving
6. Soaking in distilled water and then stirring
7. Filtration of the mixture to obtain the extracts
8. Addition of stearic acid, oleic acid, and sodium carbonate with continuous heating
9. Lubricating grease obtained as product

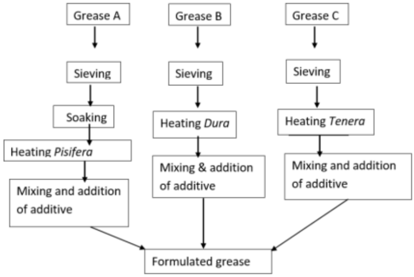

Figure 16: Experimental Procedures used in Grease Production from Three Palm Bunch Species.

Samples of Oil Palm Bunch

The samples of the *Pisifera*, *Dura*, and *Tenera* species are presented in Plates 22, 23, and 24, respectively, whereas the resulting products after processing the raw materials to achieve the desired product are presented in Plates 25, 26, and 27.

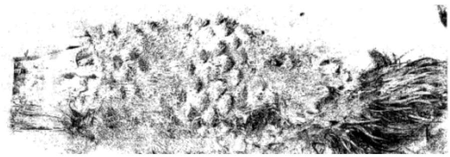

Plate 22: A Sample of Pisifera Specie of Oil Palm Bunch

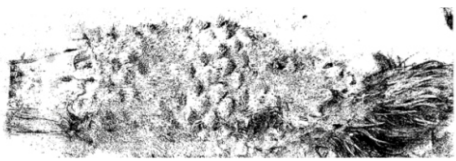

Plate 24: A Sample of Tenera Specie of Oil Palm Fruit Bunch

Plate 25: Grease Produced from *Pesifera* Oil Palm Bunch

Plate 26: Grease Produced from *Tenera* Oil Palm Bunch

Plate 27: Grease Produced from *Dura* Oil Palm Bunch

4.1.4 Variables Tested for Quality Evaluation

Consistency Test

The ASTM method D217-02 was applied as a standard method for testing the degree of cone penetration as one of the lubricating grease characteristics and the penetration level was determined by considering the millimeter trend value on it.

Unworked Penetration Test

Three samples of the grease were subjected to the penetration test. The samples had different penetration levels measured with a penetrometer by filling the grease cup. The cup is cylindrical in shape with 50ml capacity and has little disturbance. The surface was smoothened and placed on the penetrometer assembled and pressed for five seconds during which a cone on the assembly has its tip just touching the level of the grease surface at the start. The distance dropped for each sample was read from the dial indicator of the penetrometer and the result obtained was recorded.

Worked Penetration Test

The worked penetration test concept was almost the same as the unworked penetration, the slight difference being the raw materials used in the grease production, the additive added during the process, and the process conditions such as workload of elevated temperature range.

Dropping Point Test

The dropping point was examined by the ASTM D-566 and D-2265 techniques.

4.1.5 Oil Palm Bunch Ash Result Analysis

The preparation of grease requires three basic components, namely, base oil, additives, and thickener. The thickener, when mixed with base oil will form semi-fluid to solid substance. Principally, the thickeners used in this study include lithium,

aluminum, and calcium soap. The development of a unique thickener from agricultural waste is a key objective in grease production. Oil palm bunch was first crushed and sun-dried for some hours to remove moisture, burnt completely to ash, and subjected to laboratory analysis to determine the elemental composition of the ash. It was observed that calcium, phosphorous, and lithium were more pronounced in *Tenera* than in *Pisifera* and *Dura* as shown in Table 4. The presence of these elements in the ash, with the addition of sodium silicate and other substance makes the ash a suitable thickener.
Table 4 shows the characteristics of the ash obtained from the oil palm bunch, whereas the Table 5 shows selected elements (Ca, P, Li, Na, and Al) of the oil palm bunch of the three different samples. Tables 6 and 7 show the values of the dropping point of bio-alkaline based, control (1) (sodium based), and control (2) AZ, as well as the produced grease parameters in terms of penetration, pH, density, and viscosity at 6 rmp, 12 rpm, 3 rmp and 60 rmp for soft grease produced. Table 8 shows the same characteristic trend of values for hard grease produced and Table 9 shows the value of AZ grease produced. Table 10 shows the comparison of the different grease produced with international standard.

Table 4: Elemental Composition of Ash from Oil Palm Bunch

Elements	Concentrations (mg/kg)
Chromium	0.088
Zinc	0.38
Calcium	146.15
Potassium	139.35
Sodium	0.63
Magnesium	1.68
Chlorine	2280
Phosphate	47.50

Table 5: Selected Chemical Properties of Oil Palm Bunch in Powdered Form

Sample	Ca mg/c	P (mg/c)	Li (mg/c)	Na(mg/c)	Al(mg/c)
Pesifera	116.91	102.30	10.15	102.80	82.24
Tenera	128.62	110.71	17.57	130.26	150.17
Dura	100.21	97.10	8.18	99.12	82.24

Table 6: The Dropping Point of the Grease Samples

S/N	Grease sample	Dropping point
1	Bio-alkaline base	125
2	Control 1 (Sodium base)	128
3	Control (2) AZ	130

Table 7: Characteristics of the Locally Produced Grease (Soft)

Parameter	Concentration Value
Penetration	355 – 385
Ph	6.3
Density g/cm^3	0.890
Viscosity@6rmp	14211mpa.s
Viscosity @12rmp	7122mpa.s
Viscosity @30rmp	2571mpa.s
Viscosity@60rmp	852mpa.s

Table 8: Characteristics of Locally Produced Grease (Hard)

Parameter	Concentration Value
Penetration	255 – 290
pH	6.28
Density g/cm^3	0.939
Viscosity@6rmp	16241mpa.s
Viscosity @12rmp	8024mpa.s
Viscosity @30rmp	3502mpa.s
Viscosity@60rmp	1721mpa.s

Table 9: Characteristics of AZ Grease

Parameter	Concentration Value
Penetration	265 – 295
pH	6.5
Density g/cm^3	0.9126
Viscosity @30rmp	3722 mpa.s
Viscosity@60rmp	9324 mpa.s

Table 10: Comparison of Selected Properties of the Locally Produced Grease and Petroleum-Based Grease with International Standard.

Parameter	Concentration of locally produced grease (soft)	Concentration of locally produced grease (hard)	Concentration of AZ grease	International Standard Recommended
pH	6.30	6.28	6.5	4 – 7
Density	0.890	0.939	0.9126	0.9819
Viscosity@30rpm	2571	3502	3722	2880-3520
Viscosity@60rpm	852	1721	1882	1980-2420

4.2 Effect of Preservative Methods of Starch from Various Varieties of Agricultural Products for Adhesive

Adhesives are those materials which can bind surfaces of objects and other materials together, so they can resist separation without deformation in a process called adhesion. In adhesion, there is interaction of the adhesive surface with the substrate surface to be held in intimate contact such that mechanical force can be transferred across the interface. Theories that could explain the adhesion process include Van der Waals forces, chemical bonding, or electrostatic attraction.

There are various types of adhesives, which may vary in bond strength, flexibility, deterioration rate, and degree of reversibility. P***roperties that determine the effectiveness of an adhesive include*** viscosity, bonding capability, ease of application, reasonable setting time, resistance to moisture, aging, heat and fungal attack, non-staining, and gap filling. Adhesives are used for specific applications ranging from domestic, industrial, biomedical, and pharmaceutical application with each depending on the nature and shelf life of the adhesive. Such applications include floor tile and continuous flooring installation, ceramic tile installation, countertop lamination, manufacture of prefabricated beams and trusses, carpet adhesives, flooring underlayer, installation of prefinished panels, joint cements, drywall lamination and covering installations, applications in model and home supplies, decorative films, school and stationery products. Adhesives are used for other rigid and non-rigid bonding such as shake-proof fastening, furniture manufacture, manufacture of millwork, doors, kitchen cabinets apparel laminates, shoe assembly, sports equipment, book binding, rug backing, flock cements, air, and liquid filter manufacture, etc. Biomedical and pharmaceutical applications include restorative dental filings, blood transfusions, anaesthetic administration, intravenous drug delivery, heart bypass surgery, urological surgery, and plastic surgery. Bio-adhesive polymers are used in many medical devices and drug delivery systems, including transdermal patches. Just as enzymes, hormones and vitamins are required for individual wellbeing; adhesives are recognised as essential to society survival.

It is estimated that 60 million tons of starch are extracted from a wide range of cereal root, and tuber crops for use in varieties of products; which serve as stabilizers in soups and frozen food, as coating on pills and paper, as adhesives on stamps and plywood, as a stiffening agent in textiles, as raw material for making ethanol, and even as binder in concrete, beverages, confectionery, pharmaceutical, and building materials. It is an important raw material for powder in the cosmetic industries. In detergent and soap manufacture, starch is used to get better recovery and to improve the shelf life of detergents. While in the rubber and foam industries, starch is employed to get better foaming and colour.

The raw materials presented in Plate 28 were used in the production of starch namely, cassava (TMS 82/00058) and (TMS 30001) species, potato (white sweet potato and corn

(OBA 98) specie.

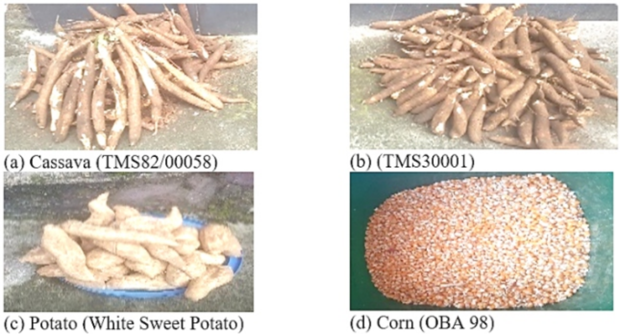

Plate 28: Samples of the Raw Materials used for Production of Starch

4.2.1 Deterioration of Starch

Although starch is beneficial, it also has some limitations. Starch is structurally weak and functionally very restricted for application. The composition and conditions of preservation have a part to play in the stability and retention of the original characteristics of starch. Starch is susceptible to mold and pest damage and are often water sensitive. They are, therefore, at risk in high humidity and water disasters period as they swell and structurally weaken. Over time, starch could deteriorate. Starch deterioration can be identified by discoloration, embrittlement, staining, adhesive failure, and movement when used as adhesive.

4.2.2 Extraction of Starch

For this study, starch was extracted from Potato, Cereal-Corn, and two different varieties of starchy Tuber-Cassava (TMS 82/00058 and TMS 30001). The basic unit operations involved in the extraction of starch from tuber crops are highlighted in Figure 17, Figure 18 shows the extraction of starch from cereals (corn), and Figure 19 illustrates the experimental matrix/chart for starch species, preservatives, and ID's.

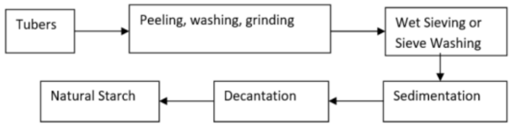

Figure 17: Flow Diagram for Starch Extraction from Tubers (Cassava and Potato).

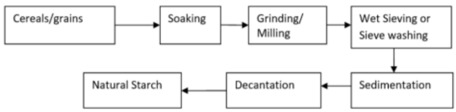

Figure 18: Flow Diagram for Starch Extraction from Cereals (Corn)

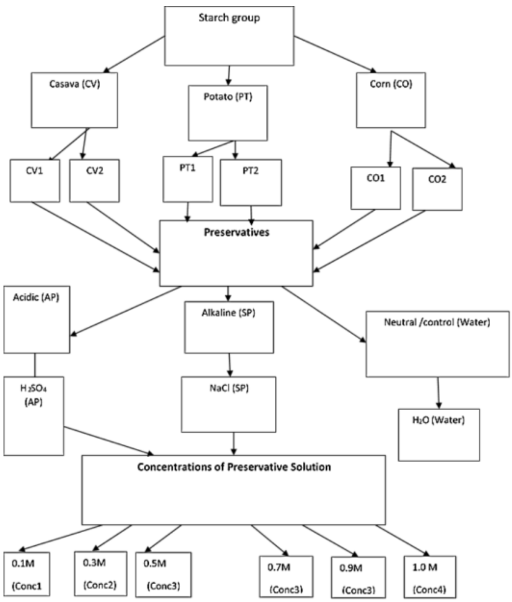

Figure 19: Experimental Matrix/Chart Showing Starch Species, Preservatives, and ID's.

4.2.3 Models for Predicting Viscosity and Concentration for Starch Preservation

In predicting the viscosity values for the different starch samples preserved in the acidic as well as the alkaline media for the various duration of preservation, a polynomial fit was used in the regression analysis in Excel (Microsoft Inc., USA). The control viscosity values for all starch species and during preservation were used as part of the data for the regression analysis.

The best r^2 value was used as basis for the choice of the order of the polynomial, leading to the use of the 5^{th} order polynomial as shown in equation (5).

$$y_m = \sum_{i=0}^{i=5} a_i . x^i \tag{5}$$

Expanding equation (5) yields the polynomial model equation (7).

$$y_m = a_0 . x^0 + a_1 . x^1 + a_2 . x^2 + a_3 . x^3 + a_4 . x^4 + a_5 . x^5 \tag{6}$$

$$y_m = a_0 + a_1 . x + a_2 . x^2 + a_3 . x^3 + a_4 . x^4 + a_5 . x^5 \tag{7}$$

Were, y_m is the viscosity (y)for a duration (m) at the given concentration level (x) of the preservative, a_0 is the value of viscosity when there is no preservative, and $a_1 to\, a_5$ are coefficients of the model.

Model samples for the cassava starch CV1 in acidic preservative for the various sample preservation periods are captured in equations (8) to (11), which were extracted from Figure 20.

$$y_0 = -6735.1x^5 + 21746x^4 - 24086x^3 + 11703x^2 - 2312.2x + 315.79 \tag{8}$$

$$y_1 = -7145.8x^5 + 22491x^4 - 24261x^3 + 11304x^2 - 2132.2x + 316.59 \tag{9}$$

$$y_2 = -7136.1x^5 + 21762x^4 - 22913x^3 + 10420x^2 - 1936.1x + 341.54 \tag{10}$$

$$y_3 = -11201x^5 + 32474x^4 - 32243x^3 + 13319x^2 - 2130.7x + 367.1 \tag{11}$$

For the cassava starch sample CV1 in alkaline preservative, equation (12) to (15) extracted from Figure 21 can be used to perform the viscosity predictions.

$$y_0 = -13049x^5 + 28518x^4 - 11795x^3 - 7824.9x^2 + 4529.7x + 318.86 \quad (12)$$

$$y_1 = 5319.7x^5 - 17921x^4 + 26554x^3 - 18152x^2 + 4493.4x + 314.64 \quad (13)$$

$$y_2 = 23600x^5 - 65653x^4 + 68052x^3 - 30832x^2 + 5044.1x + 332.94 \quad (14)$$

$$y_3 = 15166x^5 - 33422x^4 + 23182x^3 - 3655.9x^2 - 1114.4x + 363.71 \quad (15)$$

The r^2 values for the models ranged from 0.98 to 1, indicating the goodness of the polynomial fit for the data used. The models were validated simply from the measured values of the viscosity at the no preservative level and at the 1.0M concentration level for both acidic and alkaline preservatives and the result obtained are presented in Figure 20 and Figure 21 with the use of different preservative in H_2SO_4.

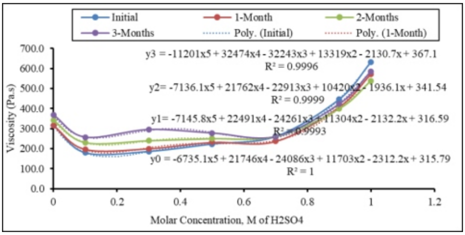

Figure 20: Fitted Polynomial of Viscosity vs Concentration for CV1 in H_2SO_4

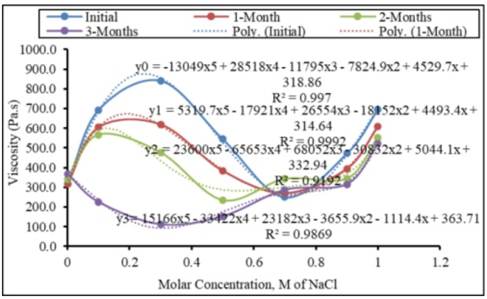

Figure 21: Fitted Polynomial of Viscosity vs Concentration for CV1 in NaCl

From the predictive models for the cassava starch species in both alkaline and acidic preservatives, the predicted viscosity values for the control samples show a very high percentage agreement with the measured values. Errors ranged from as low as -0.07 % to -2.59% for the case of 2 months after preservation in alkaline preservative. These models are also useful for the determination of the viscosity of the sample for any expected duration by linearly interpolating in between periods.

Table 11: Validation of Mathematical Models for Viscosity Estimation for CV1

Month	Mathematical model, Viscosity (y_0, y_1, y_2 and y_3); Concentration (x)	Error based on zero conc. (x=0) prediction			Error based on 1.0M conc. (x=1.0) prediction		
CV1 in H_2SO_4		Measured	Predicted	% error	Measured	Predicted	% error
0	$y_0 = -6735.1x^5 + 21746x^4 - 24086x^3 + 11703x^2 - 2312.2x + 315.79$ $R^2 = 1$	315.9	315.79	-0.0348	631.8	631.49	0.0491
1	$y_1 = -7145.8x^5 + 22491x^4 - 24261x^3 + 11304x^2 - 2132.2x + 316.59$ $R^2 = 0.9993$	315.7	316.59	0.2819	571.9	572.59	-0.1205
2	$y_2 = -7136.1x^5 + 21762x^4 - 22913x^3 + 10420x^2 - 1936.1x + 341.54$ $R^2 = 0.9999$	341.8	341.54	-0.0761	538.9	538.34	0.1040
3	$y_3 = -11201x^5 + 32474x^4 - 32243x^3 + 13319x^2 - 2130.7x + 367.1$ $R^2 = 0.9996$	367.7	367.1	-0.1632	585.2	585.4	-0.0342
CV1 in NaCl		Measured	Predicted	% error	Measured	Predicted	% error
0	$y_0 = -13049x^5 + 28518x^4 - 11795x^3 - 7824.9x^2 + 4529.7x + 318.86$ $R^2 = 0.997$	315.9	318.86	0.9370	694.3	697.66	-0.4816
1	$y_1 = 5319.7x^5 - 17921x^4 + 26554x^3 - 18152x^2 + 4493.4x + 314.64$ $R^2 = 0.9992$	315.7	314.64	-0.3358	609.1	608.74	0.0591
2	$y_2 = 23600x^5 - 65653x^4 + 68052x^3 - 30832x^2 + 5044.1x + 332.94$ $R^2 = 0.9192$	341.8	332.94	-2.5922	552.6	544.04	1.5734
3	$y_3 = 15166x^5 - 33422x^4 + 23182x^3 - 3655.9x^2 - 1114.4x + 363.71$ $R^2 = 0.9869$	367.7	363.71	-1.085	523.45	519.41	0.7778

4.2.4 Preservation of Starch

Starch is highly perishable so there is need for its preservation. The preservation methods tend to manage microbial growth and protect the starch. Some of the microorganisms to be controlled include fungi, bacteria, yeast, and others that can produce starch-degrading enzymes.

Preservation of starch should be in a way that the properties will still be maintained after preservation. The starch produced often degrades due to improper preservation thereby affecting the quality of the starch and products from it.

The research was able to address the following points:

i. Effect of the different concentrations of the preservative agents on the viscosity of the preserved starch.

ii. The pH level of the preserved starch that can inhibit microbial growth.

iii. The identification of microbes after three months of preservation of the starch.

iv. Finally, to determine which species of the starch gave a good quality adhesive with the preservative effect.

v. A better knowledge on the preservation of starch pastes for adhesive production

5. PETROCHEMICAL APPLICATIONS

5.1 Treatment of Effluent Wastewater from Petrochemical Plant

The performance of sugarcane bagasse was tested after converting it into an adsorbent. The following parameters were monitored:

1. Effect of temperature on adsorption of the metal ions

2. Effect of contact time on adsorption of heavy metal
3. Effect of the dosage of adsorbent on the adsorption of heavy metal

The kinetics parameters of the adsorption process were considered, which include:

1. Calculation of the equilibrium constant of adsorption K_o

$$Ko = {Csolid}/{Cliquid}$$

$$Ko = \frac{Concentration\ of\ adsorbate\ in\ adsorbent}{Concentration\ of\ adsorbate\ in\ aqueous\ solution}$$

2. Calculation of the Gibb's free energy ΔG^o of the process. The Gibb's free energy ΔG^o (KJ/mol) = $\Delta G^o = RTInKo$

3. Calculation of the adsorption isotherms of Langmuir, Freundlich, and Temkin

4. Calculation of adsorption capacity and removal efficiency of heavy metal ions.

The analysis conducted on the petrochemical wastewater showed the presence of the following heavy metals, Copper (Cu), Cadmium (Cd), Zinc (Zn), Iron (Fe), Nickel (Ni), and Lead (Pb) with concentrations higher than the recommended World Health Organization (WHO) standard. The characteristics of the petrochemical wastewater and adsorbent used are as presented in Table 12.

Table 12: Metal Concentration in Petrochemical Wastewater

S/No	Parameter	Metal Concentration	Adsorbent Value
1	Copper (Cu) (mg/l)	0.0227$\pm$	-
2	Cadmium (Cd) (mg/l)	0.0295$\pm$	-
3	Zinc (Zn) (mg/l)	0.9780$\pm$	-
4	Iron (Fe) (mg/l)	0.7821$\pm$	-
5	Nickel (Ni) (mg/l)	0.3706$\pm$	-
6	Lead (Pb) (mg/l)	0.0355$\pm$	-
7	pH	9.62	-
8	Total suspended solid (TSS) (mg/l)	30	-
9	Turbidity (NTU)	10	-
10	Chemical Oxygen Demand (COD) (mg/l)	90	-
11	Phenols (ppm)	<1	-
12	Aromatic	-	-
13	Cellulose	-	13.114%
14	Lignin content	-	10.301%

Table 12: ***Continued***

S/No	Parameter	Metal Concentration	Adsorbent Value
15	Moisture content	-	9.740%
16	Hemicellulose	-	4.987%
17	ash content	-	8.170%
18	Manganese (ppm)	0.154 ppm	-
19	Sodium (ppm)	4.783ppm	-
20	Potassium (ppm)	4.984pppm	-
21	Aluminum (ppm)	0.393ppm	-
22	Molybdenum (ppm)	0.178ppm	-
23	Silver	-	-
24	Silicon (ppm)	0.433ppm	-

The study showed that percentage metal removal increased with adsorbent dosage and contact time until equilibrium is achieved. The temperature range for best performance was 30 to $\leq$ 60^{o}C and above this temperature the efficiency of the adsorbent was affected and the rate of adsorption was very low, which allowed the penetration of the metals through the adsorbent without being adsorbed in the process.

5.2 Treatment of Crude Oil-Contaminated Water using Biosorbent in a Packed Bed

The activities involved in crude oil exploration affect the ecosystem due to continuous discharge of effluent and crude oil spill, especially in waterlogged area of Niger Delta region, Nigeria. However, different measures have been adopted to enhance cleanup of polluted water media, especially using bioremediation for which temperature is one of the controlling factors.

Temperature variation induces the adsorption and microbial activities in a packed bed treatment column because some organisms are more active when the operating temperature are within the range of < 20 to < 45°C (mesophilic temperature), < 20 to < 75°C (thermophilic temperature), and < 20 to 120°C (supper thermophilic temperature). In areas of industrial activity, especially crude oil processing, the activities may result in the generation of constituents that have tremendous impact in terms of the degree of pollution of the environment. The removal of contaminants by biosorption is shown in Figure 22. The device was designed and fabricated with the aim treating contaminated water medium.

Figure 22: Flow Diagram of the Treatment Plant

Figure 23 shows the flow diagram of contaminants treatment in a packed bed unit connected in series using bio-adsorbent, whereas Figures 24 and 25 show the comparison of the three different bio-adsorbents introduced into the packed bed unit 1 sun-dried and room-dried samples and the effect of temperature on TPH removal.

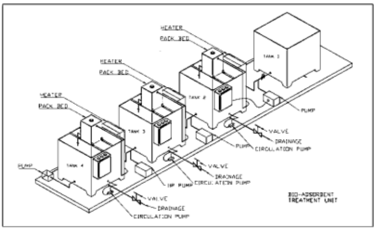

Figure 23: Flow Diagram of Contaminants Treatment in Packed Bed Units connected in series using Bio-adsorbent.

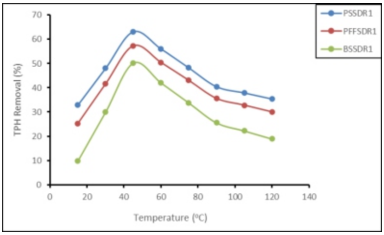

Figure 24: Comparison of the Three Different Bio-adsorbent in Packed Bed Unit 1 for Sun-Dried Medium.

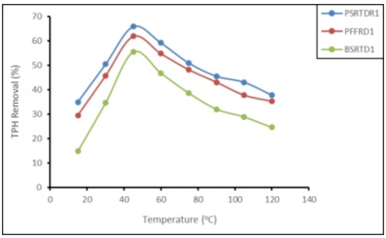

Figure 25: Comparison of the Three Different Bio-adsorbent in Packed Bed Unit 1 for Room-Dried Medium

5.3 Rate of Oil Particles Sedimentation down the Column (using Ukpaka's model)

The rate of oil particle settling down the column of the stagnant water was studied using a model. First, a general expression by Ukpaka (2011) on sedimentation of suspended solid particle, as influenced by continuous discharge of waste in pond system, was modified based on the Stokes' and Newton's laws of particles falling into fluid system.

According to Ukpaka (2011), the rate of sedimentation is determined as:

$$R_s = \frac{v_s}{z} C_{ss} \tag{15}$$

After several mathematical relations with respect to influential parameters, Ukpaka (2011) finally expressed the rate of sedimentation as:

$$R_s = \left[U - \exp\left(\frac{1}{gS_o z} \cdot \frac{v_s^2}{1 - v_s} \right) \right] \frac{v_s}{z} \tag{16}$$

where:

R_s =Rate of settling of particle (mg/l.day), U =Rate of momentum transfer (kg.m/day)

C_{ss} = Concentration of suspended solids (mg/l), g = Acceleration due to gravity (m/s^2)

S_o = Below the surface water slope (-), z = Height of sample point from water surface (m)

v_z = Settling velocity (m/s)

In this study, we modified equation (15) with the assumption that the oil particle falling in the stagnant water obeyed two laws: Stokes' and Newton's laws.

5.3.1 Rate of Sedimentation Based on Stokes' Law

The settling velocity in this case, was developed based on the concept of Stokes' law, which is expressed as:

$$v_s \propto gD_p^2\left(\frac{\rho_p - \rho_f}{18\mu}\right) \tag{17}$$

Removing the proportionality, we obtain as follows:

$$v_s = k_F gD_p^2\left(\frac{\rho_p - \rho_f}{18\mu}\right) \tag{18}$$

Since the oil volume is measurable, the particle diameter, D_p was expressed in terms of oil particle volume. Thus, the oil particle volume is assumed to be spherical in shape. The volume of sphere is expressed as:

$$V = \frac{\pi D_p^3}{6} \tag{19}$$

Hence, in terms of particle diameter, equation (19) can be stated as:

$$D_p = \left(\frac{6V}{\pi}\right)^{1/3} \tag{20}$$

Substituting equation (20) into (18) gives:

$$v_s = k_F g\left(\frac{6V}{\pi}\right)^{2/3}\left(\frac{\rho_p - \rho_f}{18\mu}\right) \tag{21}$$

After simplification and substitution of equation (21) into (15), we obtained:

$$R_s = K_F gV^{2/3}\left(\frac{\rho_p - \rho_f}{18\mu}\right)\frac{C_{TSS}}{z} \tag{22}$$

5.3.2 Rate of Sedimentation Based on Newton's Law

Expressing the settling velocity in terms of Newton's law of particle falling in a fluid, we modified the settling velocity as:

$$v_s \propto \left[gD_p \left(\frac{\rho_p - \rho_f}{\rho_f} \right) \right]^{1/2} \tag{23}$$

Removing the proportionality, we obtain as follows:

$$v_s = k_F^* \left[gD_p \left(\frac{\rho_p - \rho_f}{\rho_f} \right) \right]^{1/2} \tag{24}$$

Unlike Stokes's law, the particle settling velocity does not depend on the fluid viscosity in the Newton's law. Again, in terms of particle diameter, Equations (19) and (20) are combined and substituted into Equation (24) to give:

$$v_s = k_F^* \left(\frac{6V}{\pi} \right)^{1/6} \left[\left(\frac{\rho_p - \rho_f}{\rho_f} \right) g \right]^{1/2} \tag{25}$$

Again, simplification and substitution of equation (25) into (15) gives:

$$R_s = K_F^* V^{1/6} \left[\left(\frac{\rho_p - \rho_f}{\rho_f} \right) g \right]^{1/2} \frac{C_{TSS}}{z} \tag{26}$$

Where, R_s =Particle settling rate (mg/day), C_{TPH}= TPH concentration (mg/l), v_s = Settling velocity (m/s), z = Height of sample point from water surface (m), V = Volume of oil (m³), D_p = Oil particle diameter (m), ρ_p = Oil particle density (kg/m³), ρ_f = Fluid density (kg/m³), μ = Viscosity of fluid (kg/ms), g = Acceleration due to gravity (m/s²) and K_F and K_F^* = Constants of settling velocity of modified Stokes and Newton's equations

5.3.3 Rate of Sedimentation along the Tank Depth

The rate of oil sediment in stagnant fresh water and salt water media models was studied in terms of the measured total suspended solids (TSS). The rate of sedimentation over the investigation period for the three models was compared as shown in Figures 26 to 27 for the various weeks of the analysis.

5.3.4 Comparison of Suspended Solids Sedimentation Predicted by the Models

The concentrations of suspended solid sediment predicted by the model in the stagnant fresh water and salt water media models were compared with the measured total suspended solids (TSS) over the investigation period as shown in Figures 26 to 27.

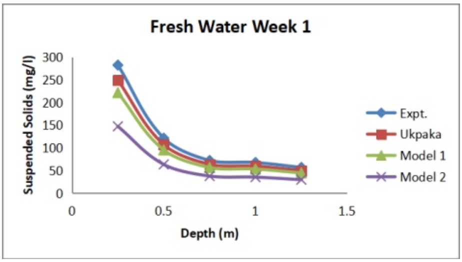

Figure 26: Comparison of Predicted Suspended Solids in Fresh Water for Week 1

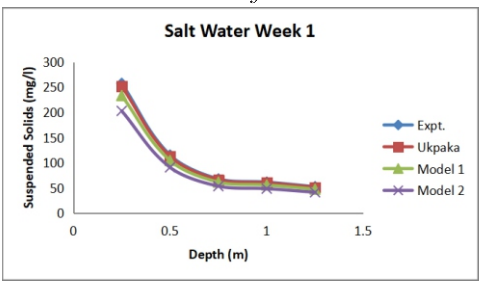

Figure 27: Comparison of Predicted Suspended Solids in Salt Water for Week 1

5.4 Selected Plant Extracts as Corrosion Inhibitor

The corrosion inhibitive effect of some selected plant extracts has been tested in terms of its potential performance of weight loss, corrosion rate and inhibition efficiency. The outcomes of the research revealed an improvement in the extracts inhibition efficiency or property of the various extracts as the extracts concentration increases in the acidic environment, thereby preventing weight loss and corrosion rate of the metal in acidic environment or medium. The various plant extracts considered are:

i. *Moringa Oleifera*
ii. Carica Papaya
iii. Coconut coir dust

5.4.1 Other Adsorbents used in Treatment of Contaminated Aqueous Media

The following adsorbents has been tested on performance and efficiency for metals and other substance removal from a contaminated aqueous media as listed below

1. Coconut shell (activated carbon)
2. Corn cob (activated carbon)
3. Plantain stem mixed with clay soil
4. Banana stem mixed with clay soil
5. Palm oil fibre mixed with clay soil
6. Wood Sawdust

The performance of each adsorbent reveals the results as demonstrated in Table 13

Table 13: Effectiveness of some Adsorbents in Treatment of Contaminated Water Medium

S/no	Material	Parameter	Thermodynamics Properties	Percentage (%)	Removal Findings
1	Coconut shell (activated carbon as end product)	Fe^{2+} Pb^{2+} Cr^{2+} Cd^{2+} Ni^{2+}	Gibbs free Energy ? G^o Enthalpy ? H^o and Entropy	84.54 79.69 75.61 72.68 67.84	The adsorption of the metals by the activated corn cob and coconut shell was not favorable at high temperature and it is exothermic and occurred on the surface with no chemical bonding between the adsorbents and the adsorbed heavy metals
2	Corn cob (activated carbon as end product)	Fe^{2+} Pb^{2+} Cr^{2+} Cd^{2+} Ni^{2+}	? S^o all negative	80.65 75.97 71.97 73.18 67.43	

6. BIOREMEDIATION EVALUATION OF CONTAMINATED SITE

Bioremediation is an eco-friendly method of decontaminating contaminated soils and underground waters using microorganisms, and the application of plants to enhance restoration or remediation of contaminated soil and water environment is called phytoremediation. Performance evaluation of different phyto-materials is as listed in Table 14.

Table 14: Assessment of Some Phyto-materials for Remediation of Contaminated Soil Environment

S/No	Phyto-material	Condition	Findings
1	*Azadirachta Indica* leaf, stem (Dogoyaro)	Sun dried and room dried and processed to powder form	(1) 92% and 90% reduction of room dried and sun dried of TPH (2) Room dried biostimulant was more effective than the sun dried and room with absorbent to nutrient (3) Remediation of polluted sandy soil was faster compared to loamy and clay soil environment and reason attributed to porosity
2	Water Hyacinth	Sun dried and room dried and processed to powder form	89% reduction of TPH after 42 days for room dried sample and 75% for sun dried. The same of 2 and 3 were observed.
3	Guava leaf	Room and sun dried and processed to powder form	(1) 83% and 80% reduction in TPH after 42 days (2) Sandy soil integrity restored following by loamy soil and clay soil
4	*Mangifera Indica* leaf and seed has been studied	Room and sun dried and processed to powder form	Range of 91.87% to 97.13% reduction of TPH was achieved
5	Oil palm fibre	Sun and room dried as well as processed into powder form	Range of 76.45% to 97.4% reduction of TPH was achieved.
6	Bitter leaf (*Vernonica amygdalina*) and the stem	Sun and room dried as well as processed into powder form	Remediation of TPH is within the range of 75.8% to 94.6% obtained
7	Neem leaf, stem and root	Extraction of the substance (Lignin) using ethanol and water	Remediation of TPH is within the range of 83.6% to 97.9% achieved with ethanol extraction high than water extraction
8	*Moringa oleifera* leaf, root, stem, seed shell	Extraction of the substance (lingnin) using ethanol and water. Sun and room dried as well as processed into powder form	Remediation of TPH is within the range of 89.7% to 98.3% achieved. Extracts from ethanol possesses high performance than extracts from water. The remediation of TPH using moringa component or parts show high efficiency in TPH reduction in soil environment.
9	Orange peel (*citrus sinensis*)	Room and sun dried as well as processed into powder form	The effectiveness in terms of performance for polluted soil restoration was encouraging
10	Aloe vera juice	Juice extraction from Aloe vera and stem processed into powder form	The research reveals the importance of Aloe vera as a good bio-stimulant which can be utilized in actual field to boast the rate of contaminants degradation especially in clay soil.
11	Cassava liquid	Fermented	The fermented cassava liquid was identified as a good remediant for treatment of contaminated soil with crude oil
12	Hospital too far (*Jasticiacarnea*)	Room and sun dried and processed into powder form	Good biostimulant as well as medicinal plant to boost red blood cell production
13	Elephant grass	Room and sun dried and processed into powder form	Good bio-stimulant. The remediant or biostimulant build up the required nutrients that catalyze the process and induced the inhibiting factor as well as increased the microbial nutrient level to facilitate the biostimulation and restoration of the polluted soil environment.

6.1 Bioremediation Findings

After intensive studies on bioremediation the following contribution to knowledge were made

1. Biostimulant materials are good crude oil bioremediant
2. Blended room dried biostimulant gives better crude oil remediation compared to the sun dried

3 Crude oil remediation occur faster in sandy soils than in loamy and clay soils

4. Every 1kg of soil polluted with 100ml crude oil requires 100g of blended room dried biostimulant to achieve significant remediation of its TPH in 35 days to 42 days
5. Oxygenation by addition of oxygen/water to enhance the rate of bioremediation.

6.2 Production of Improved Organic Fertilizer

The materials used in the production of the improved organic fertilizer were all sourced from Rivers State abattoir and timber shade within Port Harcourt and were all based on some of the following factors

1. Material availability
2. Environmental and human health values
3. Cost effectiveness
4. Strength of material (Inherent nutrient contents)

Based on the above factors the following materials were selected to achieve the purpose of the production and the materials include;

1. Poultry droppings
2. Swine droppings
3. Wood ash
4. Bone meal
5. Blood meal

6.2.1 Production Methods

The productions considered in this production were viewed to have high and appropriate macronutrients and micronutrients trace elements, essential for our kind of product. However, about four different experiments were carried out using various ratios as shown below, which were used in achieving the various nutrient concentrations of the four experiments in this work.

Calculating the nutrient requirement in the first experiment
The molar concentration of the materials of choice is very vital in determining the nutrient requirement and calculation, hence the first production experiment was based on the following ratio
$0.4V + 0.1N + 0.3X + 0.1X + 0.1Z = 1$.
where, V is poultry droppings, W is swine droppings, X is wood ash, Y is bone meal and Z is blood meal.

The study reveals that, the factorial design of $0.2V + 0.5W + 0.1X + 0.1Y + 0.1Z = 1$, yielded the best total nutrient values followed by $0.5V + 0.2W + 0.1X + 0.1Z = 1 > 0.1V + 0.1W + 0.2X + 0.5Y + 0.1Z > 0.1V + 0.1W + 0.5X + 0.2Y + 0.1Z = 1$. The observation is dependent on the type of the source and specie of component used for the formulation of the organic fertilizer.

7. OIL EXTRACTION AND APPLICATION

7.1 Oil Extraction Using Different Application

In the production of oils, there are different applications used such as solvent extraction, mechanical extraction and other recommended methods. After the oil has been extracted from the seeds, through the mechanism adopted there is need to further process the oil to achieve the best quality for the purpose in which the oil is produced. The extracted oil can then be purified and if required refined or chemically, altered. The commonly used extraction methods are

1. Mechanical extraction – crushing and pressing
2. Solvent extraction – ethanol, hexane and others

The best choice for extraction is the solvent extraction due to the following properties;
Solubility – They can effectively dissolve component of the

mixture required to be separated
Stability – They are chemically stable when in contact with metallic surface
Separability – The solvents can be separated from the mixture
Cost implication – The solvents are affordable
Toxicity – The solvents are non-toxic (non-poisonous)
Corrosiveness – They are non-corrosive
Recoverability – They exhibit high volatility for effective and low-cost recovery by distillation for re-use
Currently, we have discovered a new technique of oil extraction known as "Non-Solvent Extraction". The process involves the use of stem and the properties of oil obtained possesses the characteristics of that of the solvent extraction.

7.2 Different Oil Extraction Carried Out

The following listed raw materials has been investigated by the application of different extraction method as demonstrated in the Table * below

Table 15: Different Raw Materials for Oil Extraction

S/No	Raw Material	Extraction Method	Findings
1	Coconut	Solvent extraction (Ethanol and Hexane	Dwarf coconut species gave more oil than tall and hybrid coconuts spices
2	Native pear seeds	Mechano-Thermal	Process was achievable with high yield
3	Avocado seeds	Mechano-Thermal	Process was achievable with yield but more yield obtained from native pear seeds
4	Mango seeds	Mechano-Thermal	Process was achievable with yield but more yield obtained from native pear seeds
5.	Onion	Stem extraction	Good quality of oil obtained but the best was white onion species followed by brown onion specie and the last one is the red onion specie.

8. HYDROCARBON CONTAMINATED AREAS AND EXPLORATION OF THE USE OF PLANT EXTRACTS FOR REMEDIATION AND CLEAN-UP

Crude oil is known as a black gold and is made up of high molecular weight of petroleum hydrocarbon, and non-hydrocarbon substance such as; oxides of sulphur, nitrogen, phosphorous, potassium, metallic compounds and some volatile organic compounds such as benzene, toluene, xylene etc.

The application of Coconut fiber for remediation and clean-up of polluted or contaminated area involves the concept of Bioremediation. This is achieved through environmental, biological and engineering design principles. In most biological process, the reactions are catalyzed by a biocatalyst produced by microorganisms for the breakdown of targeted hazardous compound. The use of microbes in a bioremediation process requires a clear understanding of the reaction mechanism, microbial interaction and kinetics of the reaction. Research conducted by Ukpaka (2018), reveals that, these parameters vary in different environments, contaminants and the type of microorganism, which cannot be easily obtain theoretically. Therefore, for any proposed bioremediation programme to be successful, a pilot plant is required to study these parameters for proper development to an industrial scale.

How can we Carryout Remediation of Hydrocarbon Contaminated Areas:

Reasons:

- Ø To identify, isolate and characterized the possible microbes present in the contaminated soil environment.
- Ø To classify the typical composition of hydrocarbon or petroleum such as paraffinic, aromatic, naphthenic, intermediate products.
- Ø To detect the elementary composition/weight

percentage of petroleum such as carbon, hydrogen, sulphur, nitrogen, oxygen, metals etc.

Ø To ascertain factors affecting bioremediation.

Soil Environment

Mapping of the Polluted Site

In surveying the land contaminated with pollutant there is need for mapping, before sample collection for gnalysis.

Table 16: A Simple Mapping System for Sample Collection

A	A_1	A_2
B	B_1	B_2
C	C_1	C_2

Bioremediation Engineering

Bioremediation engineering is a process of enhancement of the natural remediation either by adding micro-organisms to the soil, referred to as bio-augmentation or creating appropriate condition by the addition of oxygen, nutrient or mineral salts for growth of the micro-organism's resident in the soil. The latter is known as bio-stimulation.

However, a good bioremediation project can only be achieved if the three major components are incorporated. This can be illustrated with a triangle as shown in Figure 28.

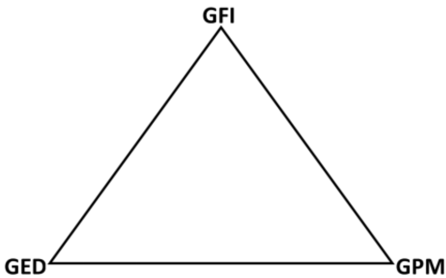

Figure 28: Good Bioremediation Triangle

Where GED is Good Engineering Design, GPM is Good Project Management and GFI Good Field Implementation.

Bioremediation Phases

- Site visitation to determine the extent of pollution.
- Site characterization: a scientific and intensive process, a proper investigation is required for good design.

Bioremediation Step

- After a proper site characterization, the various bioremediation options are considered with a view of choosing the optimum bioremediation techniques, which include, evaluation of technical factors, feasibility studies, environmental impact assessment and clean-up schedule

The result of the exercise will enable the team to screen and select the appropriate bioremediation option for the project.

Good Design Concept

The next phase is the determination of the zone of contamination on the bases of which a conceptual design can be made.

Assuming a bioremediation option is to be applied in restoration of the polluted or contaminated soil environment as seen in Figure 29.

In-Situ Treatment

Figure 29: Polluted Soil Environment in Niger Delta Area of Nigeria

The techniques of carrying out treatment on site and the flow diagrams are shown in Figure 30, 31 and 32.

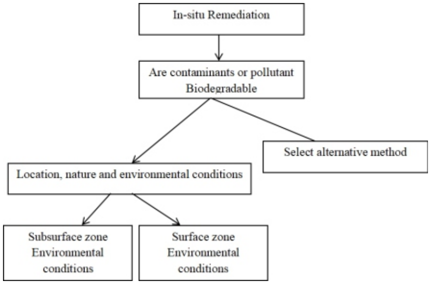

Figure 30: In-situ Remediation for Biodegradation Site

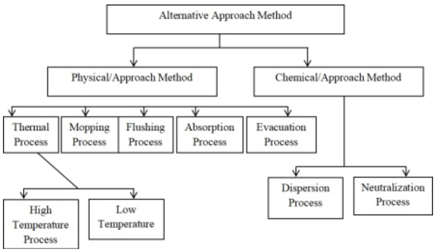

Figure 31: In-Situ Remediation for Non-Biodegradable Site

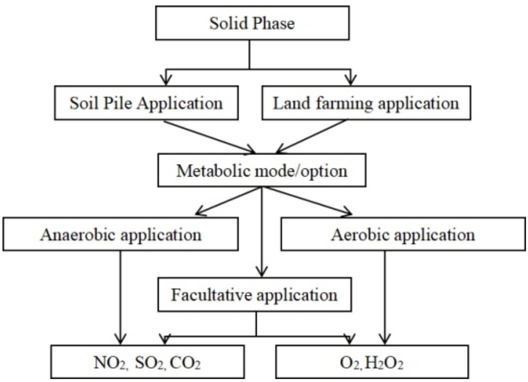

Figure 32: In-Situ Remediation for Solid Biodegradable Site

Preparation of the Remediant

The following procedures are required to obtain good quality remediant, such as;

- Ø Sample collection (Remediant)
- Ø Washing, if necessary
- Ø Drying (sun and room dry) to reduce moisture content and retain useful nutrient.
- Ø Crushing to achieve powder form
- Ø Identification of elements presence using X-ray fluorescence spectrometer
- Ø Identification of possible microorganism presence (types and quantity).
- Ø Examination of the physicochemical parameters
- Ø Identification of various nutrient and useful elements present

Contaminants (Petroleum hydrocarbon) Examination

The following procedures are required to examine the characteristics of the contaminated site with petroleum hydrocarbon, such as: Sample collection (petroleum hydrocarbon) and analysis of contaminants in terms of physicochemical analysis, microbial analysis, individual hydrocarbon analysis and total petroleum hydrocarbon (TPH) analysis

Microbial culture (Bioenergy – AMP to ATP). The highly populated microbes identify and isolated from the crude oil (petroleum hydrocarbon) will be cultured based on the standard method of culturing microbes to achieve high energy level, which include, Adenosine monophosphate (AMP), Adenosine diphosphate (ADP) and Adenosine triphosphate (ATP)

Soil Analysis

The soil analysis includes the following, such as: Physicochemical parameters, soil texture, soil porosity, bulk density, particle size and soil structure

Design of Bio-stimulation

In this case, a factorial design is required to test the effectiveness of the remediation. The process may lead to 5 x 5 matrix, in this case, the remediant or bio-stimulants will be added in different proportion. The result will serve as a guide for the field preparation and programme take off.

Remediation Application on Site

- Ø Evacuating the top soil up to the level of contamination
- Ø Applying the factorial design mixture of the remediant on excavated top soil with contaminants.
- Ø Backfilling the evacuated contaminated soil on the surface of the remediant
- Ø Apply the remediant on the surface of the contaminant
- Ø Application of good bioremediation triangle

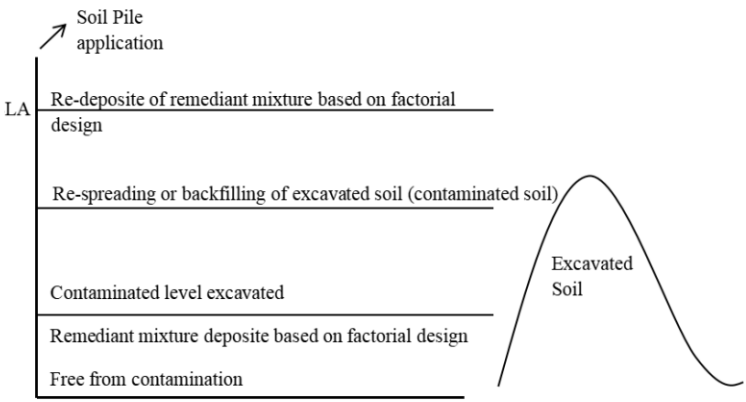

Figure 33: Remediation Application on Site (SLA is Soil Level for Application)

Ex-Situ Remediation

Treatment outside the site and the preparation of the treatment point can be set-up as presented in the diagram below.

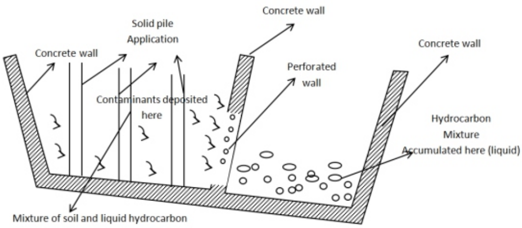

Figure 34: Schematic Diagram of Ex-situ Treatment

Ø The method applied in Figure 6 can be adopted on ex-Situ treatment of contaminant.

Other Phases

Ø Liquid Phases
Ø Saturated zone
Ø Unsaturated zone

Overview of Bioremediation Process

When the properties of a system such as soil, water or air is altered, such that it deviates from its original state, it takes several days or even years to return to its original state or to return the system to its normal state, it will require a mechanism to restore it. Therefore, in bioremediation, the mechanism required to restore polluted environment can be achieved with the application of microorganisms.

Factors influencing Biodegradation of Petroleum Hydrocarbon

Temperature, pH level, salinity, nutrients, oxygen availability, treatment techniques adopted, remediation period, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO),metals, turbidity, total dissolved solid (TDS), total suspended solid (TSS), conductivity, moisture content, total organic carbon, Total organic matter, Total petroleum hydrocarbon (TPH) content, inhibitor, weathering conditions and lack of adequate implementation of good bioremediation triangle

Effect on Transient Microbial Growth

The diagram below illustrates the effect of the factors on transient microbial growth during bioremediation process.

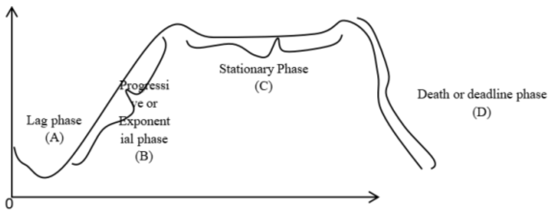

Figure 35: A Progressive Transient Microbial Growth

Figure 35 demonstrates high efficiency on remediation of the total petroleum hydrocarbon, reason because of positive acceleration of the microbial growth (favorable environment).

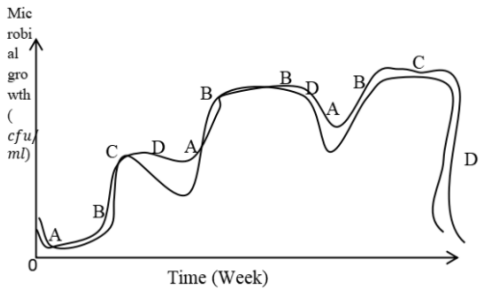

Figure 36: A non-Progressive Transient Microbial Growth (multiple phases)

Figure 36 demonstrates low efficiency on remediation of the petroleum hydrocarbon, reason because of high inability factors of the active size of the microbes (partially favorable environment).

Enzymatic Reaction Mechanism (Metabolic Pathways)

The possible reaction can occur in bioremediation and degradation of aliphatic hydrocarbon oxidation.

(i) $CH_3-(CH_2)_n-CH_2-CH_2-CH_2-(CH_2)_n-CH_2\ CH_3$ →**Paraffinic Hydrocarbon**

$$\xrightarrow{O_2}\ \downarrow$$

$CH_3-(CH_2)_n-CH_2-CHOH-cH_2-(CH_2)_n-CH_2\ CH_3$ →**Alcoholic compound**

$$\xrightarrow{O_2}\ \downarrow$$

$CH_3-(CH_2)_n-CH_2-CHO-CH_2-(CH_2)_n-CH_2\ CH_3$ →**Aldehyade compound**

$$\xrightarrow{O_2}\ \downarrow$$

$CH_3-(CH_2)_n-CH_2-C=0-(CH_2)_2-(CH_2)_nCH_2\ CH_3$ →**Kestone compound**

$$O_2$$

$CH_3-(CH_2)_n-CH_2-CHOH+CH_3-(CH_2)_n-CH_2\text{-}COOH$ → **Acidicand Alcoholic compound**

$$\downarrow$$

$CH_3-(CH_2)_n-CH_2-\ COOH$ → $\boldsymbol{\beta}-$ **Oxidation**

End products are environmentally friendly.

(ii) $C_nH_{2n}+O_2\ \rightarrow CH_4+\ CO_2+biomass+heat\ release$

End products are environmentally friendly.

Reaction Kinetics

Biodegradation rate of petroleum hydrocarbon for study will be obtained using the principles of the law of Conservation of Mass for batch reactor, continuous stirred Tank reactor (CSTR) and plug flow reactor

For Batch reactor

The reaction taking place in the reactor can be represented as shown below

$$TPH+E\ \overset{k_d}{\rightarrow}\ P \tag{27}$$

Where, TPH is Total petroleum hydrocarbon $(g)E$ is enzyme or bacteria count (efu/ml) K_d is degradation rate constant $(day^{-1}$ or $week^{-1})$

First Order Rate Kinetics

The first order rate kinetics, the rate of degradation of TPH can be expressed as

$$-r_{TPH}=-\frac{dC_{TPH}}{dt}=K_dC_{TPH} \tag{28}$$

Where K_d is Total petroleum hydrocarbon degradation rate constant (day^{-1}).

The general solution of the first order rate kinetics is express as;

$$C_{(T)}=C_0\exp\ (-K_d\,t) \tag{29}$$

Second Order Rate Kinetics

For second order rate kinetics, the rate of degradation of TPH can be expressed as

$$-r_{TPH} = -\frac{dc}{dt} = K_d C^2 \tag{30}$$

In this case C_{TPH} is equal to C and the resolving the equation (30) we have a general solution of;

$$C_{(t)} = \frac{C_0}{1 + C_0 K_d t} \tag{31}$$

Michael's Menten Model Equation

In this case the reaction taking place in the reactor can be represented as shown in equation (32);

$$[TPH] + [E] \underset{K_2}{\overset{K_1}{\Leftrightarrow}} [TPH]\,[E] \overset{K_p}{\rightarrow} P + E \tag{32}$$

Where, $[TPH]$ is Total Petroleum hydrocarbon, $[E]$ is Enzyme, $[TPH]\,[E]$ is Total petroleum hydrocarbon enzyme complex and $P + E$ is product free enzyme.

The kinetic model equation for Michael's Menten is expressed in terms of the substrate as;

$$r = \frac{r_{max}[TPH]}{K_{(TPH)} + [TPH]} \tag{33}$$

Monod's Model Equation

The kinetic model for the Monod's equation can be expressed in terms of microbial as

$$\mu = \frac{\mu_{max}[TPH]}{K_m + [TPH]} \tag{34}$$

The kinetics model functional parameters are found useful in following areas;

- Ø To monitor, predict and simulate the bioremediation process.
- Ø To estimate the effective period of remediation.
- Ø To estimate the performance of the remediant (Bio-stimulation process)
- Ø This information serves as a guide for the drawing of the cost estimate for clear-up programme.

The performance of remediant for remediation of petroleum hydrocarbon contaminated soil has been presented in this paper. The following functional parameters are to be considered for effectiveness in remediation of petroleum hydrocarbon in soil environment and other environment.

(i) Physicochemical Analysis of the petroleum hydrocarbon, soil environment, remediant in powder form.

(ii) Identify the significant evidence of the characteristics and concentration of the functional parameters and elements such as; the density, electrical conductivity (EC), moisture content (MC), Total organic carbon (TOC), total nitrogen (TN), phosphorus (p), potassium (k), pH, metals etc.

(iii) Bioremediation of Petroleum hydrocarbon contaminated soil using remediant can be proven to be very effective in restoring the soil to its original status, if it contains the useful functional parameters. The NPK values from the powder form of remediant are good for remediation. Research conducted by Ukpaka revealed that remediantdried in the absence of sunlight gives optimum performance than those dried in the present of sunlight.

(iv) The ratio of the factorial design is a contributing factor on bioremediation of petroleum hydrocarbon.

(v) The inhibiting parameters should be monitored during planning of the good bioremediation triangle.

(vi) A plot plant is necessary to experiment, and thereafter the scale up process of the remediation.

(vii) Most of bio-stimulants can be considered to be a good remediant, if the functional parameters, characteristics and composition merits the general concepts.

9.0 MY CONTRIBUTIONS TO KNOWLEDGE

9.1 Modelling and Simulation of Chemical and Petrochemical Processes

In the areas of modeling and simulation of chemical and petrochemical processes using experimental data or results as well as all necessaries boundary conditions and assumptions enhance the prediction of the system or process theoretically on the important parameters of interest. Different models were developed base on the law of conservation of mass, heat and momentum as demonstrated below

9.1.1	**Predictive Model for Petroleum Hydrocarbon Degradation in Aqueous Environment (Mass and Momentum)**	$VR = \frac{1}{t}\left[\frac{Km}{r_{max}} In\left[\frac{Cs}{Cso}\right] + \frac{1}{r_{max}}\left[CS - Cso\right]\right]$ The effect of pH, electrical conductivity, dissolved oxygen, biochemical oxygen demand, salinity and temperature were monitored and the rate of TPH degradation was affected by these factors. The TPH degradation was faster in fresh water medium than salt water medium
9.1.2	**Evaluation of the Degradation of Lubricating Oil Characteristics on Utilization in Automobile Engine:** The model developed predict the coverage of a distance of 600km and parameters monitored are density, pour point, flash point, kinematic viscosity at 40°C, kinematic viscosity at 100°C, pH, refractive index, viscosity index, water content, TBN, sediment, sulphate ash and TAN	$InP - InPo = \beta t$ $InP = \beta t + InPo$ where $\beta = 1/t\ Inp/p_o$ The properties of the lubricating oil vary greatly after the automobile engine
9.1.3	**Simulation Model for Production of Chloromethane Products**. The developed model equation for the CSTR and PFR which consist of system of ordinary differential equation and system of partial differential equations respectively was solved using MATLAB R2015a ODE 45 solver (Runge-kutta 4th order algorithm) for the ODE and the finite difference method for the ODE	The sensitivity analysis carried out on temperature variation in the two rector's shows that the CSTR has good temperature characteristics compared to the PFR with outlet temperature of 250°C to 446°C and 250°C to 727°C

The kinetics of the process of thermal chlorination of methane is expressed as

$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$

$CH_3Cl + Cl_2 \longrightarrow CH_2Cl_2 + HCl$

$CH_2cl_2 + Cl_2 \longrightarrow CHCl_3 + HCl$

$CHcl_3 + Cl_2 \longrightarrow CCl_4 + HCl$

For methane

$$\gamma_{CH\,4} = K_{CH\,4}\ C_{CH\,4}\ {}^{0.5}Ccl_2,\ where\ K_{CH\,4} = 2.31 * 10^{11} \exp\left(\frac{-129000}{RT}\right)$$

$$\gamma_{CH\,4} = 2.31*10^{11} \exp(-129000/RT)\ C_{CH4}\ {}^{0.5}Ccl_2$$

For Monochloromethane

$$\gamma_{CH3}cl = K_{CH3}cl\ C_{CH}3cl\ {}^{0.5}Ccl_2$$

Where, $K_{CH3}cl$ = 2.09* 10^{12} exp (-131900/RT)

$$\gamma_{CH\,3}cl = 2.09 * 10^{12} \exp\left(-131900/_{RT}\right) C_{CH\,3}cl\ \ 0.5cl_2$$

For Dichloromethane

$$\gamma_{CH\,2}cl_2 = K_{CH\,2}cl_2\ C_{CH\,2}cl_2\ {}_{0.5}Ccl_2$$

Where,

$K_{CH2}cl_2$= 1.57* 10^{12} exp (-136200/RT)

$$\gamma_{CH2}cl_2 = 1.57 * 10^{12} \exp\left(\frac{-136200}{RT}\right) C_{CH2}cl_2\ {}^{0.5}Ccl_2$$

For Trichloromethane

$$\gamma_{CH}cl_3 = K_{CH}cl_3\ {}^{0.5}Ccl_2$$

Where,

$K_{CH}cl_3$ = 2.94* 10^{11} exp (-138900/RT)

$$\gamma_{CH}cl_3 = 2.94 * 10^{11} \exp\left(-138900/_{RT}\right) C_{CH}cl_3\ {}^{0.5}Ccl_2$$

For Tetrachloromethane

γccl_4 = $Kccl_4$ $Cccl_4$ ${}^{0.5}Ccl_2$

Where,

$Kccl_4$ = 1.09* 10^{11} exp (-142800/RT)

$Cccl_4$ = 1.09* 10^{11} exp (-142800/RT) $Cccl_4^{0.5}Ccl_2$

9.1.4	**Biokinetics Model for Crude Oil Remediation:** The concept of the activator and inhibitor of factors affecting enzymatic reactions	Michaelis Menten model was modified and in terms of pH as an activator $R = \frac{R_{max}\ TPH}{K_{TPH} + TPH}\ x\ pH$
	The biokinetic models from the research pose as a guide in predicting the time it will take to acquire a desired degree of degradation across the different soil types if	In terms of inhibitor
	this stimulant is used in appropriate quantity in the actual field. There may be some discrepancies due to the influence of natural phenomenon such as climate condition, microbial population, influence of microorganisms, constituent of the soil erosion, flooding, composition, human content porosity and permeability	$R = \frac{R\max\ TPH}{K_{TPH} + TPH}\ x\ \frac{1}{pH}$

9.1.5 Predictive Model of Diffusion of Crude Oil in Soil

The model was developed by considering the following two dimensional, thus is θ and Z as described in the equation below

$$R\frac{\partial ci}{\partial t} = D\left(\frac{\partial^2 ci}{\partial \theta^2} + \frac{\partial ci}{\partial z^2}\right)$$

Where, R – retardation factor = 1 + ?$_b$Ks/?

?$_b$ = bulk density of the soil, Ks – dissociation coefficient, ? = effective porosity

Using the following boundary condition

C (0, 0, t) + 0 for all t $\geq$ 0

C 9l, b, t) = 0 for all t $\geq$ 0

C (θ, z, 0) = f(0) for 0 $\leq\theta\leq$ l and 0 $\leq$>$\leq$ b

We assume a trial solution of the form

C (θ, z, t) =θ(θ) Z (z) T (t)

The general solution obtained after applying all mathematical tools and techniques becomes

$$C\ (\theta, z, t) = \frac{2Co}{l}\sum_{r=1}^{\infty}\left(l\int_o f(\theta)\sin\frac{r\pi\theta}{l}d\theta\right)e^{-r\theta}\sin r\frac{-DP^2t}{e^{1+\rho bKs/\phi}}$$

The study revealed that crude oil diffusion is faster in sandy soil > loamy soil > clay soil and the Ks values of the three different soil environments were used in the determination of the effect of it on the concentration of the total petroleum hydrocarbon using functional physical parameters.

The study revealed that crude oil diffusion is faster in sandy soil > loamy soil > clay soil and the Ks values of the three different soil environments were used in the determination of the effect of it on the concentration of the total petroleum hydrocarbon using functional physical parameters.

9.1.6 Momentum Transfer and Kinetic Model for Hydrocarbon Degradation in a Flowing Stream

The study revealed that the physicochemical parameters of the flowing stream was influence by the effect of the momentum transfer which indeed, influence the chemical, physical and the biological behavior of the degradation. Furthermore, the study shows that lower molecular weight of individual hydrocarbon could be degraded before higher ones, such as

$$\overline{M}_{c6} > \overline{M}_{c7} > \overline{M}_{c8} > \overline{M}_{c9} > \overline{M}_{c10}$$

$$\overline{M} = \frac{A_{V\max} \frac{L^2}{2}}{\frac{Ks}{Si} - \frac{Ks}{Kf} + In\frac{Si}{Sf}}$$

The momentum transfer and kinetic model for monitoring individual hydrocarbon degradation in a flowing stream system can be achieved by using the developed model

9.1.7 Sodium Benzoate Production – Model Base Approach

The performance of the Batch Reactor, Continuous Stirred Tank Reactor (CSTR) and Plug Flow Reactor (PFR) for production of sodium benzoate from the reaction of sodium hydroxide and benzonic acid were investigated. The performance equations for the production of Sodium Benzoate can be achieved using batch reactor, CSTR and PFR in which models were developed for the analysis of the reactor's functional dimensions and

parameters. The analysis of the reactor's functional parameters was performed at molar ratio of benzonic acid of 1.5 to 3.0 at intervals of 0.5 and at the same reactor operating conditions.
The study revealed that any of the three reactors could be used in the production of sodium benzoate, especially the batch reactor and the continuous reactor (CSTR) since the reacting species are in liquid state. Accurate molar feed ratio of the reacting species charged into the reactor will not only improve the yield of sodium benzoate, but also will improve the performance of the reactor functional parameters, thereby reducing cost.

9.1.8 Adsorption of Crude Oil using Sawdust

Study was carried out to investigate the suitability of sawdust for oil spill cleanup. Theoretical and experimental methods were applied to evaluate the adsorption capacity of sawdust on crude oil contaminated aquatic environment. The effect of particle sizes of 0.4mm, 1.18mm, 2.80mm, 3.35mm and 5.0mm obtained by sieving were tested in terms of their suitability. The different wood sawdust was monitored with respect to the rate of adsorption in order of magnitude and the result obtained revealed hard wood sawdust > semi-hard wood sawdust > soft wood sawdust. The observation demonstrates that, particle size influences the rate of contaminants adsorption in the process. Therefore, sawdust is a material with fine particles size with high surface area and with the capability of oil uptake. Sawdust which is cheap and available waste from most sawmills within the Niger Delta area has been successfully used as an adsorbent for the adsorption of crude oil on aquatic environment.

9.1.9 Adsorption of Kerosene using Mixture of Clay and Sawdust

The investigation of locally formulated adsorbent, made from clay and sawdust for the adsorption of kerosene in fresh water was carried out. Kerosene, as one of the fractions of crude oil was used in the study and the three formulated clay and sawdust were R9:1, R7:3 and R8:2 and clay sample only as control. The performance of the formulated adsorbents was rated as 92.6% for R8:2, 88.94% for R7:3 and 83.07% for R9:1 and 53.92% for control sample. The potential of the mixed adsorbents revealed that a mixture of clay and sawdust are more effective for the removal of Kerosene in water than clay sample only as adsorbent. Therefore, can be utilized for remediation of oil polluted water especially, as they are readily available at a cheap price.

The study has shown that formulation of clay and sawdust is effective for the removal of kerosene in extension, polar solvent in water. Although, clay alone can remove the kerosene, increasing the ratio of sawdust in the clay formulation improves the efficiency of kerosene removed. Also, the utilization of this formulant can help the nation's economy through reduction in cost of importation of adsorbent. This is because the raw materials are always available in most our local communities.

9.1.10 Domestic Solid Waste Degradation Model

The concept of Taylor's Theorem was used in monitoring some domestic solid waste degradation in a close system. The Taylor's variable model for domestic solid waste degradation is

$$f(a,h) = f(a) + hf^{1}(a) + \frac{h^{2}}{2} f^{1}(a) + \ldots\ldots\ldots \frac{h^{n}}{b1} fn(a)$$

Truncating after second order

$$f(a+h) = f(a) + hf^{1}Ca + \frac{h^{2}}{2^{1}} f^{2}(a)$$

The general solution equation obtained after the simplification of the Taylor's Theorem in terms of functional parameter is

$$W = \frac{1}{2}\lambda h^{2} + \beta h + \gamma$$

where W = weight loss of the domestic solid water

$$\alpha = \partial^2 c / \partial x^2,\ \beta = \partial c / \partial x,\ \lambda = C(P, w) = C(p) = C(w)$$

The developed model can be applied industrially to determine the rate at which municipal solid waste dumps can degradate as well as evaluating other controlling factors that influence solid waste degradation.

9.1.11 Metal Corrosion – Finite Element Analytical Methods

Metal corrosion was study in different soils environment of Niger Delta Area of Nigeria. The various metals studied include mild steel, carbon steel stainless and copper steel. The metals were buried in different soil environments of clay, sandy and swampy. The partial differential equation of second order was resolved using Laplace transformation techniques as well as with the necessary boundary conditions to obtain a general solution as a function of time and distance. The Galerkin's finite element method (GFEM) was resolved by expressing the partial differential equation to obtain the matrix of 5 x 5 forms to monitor, predict and simulate the corrosion rate of the various metal specimen examined. The functional parameters studied includes, pH value, electrical conductivity, moisture content, density and organic matter (physicochemical parameters). The velocity space time, weight loss, functional coefficients (K_1, K_2), coefficient function (k) were evaluated and correlated to monitor, predict and simulate the corrosion rate of each metal in the various soils environment.

The expression of the matric of 5 x 5 in terms of weight loss is given as

$$\begin{vmatrix} K_1 + K_2 & K_1 - K_2 & 0 & 0 & 0 \\ -K_1 + K_2 & 2K_1 & -K_1 - K_2 & 0 & 0 \\ 0 & -K_1 + K_2 & 2K_1 & -K_1 + K_2 & 0 \\ 0 & 0 & -K1 + K2 & 2K1 & -K_1 + K_2 \\ 0 & 0 & 0 & -_{K1} + K_2 & -K_1 - K_2 \end{vmatrix} \begin{vmatrix} Ce_1 \\ Ce_2 \\ Ce_3 \\ Ce_4 \\ Ce_5 \end{vmatrix} = \begin{vmatrix} WL_1 \\ WL_2 \\ WL_3 \\ WL_4 \\ WL_5 \end{vmatrix}$$

where, $K_1 = {}^{K}\!/_{V}$ *and* $Kn = {}^{Vx}\!/_{2}$, $V = {}^{dw}\!/_{dt}$, $K = {}^{v}\!/_{t}$, $K_2 = {}^{K}\!/_{2}$

The rate of corrosion is dependent of diffusion and the velocity of influence factors, which are V, K and K_2.

The following observations were made, such as

- The chemical, physical and biological characteristics of any given soil in contact with metal specimen remarkably induced or increased the deterioration of the metal in the environment (high level of metal degradation) as the properties of soil changes either in wet or dry seasons
- The acidification or alkalization of the soil environment with metal interaction is dependent on not only the chemical nature of the metal's specimen immersed, but also the prevailing environmental factors.
- The nutrients that leach out from the metals as a result of deterioration or degradation of the metal was useful for the various bacteria and fungi isolated and identified for the purpose of catalyzing the process

10. CONCLUSION

The production of chemical and petrochemical products for national development using locally sources raw materials especially the waste parts and converting it to useful products for the purpose of improving the Nigeria economy in terms of revenue generation, job creation etc. has been projected out in this inaugural lecture.
The need for production of chemical and petrochemical products using local raw material for the purpose of national development can be achieved by applying the required potential in terms of the techniques, material selection and preparation as well as processing methods. The productions of some chemical and petrochemical products obtained by using local raw materials are described below.

Description	Product Obtain and Comment 's	Findings
Production of cement from mixture of palm kernel and periwinkle shell The periwinkle and palm kernel shell were sourced, cleaned and heated in an electric furnace at temperature of 600°C and 400°C respectively and thereafter ground and sieved through 75 microns sieve to fine ash. Chemical analysis was conducted in the PKSA and PSA and the result obtained compared with the chemical analysis of Dangote and BUA cement. The cement was produced from the varying mixture of PKSA and PSA in ratio of 4:1, 3:2, 2:3, 1:4 and 1:1 respectively by heating each mixture at temperature of 350^0 C and additives added to produce the samples of cement A, B, C, D and E respectively.	Cement produced The setting time of each sample were conducted. Fifteen concrete mix (three from each sample) were produced by combining each sample fine aggregate and coarse aggregate to ratio of 1:2:3 with cement to water ratio of 0.6 and were aired for 7, 14 and 21 days	Observation shows that PKSA and PSA has the same elemental constituent with that of Dangote and BUA cement, though on varying proportion. Combination of PSA and PKSA in ratio of 4:1 (sampled) has the highest compressive strength compare to others. However, additives of Fe_2O_3, SiO_2 and Al_2O_3 were further added to sample D to produce cement of satisfying quality compared to Dangote cement

Others

Production of cement using periwinkle shell ash and clay soil ash

Production of cement using palm kernel shell ash, palm fiber ash, chipping dusts and clay soil ash.

2. Production of Soap using Different Sawdust Ash

- The study reveals that soap production using hard wood sawdust ash yielded the best quality when compared to semi hard wood sawdust and softwood sawdust
- The lye without the addition of distill water yielded high quality bar soap with reduced moisture content
- The study has demonstrated that both liquid and bar soap can be produced using sawdust ash and this approach is a new innovation

3. Production of Corrosion Inhibitors

Different plant extracts and plant extracts blended with polyethylene glycol was investigated in the production of corrosion inhibitors and the following parameters were checked such as:

- Inhibition properties – gravimetric measurement and potential measurement
- Performance evaluation of formulated inhibitor by Gravimetric measurement
- Corrosion rate
- Surface coverage and inhibitor efficiency
- Determination of electrochemical measurement parameter, such as: Corrosion current, corrosion potential and Inhibition efficiency of the inhibitors
- Determination of adsorption isotherms parameters, such as: Freundlich isotherm, Langmuir isotherm and Temkin isotherm
- Determination of the nature of the adsorption include: Physisorption and Chemisorption
- Determination of thermodynamic and activation parameters of the inhibitors

The following observations were drawn from the study, such as

- Crude extract inhibitors can be produced with less energy requirement
- Developed an effective local content alternative of metal corrosion inhibitor to be used for picking of oil and gas tubing's, using crude extract and an improved formulation with the blend of crude extracts
- The inhibitor produced can be used for pipeline cleaning and integrity assurance
- The production process will generate increased economic opportunities such as foreign exchange and create employment
- Blending of crude extracts with water soluble polymer

improved the stability of crude extracts used for corrosion control in acidic media

4. Production of Polymer Composite

The production of the polymer composite was achieved by using thermoplastic, sharp sand and sawdust as well as introducing the application of mix techniques. Polyethylene Terephthalate (PET) is the most widely used material in the modern world because of its light weight and durability. PET is non-biodegrable and contribute majorly to waste and land pollution. The quantity of plastic waste is expanding rapidly due to its use which is of great threat to the environment. The PET waste plastic is utilized in manufacturing fibre-reinforced polymer composite by combining sawdust which is another waste product from woodwork operations and sand, a major component in construction, whose use is greatly threatening the ecosystem. The fibre reinforced polymers composite was combined in different ratios of 0:0:10, 0:1:9, 1:1:8, 1:2:7 and 1:3:6 similar to A: B: C, where A represents ratio of sand, B represents ratio of sawdust and C represents ratio of PET. The following observations were drawn from the research as stated below:

- That the density of the fibre reinforced polymer composites reduced from 1.38g/cm^3 in ratio of 0:0:10 to 1.0676g/cm^3 in ratio 1:3:6 as the ratio of PET was reducing in the composite and sawdust was increasing.
- The percentage water adsorption was observed to range from 0.3147 in ratio of 0:0:10 to 5.53 in 1:3:6 and the compressive strength from 1.792N/mm^2 in ratio 0:0:10 to 3.689N/mm^2 ratio 1:3:6
- PET plastic was used as resin matrix in producing fibre reinforced polymer composite and sawdust was applied as biofillers or natural (green) fibre.
- The composite produced could be a good alternative to

conventional clay bricks to reduce the consumption of natural resources such as sand and for effective and efficient utilization of waste plastic for a healthy environment.

- Plastic can actually be combined with sawdust to develop a composite material hard enough to be applied in various areas.
- The research has presented an alternative route in the waste management of PET plastics and sawdust and has shown a way to reduce the consumption of cement and sand in the construction of building fillings.

Design Works on Chemical, Petrochemical and Biochemical Engineering

Performance evaluation of reactor types and design of different chemical, petrochemical and biochemical processes for the production of chemical and petrochemical products using different local raw materials have been researched on. And the following have been considered as a way forward in the production of bio-methane a suitable alternative to natural gas.

1. Design for Production of Methane from Food Waste

The following concepts was considered to achieve the methane production from the food waste as demonstrated, such as: Characterization of food waste, Proximate composition analysis of food waste, Identifying hydrocarbon degrading bacteria, Determination of the effect of 1/S at constant HRT, Development of process models, Material balance equation, Application of material balance on reactor processes (CSTR), Energy requirement of the process, Application of heat effect to CSTR, Optimization of fabrication, Determination of specific heat capacity cp of feedstock, Determination of thermodynamic parameters, Estimation of reactors cost and Mechanical design of continuous stirred tank bioreactor (CSBr)

Performance analyses of different reactor types were evaluated and followed by the design of a continuous stirred tank bioreactor (CSBr). In the study, food waste (FW) and cattle rumen content (CRC) which served as the feedstock and biostimulant respectively were subjected to proximate analysis using standard methods. Further, experimentation was carried out to determine the effect of inoculum dosage on biogas and methane yields using four different sample runs of 0% for control, 25%, 50% and 75% dosage. Furthermore, the effect of organic loading rates (OLR) an important parameter for flow processes was evaluated. The outcomes of the findings revealed the following, such as: Determination of some thermodynamic parameter. The research also presents a method for calculating enthalpy change of reaction for anaerobic digestion. Comparative analysis of different growth rate models for solid suspended media such as food waste. Existing comparison of different growth rate models were centred on soluble nutrients for easy measurement of microbial mass. The research revealed that CSTR is cheaper as well as more productive than BR
And on continuous production, one-time biostimulation showed an increased biogas quality which has not been reported.

11. RECOMMENDATIONS

Vice-Chancellor, Sir, based on the projected monumental discoveries and innovations as demonstrated in today's Inaugural Lecture, the following recommendations are outlined for the purpose of national development, which include:

1. The Rivers State Government should collaborate with the Rivers State University in the areas of their interest for research that can enhance development of the State by using the basic raw materials available within the state, specifically, applying processes that can be used in

converting waste into wealth as well as for job creation, revenue generation, and ensure that the products obtained are found useful for human utilization and existence.

2. The University should partner with industrial developers in the areas of good research that demonstrates new discovery and innovation of products for the purpose of establishing industries, provided the raw materials are available within the State.
3. The Nigerian Content Development Board (NCDB) should collaborate with the State local content board, if existing, to harness the opportunities of university research outcomes from the field of chemical and petrochemical engineering for the development of our state and country economy. The useful products that were revealed today from the process of converting waste materials into useful products has demonstrated the manner in which wealth is wasted.
4. The Federal and Rivers State Government should consider Industrialization as a major key for the state and national development, considering the fact, that the products obtained are health wise and environmentally friendly to humanity. However, the cost implication for production is less when compared to imported material as a major constituent. This can help devaluate the dollar to naira exchange rate.
5. The Federal Government of Nigeria should collaborate with the Rivers State university research unit to be part of cleanup project in Ogoni land, because most of the bio-stimulant used in the treatment of contaminated soil and water by crude oil and its products can be formulated within the state due to availability of the raw materials.
6. The establishment of industries by States and Federal Government will help mitigate high level of

unemployment within the country and the products produced can be exported for revenue generation.

7. Researchers are advice to adopt the concepts of modelling and simulation in handling scientific and engineering issues; this will reduce cost and project the trend behavior of the system.
8. This outline points can be achieved with the availability of power. A country without steady light cannot develop, because all the key plays for the workability of industrialization is power, therefore, government must play their role to ensure that light is available for production and smooth operation of the industry.
9. Government should project a good policy that can enhance industrialization.
10. The university research unit should in collaboration with industry in areas of research interest for the purpose of providing solutions to some of their challenges. This medium can enhance internally revenue generation of the institution.

12 ACKNOWLEDGEMENTS

Blessed be the God and Father of Our Lord Jesus Christ, which according to His abundant mercy hath made it possible for me to present this inaugural lecture today in good health. I build my home on the book of Isaiah 41:10 that says "Fear thou not; for I am with thee: be not dismayed; for I am thy God; I will strengthen thee; Yea, I will help thee; yea, I will uphold thee with the right hand of my righteousness" and "for I the Lord, thy God will hold thy right hand, saying unto thee, fear not, I will help thee; on these words of God I trusted my faith and wisdom so I was endowed from the knowledge of discovery and innovation in the field of Chemical and Petrochemical Engineering as well as Biochemical Engineering exceptionally.

I hereby use this medium to acknowledge great men and women, which have impacted my life positively in my education and career advancement. Let me begin by thanking the Vice-chancellor of our great University, Professor Nlerum S. Okogbule, DSSR, FCIArb for giving me this opportunity to showcase my academic achievements as well as his approval and support towards the success of this inaugural lecture.

And with joy in my heart, I humbly appreciate the Deputy Vice-chancellor (Administration) Professor Victor Akujuru and Deputy Vice-chancellor (Academic), Professor Valentine Omubo Pepple, for their words of encouragement and support.

My gratitude goes to the former Vice-chancellor of Niger Delta University (NDU) Wilebeforce Island Bayelsa State Engr. Prof. H.A. Ogoni for his advice and mentorship. Sir, the fatherly role you played in my life has showed the love you have for me and my entire family. My deep appreciation goes to late Prof. S.A. Amadi former Dean of Engineering and late Prof. J.A. Akor of Department of Agricultural/Environmental Engineering for their encouragement and fatherly love while in active services.

I wish to appreciate the former Vice-chancellors of this great University for their fatherly love and encouragement. I thank Prof. Blessing Chimezie Didia, Sir you are the one that the Almighty God used to affirm my growth and success to attain the rank of Professor in this great University in 2018. Sir, the God we serve and worship will stand for you and your family in times of trouble and tribulations. I am most grateful, thank you sir. It is important for me to appreciate the former Vice-chancellor Prof. S.C. Achinewhu, Sir, I was employed into this great University in your tenure as Vice-chancellor. Sir you gave approval to my application as a Graduate Assistant and the Almighty God used you as instrument and a vessel in his hand to change my life.

I am very grateful to all past Vice-chancellors, Deputy Vice-chancellors, Registrars, Bursars, other principal officers of this great University. My appreciation also goes to the Chairman Senate Lectures Committee Prof. N.H. Ukoima and to all Professors and Senate members of this great University for their support and encouragement.

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Professor Chukwuemeka Peter Ukpaka is married to Deaconess Chiwetara Chukwuemeka Ukpaka and the family is blessed with beloved children of three boys and three girls.

Special appreciation goes to all members of Ukpaka's family, all members of Obite community and Egi clan. Also, to my mother Deaconess Jerina Peter Ukpaka and my late father Elder Peter N. Ukpaka. Thanks for the sacrifices you made for my upbringing, especially in the area of Christianity, academic foundation, love and prayer over my life. Let me specially appreciate my children for their love, prayer and encouragement as well as acknowledge with thanks the contribution of my children for their positive role played in the family and for the success of this inaugural lecture.

CITATION

PROFILE OF PROF. CHUKWUEMEKA PETER UKPAKA, MNSE, MNSCHE, FSINRHD, COREN, MIOGR

Professor Chukwuemeka Peter Ukpaka is the first child out of seven children of boys and girls born into the God fearing and humble family of late Elder Peter Ukpaka and Deaconess Jerina Peter Ukpaka of Umu-Amadi compound in Umu-Ohali Group family of Obite town in Egi clan of Ogba/Egbema/Ndoni Local Government Area of Rivers State. He is a Professor of Chemical and Petrochemical Engineering Department of this University.

Professor Chukwuemeka Peter Ukpaka started primary education in Obite State School from 1975 to 1982 where he obtained the First School Leaving Certificate. Professor Chukwuemeka Peter Ukpaka attended Government Secondary School Akabuka from 1983 to 1988 and Government Secondary School Emelego from 1990 to 1991 where he obtained his Senior Secondary Certificate Examination.

Professor Chukwuemeka Peter Ukpaka attended Rivers State University of Science and Technology in 1992 where he obtained his Bachelor of Technology Degree in Chemical/Petrochemical Engineering in 1999. He obtained his Master of Technology Degree in Chemical Engineering in 2004 and Doctor of Philosophy Degree in Chemical Engineering in 2009.

Professor Chukwuemeka Peter Ukpaka worked briefly with Academic Commercial Secondary School as a Teacher from 1989 to 1990, Bestman Commercial Secondary School as a Vice-Principal from 1992 to 1993 and Pabod Breweries Plc as Accounts Clerk from 1993-1995. He was employed by the Rivers State University of Science and Technology now Rivers

State University Port Harcourt as a Graduate Assistant after successful completion of his First Degree in Bachelor of Technology (B.Tech) Degree in Chemical/Petrochemical Engineering in 1999.

Professor Chukwuemeka Peter Ukpaka is a full-time lecturer in the department of Chemical/Petrochemical Engineering of Rivers State University and he started as a Graduate Assistance from 2001-2004, Assistance Lecturer in 2004, Lecturer II from 2004-2005, Lecturer I from 2005-2008, Senior Lecturer from 2008-2011, Reader from 2011 to 2015 and Professor from 2018 to date. He has supervised several postgraduate and undergraduate research works of which 20 Ph.D students have graduated under his supervision, 120 students of Master of Technology (M.Tech) and Master in Engineering Management (MEM), 4 students of Post Diploma Programme (PGD) and over 200 students of undergraduate programme.

He was Head of Department of Chemical/Petrochemical Engineering from 2016-2021 and he has served as Postgraduate coordinator of the departments from 2009-2010, Centre for Continuing Education (CCE) Coordinator of the Department from 2007-2012. He has served as the Editor of the Rivers State University Journal sector of Nigerian Journal of Oil and Gas Technology from 2016-2021, Student Union Government (SUG) 2016 Electorate Committee, ad-hoc Committee for Affiliation of Valley View Polytechnic with Rivers State University as Chairman, ad-hoc Committee constituted by Senate to produce for appointment the Head of the Professorial chair in Marketing, a member ad-hoc committee constituted by Senate to review the Rivers State University Ethic guidelines as member. He was the regional editor World Journal of Biology and Medical Sciences:

Professor Chukwuemeka Peter Ukapka was dedicated from childhood as a devoted Seventh-Day Adventist Church member, who believed in the words written in the Holy Bible. He has served as Head Deacon, Patron, Elder, Supervisory Elder and Leader. He was made First Elder in Seventh-Day Adventist Church Elioparawo and Associate Stewardship Director of Old Port Harcourt Conference of Seventh-Day Adventist Church and presently, the Associate Stewardship Director of the Port Harcourt East Conference of Seventh-Day Adventist Church.

Professor Chukwuemeka Peter Ukpaka area of specialization are Chemical, Petrochemical and Biochemical Engineering, which include Instrumentation, Process Control and Dynamics, Material Science, Pollution Control, Petrochemical and Organic Synthesis, Chemical Processes and Technology, Modeling of Chemical Processes, Corrosion, Petrochemical Technology Reliability and Risk Analysis in Chemical and Petrochemical process Plant, Fluid Mechanics, Design, Bioremediation etc.

Professor Chukwuemeka Peter Ukpaka is vast in teaching and research. He has published over 560 papers on areas of Chemical, Petrochemical and Biochemical disciplines in National and International referenced journals. He was the first Editor of the Nigerian Journal of Oil and Gas Technology, Associate Editor with International Journal of Chemistry and Chemical processes – Hard publishing company and Editorial Board member of STM Journals and Journal Pub in the following journals, International Journal of Thermodynamic and Chemical Reaction Kinetics and Control, International Journal of Chemical Synthesis and Chemical Reactions. He has published three textbooks in the field of Chemical, Petrochemical and Biochemical Engineering with the following topics (1) Instrumentation, Process Control and Dynamics (2) A Textbook on the Concepts of Biochemical Engineering and its Application (3) Materials Science and Dielectric Materials Properties.

He has reviewed different articles and a reviewer to several journals which includes Greener Journal of Science Engineering and Technology Research, Greener Journal of Physical Sciences, International Association for the Advancement of Modeling and Simulation Techniques in Enterprises, International Journal of Novel Research in Engineering and Pharmaceutical Sciences, International Journal of Applied Chemical Science Research, Academia Scholarly Journal, Journal of Petroleum Technology and Alternative Fuels, Herald Journal of Geography and Regional Planning, Global Research Journal of Agriculture and Biological Science, Open Science Journal, African Journal of Biotechnology, World Journal of Medicine and Medical Science Research, International Research Journal of Public and Environmental Health, American Multidisciplinary International Research Journal, Chemistry International etc.

Professor Chukwuemeka Peter Ukpaka is presently an external examiner to Federal University of Otuoke, Bayelsa State and has served as an External Examiner to Federal University of Technology Owerri and University of Port Harcourt. He had assessed academic staffs of other University to the rank of Associate Professors and Professors of different professorial carders. He was an adjunct lecturer in Niger Delta University (N.D.U) Bayelsa State. He has also attended several local and international conferences and paper presented.

Professor Chukwuemeka Peter Ukpaka is a member of different professional bodies (1) Member of Science and Technology Forum (International Research and Development) (2) Member of Nigerian Society of Engineers (NSE) Omoku Branch and once a Chairman as well as served in different committees such as a member of : (i) Prevention, Investigation and Failure Analysis Committee of Nigeria Society of Engineers (NSE), Port Harcourt and Omoku Branch (ii) Professional Interview Committee of NSE (iii) Treasurer in Nigerian Society of Engineers (NSE) Omoku Branch and Chairman of Prevention, Investigation and Failure Committee of Omoku Branch as well as member of National Committee (3) Member of Nigerian Society of Chemical Engineers (4) Member of Council for the Regulation of Engineering in Nigeria (COREN) (5) Fellow of Strategic Institute for National Resources and Human Development (FSINRHD) (6) Member of the Institute of Oil and Gas Research (MIOGR)

Professor Chukwuemeka Peter Ukpaka has received several awards, such as:

1. Outstanding Sponsor award presented by the Adventist Students Fellowship RSUST Chapter on 2007/2008 Academic Session
2. Excellence award presented by Nigeria Society of Chemical Engineers (Student Wing) National Secretariats (A Division of Nigerian Society of Engineers, NSE) reads “In appraised of your technical expertise in environmental problems, solution and bioremediation and the application of same in capacity building of engineering students during the 2010 National Convention”. This day 27th February 2010
3. Merit award presented by Seventh-Day Adventist Church Ula-Okobo District which reads “In recognition of your unflinching support and dedication to the service of God and Humanity”. This Day of August 2010.
4. Merit award presented by Rivers Conference of Seventh-Day Adventist Church, Adventist Men Organization (AMO), This 3rd Day of August, 2014
5. Pinnacle award presented by Nigerian Society of Chemical Engineers (A Division of Nigeria Society of Engineers, NSE). International Conference and Exhibition of 44th Annual General Meeting and Conference Owerri 2014 and too numerous to mention.

Professor Chukwuemeka Peter Ukpaka appraisal of his unflinching support to humanity and dedication to the service of God is a gift from the Almighty God. He has supported in paying school fees of many indigent students, build churches and rendered stewardship service to communities.

Professor Chukwuemeka Peter Ukpaka is visible in Research gate, publish or perish, Google scholar, Scopus such as in publish or perish of name Ukpaka, C.P., the available papers: 496, citations: 1408, h-index:17, g-index: 21, hI, norm: 11, citation years 20 (2004-2024) for Chukwuemeka Peter Ukpaka the available paper: 36, citations: 196, h-index: 7, g-index: 13, as well as in Google scholar- citations: 1404, h-index: 17 and i10-index: 36, total articles in Scopus, a vailable papers: 37, citations: 22 and he has published 560 articles

Professor Chukwuemeka Peter Ukpaka is the first to attain to the rank of Professor in Obite community among the three professors and second to present an Inaugural lecture. He was the first to win the pinnacle award issued by Nigerian Society of Chemical Engineers. The first to be awarded a professor of Chemical and Petrochemical Engineering in Nigeria. He has received several awards of Excellences and certificates on articles reviewed in National and International Journals as Editor and Editorial board member of several journals. He was the person who design and developed the conceptual procedures adopted by Total Energies for the treatment of the contaminated underground water after the 2012 flood in Egi communities and the concept yielded a positive outcome. He is a role model and has mentored many persons as well as supervised many Ph.D , M.Tech, MEM, PGD and B.Tech students, a patriotic community leader, a great footballer by name Pele. He has an unflinching support and dedication to the service of God and humanity. He is married to Deaconess Chiwetara Chukwuemeka Ukpaka and the family is blessed with God fearing three boys and three girls.

Professor Chukwuemeka Peter Ukpaka is presently a member of the 8th Governing Council of Federal College of Education (Technical) Omoku. He presented the keynote lecture to mark the Common Wealth Oil and Gas Induction Programme at Abuja 2020 under the Institute of Oil and Gas Research & Hydrocarbon Studies, which was held at Nicon Luxury, Abuja on Wednesday October 28, 2020 on the topic: "Hydrocarbon Contaminated Areas and Exploration of the Use of Coconut Fibre for Remediation and Clean-up".

Distinguished Ladies and gentlemen, I present to you the only professor of monumental discovery and innovation, a silent team leader, a game changer, a visioner, a team player, a great researcher of discovery and innovative mind. a rugged Pele in football, a dynamic researcher and game changer, a professor of positive mind that can never say no to academic demands, a reputable professor that is visible online globally, a professor who is a member of many academic editorial boards, a creative and productive professor in chemical and petrochemical industry and a man who has unquantifiable devotion and love for the service of God and humanity. The Ogba land firstborn professor of chemical and petrochemical engineering and by the grace of God, the first to become a professor of combine field of chemical and petrochemical engineering in Nigeria.

REFERENCES

Achadu M. A., &**Ukpaka, C. P**. (2023). Monitoring the effect of temperature on percentage of petroleum hydrocarbon remediation in packed bed units using agro-based adsorbents. *International Journal of Chemical Engineering and Processing*, 9(2), 35–47.

Amadi, S. A., & **Ukpaka, C. P.** (2007). Impact of corrosion inhibitors on the environment, *Journal of Modeling, Simulation and Control (AMSE)*, 68(4),1-15.

Amadi, S. A., & **Ukpaka, C. P**. (2015). Studying the synergistic effect of monochloramine and glutaraldelyde biocides against biofilm microorganisms in produced water. *American Journal of Applied Scientific Advances*, 1(3)105 – 139.

Eluozo, S. N., Ademiluyi, J. O., & **Ukpaka, P. C.** (2012). Comparative study to evaluate the effect from Nitrogen on the transport to E-coli in Pheratic aquifers at Obio-Akpor in Rivers State, Nigeria. *Journal of Middle East Applied Science and Technology (JMEAST),* 3(10), 192-200.

Ogoni, H. A.,& **Ukpaka, C. P**. (2004). Environmental Pollution of Drilling mud and Cuttings. *Nigerian Journal of Research and Production*, 4(4), 1-9.

Ogoni, H. A., & **Ukpaka, C. P.** (2016). Predictive model on the characteristics of substrate uptake by microbial film in a non-gel-like medium. *International Journal of Exclusive Global Research*, 1(2)1-10.

Ogoni, H., A & **Ukpaka, C. P**. (2004). Instrumentation, Process Control and Dynamics" 1st edition, (Textbook) Library of Congress Cataloging in Publication Data.

Ogoni, H.A., & **Ukpaka, C.P.** (2016). Evaluation of Substrate uptake by microbial film in a gel-like medium. *Chemistry International*, 2(4), 176 – 188.

Okirie, F. U.,& **Ukpaka, C. P.** (2018). Characteristics and Usefulness of Palm Oil in the Production of Calcium

Stearate, *Journal of Scientific and Engineering Research*, 5(5), 170 – 176

Peter, U. C., & Abah, A. M. (2024). Examination of microbial potential in packed bed on the effect of temperature for petroleum hydrocarbon treatment using adsorbent. *Discovery,* 60, e6d1398 doi:

Remediation of Crude Oil Polluted Soil Environment, *International Journal of Chem-informative Research,* 6(2), 1-8.

Ukpaka and Achadu M. Abah. (2023). Modeling and simulation of the packed-bed reactor for anaerobic treatment process of the refinery effluents. *Chemistry International,*9(4),167-175.

Ukpaka C. P., & Okedami Omiloli (2015). Studying the thermal death characteristics of microbes during ethanol production. *CASRP Journal of Applied Sciences*, 1(1), 51-50

Ukpaka C. P., Achadu M. Abah, & Obinna Isaac Ikechi. (2023). Potential of the Biokinetic Integrity of *Chromolaena Odorata* leaf as Bio-stimulant for Petroleum Hydrocarbon Remediation in Soil. *Journal of Petroleum Engineering & Technology*, 13(2): 47–75.

Ukpaka, C. P. (2011).Predictive Techniques to estimate the oxygen utilization by *Pseudomonas* Aeruginosa in petroleum Hydrocarbon in a fluidized bed Reactor. *ICASTOR Journal of Engineering,* 4(1), 91-106.

Ukpaka, C. P. (2011). Sedimentation model of suspended solids upon the influence of continuous discharge of waste water in pond system for dry season, *Global Journal of Engineering and Technology,* 4(4), 507-520.

Ukpaka, C. P. (2011). The Effect of Mesophilic and Thermophilic temperature on Bonny light crude oil degradation in Niger Delta Area of Nigeria using pseudomonas sp. *International Journal of Engineering and Technology Research,* 3(7), *203-208.*

Ukpaka, C. P. (2011). The Effect of some Physicochemical Parameters in Aromatic compound degradation in salt water medium. *ICASTOR Journal of Engineering,* 4(2), 177-200.

Ukpaka, C. P. (2012). Influence of Biokinetic Parameters for the Production of Ammonia from Fertilizer Company Effluent for Agricultural Application and Improvement on Soil/Water Environment. *Journal of AMA The book of Abstracts No. 1086,* 43(4), 88.

Ukpaka, C. P. (2012).Characteristics of produced Water from an Oil terminal in Nigeria, Delta Area of Nigeria. *Journal of Research in Environmental, Science and technology.* 1(5), 115-130.

Ukpaka, C. P. (2012). Investigating the kinetics of xylene production from 1,3,5-TMB in a fluidized bed reactor *Journal of modeling, simulation and control (AMSE),* 73(2), 1-17.

Ukpaka, C. P. (2012).Sodium chloride Concentration on the Rheological and Dynamic Properties of Aloe-Vera Gel. *Journal of Engineering and Technology Research,* 4(7), 136-148.

Ukpaka, C. P. (2012).The effect of functional parameters on microbial characteristics in crude oil degradation. *Journal of Research in Environmental Science and technology.* 1(4), 66-90.

Ukpaka, C. P. (2012). The effect of Substrate Characteristics Medium on Improvement of MEOR in Niger Delta Area of Nigeria. *International Journal of Current Research,* 4(1), 100-110.

Ukpaka, C. P. (2013). Application of competition model to predict and monitor the bacteria and fungi characteristics in solid waste degradation, *International Journal of Novel Research in Engineering & Pharmaceutical Sciences*, 1(01), 30 – 42.

Ukpaka, C. P. (2013). Application of discrete compartment models to predict and monitor degradation of crude oil in an ecosystem using matrix. *Journal of Modelling, Simulation and Control (AMSE),* 74(2), 50-60.

Ukpaka, C.P. (2020). Comparison on the performance of moringa and neem root extracts on crude oil degradation in soils environment. *Petroleum & Petrochemical Engineering Journal,* 4(3), 1-9.

Ukpaka, C.P. (2023). Evaluation of adsorption isotherm parameters on corrosion rate of metal using water-based extracts as an inhibitor in acidic medium. *International Journal of Polymer Science & Engineering,* 9(1), 14–25.

Ukpaka, C.P. (2023). Evaluation of adsorption isotherm parameters on corrosion rate of metal using water-based extracts as an inhibitor in acidic medium. *International Journal of Polymer Science & Engineering,* 9(1), 14–25.

Ukpaka, C.P. (2023). Plant extracts volume effects on the corrosion of mcs metal sample using water-based as an inhibitor. *International Journal of Chemical Engineering and Processing*, 9(1), 1–8.

Ukpaka, C.P. and Ekperi, N.I. (2021). A Predictive model on pipeline corrosion. *International Journal of Metallurgy and Alloys*. 7(1),15-25.

Ukpaka, C.P., Adaobi Stephenie Nwosi-anele. (2023). Monitoring of microbial growth on crude oil remediation using processed palmfruit fermented waste water and NKP Fertilizer. *International Journal of Pollution: Prevention and Control*. 1(2), 10–0.

Ukpaka, C.P., Eluozo, S. N & Orji, C. U. (2011). Impact of road construction dust on Plantain Vegetable in Port Harcourt Rivers State, Nigeria. *International Journal of Current Research,* 3(10), 92-98..

Ukpaka, C.P., Eno, Okon & Farrow, T.S. (2010). Modeling the effect of physical parameter: Euler and Stanton Number on the Temperature Fields and Velocity of gas distribution on a Steam heater Tube, *A Multidisciplinary Journal of Environment, Agriculture, Science & Technology,* 1(1), 1-18.

Ukpaka, C.P., Madumere Obinna Chidiebere. (2023). Examination of physicochemical parameters of crude oil remediation in soil environment using agro-based material. *Journal of Materials & Metallurgical Engineering,* 13(2), 22–30.

Ukpaka, C.P., Nnadi, V.G. (2024). Investigation of adsorbent morphology characteristics of some agro-based materials for treatment integration,*International Journal of Chemical Engineering and Processing*, 10(1), 27–40

Ukpaka, C.P.,Sinee, B.L & Harmony Nwosu. (2020). Crude oil degradation in loamy soil using neem root extracts: an experimental study. *International Scientific Organization: Chemistry International,* 6(3), 160-167.

Ukpaka, C.P., Uku, Philip Eruni., Amadi, S.A., Dagde, K. K. (2020). Mathematical modeling of the effect of functional parameters on the biodegradation rate of hydrocarbon. *Research and Reviews: Journal of Bioinformatic,* 7(3), 34-43.

Ukpaka, C.P., Umah, K.M.(2024). Comparative study of effect of weight, time and temperature on extracted oil recovered from some mango seed. *International Journal of Chemical Engineering and Processing*, 10(1): 41–58

Ukpaka, C.P., Vidose-Eli, E.A. (2024) Modeling the biokinetic of crude oil degradation in loamy soil using the citrus sinensis of flavedo part. *International Journal of Thermodynamics and Chemical Kinetics,* 10(1), 1–25

Ukpaka, Chukwuemeka Peter, Gladys Nneoma Charles-Orji, Ikenyiri Patience Nna (2021). Investigation of cassava starch characteristics for adhesive and integrity of preservative methods. *Discovery.* 57(311), 732-748.

Ukpaka, CP, Ugochukwu TM, Goodhead, TO (2021). Investigation into the physicochemical property of lye extracts suitability for soap product. *Indian Journal of Engineering*. 18(50), 398 – 405.

Ukpaka. C. P. (2022). Simulation analysis of reliability on available power consumed versus lube oil quality.

Chemical International 8(1), 33-41.

Ukpaka C. P., Victor Chukwuemeka Ukpaka, Joy Chukwuemeka Peter Ukpaka, Abraham Peter Ukpaka (2024). Evaluation of lemon grass (*Cymbopogon citratus*) performance for petroleum hydrocarbon degradation in soil environment. *Journal of Catalyst & Catalysis*, 11(2): 33–49.

UkpakaC.Pand Tekena KashmonyBala(2024).The concepts of chemical behaviors and electron structure relationship of group III elements. *Chemistry International*, (2024), (01), 10-15

Ukpaka, C.P (2023)**.** Effect of temperature on particle size mixed ratio on petroleum hydrocarbon treatment in packed bed unit using adsorbent. *International Journal of Thermodynamics and Chemical Kinetics*, 9(2): 1–12.

Victor Chukwuemeka Ukpaka, Abraham Peter Ukpaka and **Ukpaka C.P**. (2024).Effect of temperature on packed bed column adsorption performance for the treatment of contaminated water.*Chemistry International*, 10 (3), 93-98.