RECOVERY OF CAUSTIC POTASH (KOH) FROM AGRICULTURAL WASTES

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DECLARATION

I hereby declare that **JIBUNOR DANIEL N.** with registration number **99/8214EH** wrote and carried out this project. Information obtained from published or unpublished works of other have been well acknowledged by means of references and to the best of my knowledge it has never been presented in any seminar, symposium or else where in any form for the award of diploma or degree.
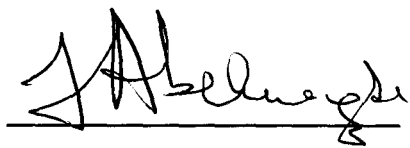
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DANIEL JIBUNOR N.   **DATE**
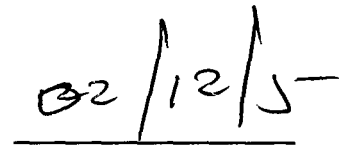**99/8214EH**

CERTIFICATION

This is to certify that this project write up was performed and carried out by **JIBUNOR DANIEL N**. for the partial fulfillment of the award of Bachelor Degree in Chemical Engineering. It has been read and approved by the undersigned on behalf of the Department of Chemical Engineering, the Federal University of Technology, Minna, Niger State.
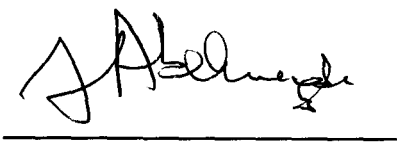
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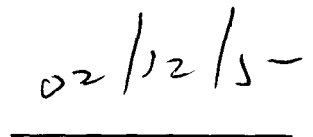Project Supervisor   Date

Dr. Aberuagba, F.

_____   _____
Head of Department   Date

Dr. Aberuagba, F.

_____   _____
External Examiner   Date

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DEDICATION

This project work is affectionately dedicated to the Almighty God for keeping me alive throughout my stay in the school.

Also, to my beloved parent, Mr. and late Mrs. Jibunor for their supports, encouragement and understanding.

ACKNOWLEDGEMENT

Firstly, I would like to express my thanks and appreciation to Almighty God, for the successful completion of my course of study in Federal University of Technology, Minna. This brings another milestone to an end.

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ABSTRACT

The research project entails the recovery of caustic potash (KOH) from agricultural waste and the determination of the caustic potash content in the waste at an ashing temperature of 600^0c for 3hours.

Different weight of ash sample were leached for 3 stages using batch leaching process with 500ml of distilled water at 100^0c for 2hours. The impure KOH recovered was analysed using pH and titration method, various leaching time of (30-180) minutes were also used to obtain the optimum leaching time.

The caustic potash content was determined using classical method. The result obtained shows that the pure yield increases as the weight of the ash increases, while the percentage yield decreases with increase in weight; for maize cob, the pure extract increases from 1.497g to 2.328g for ash of 15g and 60g, while the percentage yield decreases from 9.98 to 3.88 for the same weight of ash.

Finally, from the graph of yield versus the leaching time, the optimum leaching time of (120-150) minutes was obtained which shows that irrespective of the weight of materials to be leached, maximum of 150 minutes leaching must be employed.

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CHAPTER ONE

INTRODUCTION

1.0   BACKGROUND INFORMATION

Chemical Engineering as a discipline is primarily concern with the conversion of waste materials to useful products. By waste materials we mean those things that are seemingly useless to man and which sometimes constitute health hazard to man. Agricultural wastes form the bulk of these particulates. By Agricultural wastes we mean those by-products obtained from plant and animals, but for the purpose of this project, we shall lay emphasis on the by-product of plants. Plant wastes are the by-products obtained after the useful part of the crops have been carefully removed and used by man. The by-products are later discarded as waste. It is from these wastes that caustic potash is to be recovered.

Caustic potash is one of the most significant raw materials which find its uses in many chemical industries in Nigeria. The Nigeria economic recession has led many researchers to carry out various studies on how the country can improve on her economy. In view of the use of this product i.e (caustic potash) in our industries, effort has been made by the chemical engineer to search for local raw materials, applying all their engineering knowledge required during the training in this aspect, so that Nigeria will be less dependent on the foreign countries.

Caustic potash has been in existence in centuries dated back as 1853. The production of caustic potash came into being or was introduced by Le Blane, the 'soda maker'. From the beginning, the production was carried out by batch-wise method before electrolytic method in 18th century was discovered and later introduced and used. In 1938 to 1940, electrolytic method of caustic potash was used in the production of lime soda caustic. And in 1960, the method of lime soda

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was almost abundant, presently 90 percent of caustic potash producers sticks to electrolyte method.

Caustic potash has a general meaning of corrosive and applied to all water soluble hydroxide of light metals to distinguish them from their carbohydrate, or they are referred to as "Alkalis" compounds of which is a basic hydroxide of basic metal like sodium, calcium and potassium. For this particular project, emphasis would therefore be laid on the "Recovery of caustic potash" of which it is just a product obtained when a crop is harvested and utilized, what remain thereafter is the agricultural waste.

1.1   DEFINITION OF CAUSTIC POTASH

Caustic potash is a compound made up of light metal and hydroxyl group (OH^-), which is soluble in water and corrosive in reaction. In other words, this refers to basic metal of hydroxides such as sodium (Na), calcium (Ca) and potassium (K).

1.2   NATURAL RESOURCES OF CAUSTIC POTASH

The mineral deposit (soils, rock), agricultural products (sea weed, potato stem, sugar beet, palm in florescence, wood ash, sun-flower, cotton pod, cocoa pod husk and industrial waste (Castner-Kellner, Kellner cell and Nelson cell) e.t.c.

Potassium, a chemical element with symbol k, valency electron 1, group 1 in reactivity series, atomic number 9, atomic weight 39.102, an alkali metal also known as kalium (k), its hydroxide KOH, and potassium (k) is relatively abundant in earth's crust, the seventh most abundant element.

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The word alkali is derived from an ancient Arabic word meaning "plant ashes". Potassium and sodium are found in the ashes of burnt plant material. An alkali is a basic hydroxide which is soluble in water e.g. potassium hydroxide (KOH), sodium hydroxide (NaOH), or caustic soda, calcium hydroxide $Ca(OH)_2$ or slaked lime, lion lithium hydroxide and barium hydroxide $Ba(OH)_2$. Basically, only a few alkalis are known, the common ones are listed above.

Caustic potash (KOH) which is also called potassium hydrate or lye is an alkali metal that occurs naturally in most rocks and soils. The total potassium content of the earth's crust is about 2.4 to 2.6 percent but only a small proportion of it becomes available to plant. Potassium is one of the least 16 elements that are essential for both plant and animal life. Plant require potassium in comparatively large quantities, hence it is regarded as one of the three major plant food elements.

In modern intensive agriculture, the natural supply of potassium from soil is not adequate to sustain high yields. For this reason soil supplies have to be supplemented by potash fertilization which increases the amount of potassium readily available for uptake by crops. Potash occurs in sedimentation rocks and is commonly inter-bedded with common salt.

Economic potash deposits are known to occur in beds only in a few sedimentation basin in the world, of which the Saskatchewan's deposits in Canada of Devonian age are probably the most extensive.

1.3 PHYSICAL AND CHEMICAL PROPERTIES OF KOH

(a) Physical Properties of (KOH)

1. Caustic potash is a white crystalline solid.

2. It is deliquescent and it melts at about 380^0c

3. It has a density of $2040 kg/m^3$

4. It is soluble in cold water with a temperature of $970^0 c$ and in hot water with a temperature of $178^0 c$.

5. Caustic potash has a boiling point of $1,320^0 c$.

(b) **Chemical Properties of (KOH)**

(1) *Reaction with acids and acidic oxides*: KOH solution is a strong electrolyte which ionizes completely in solution

$$KOH_{(aq)} \longrightarrow K^+ + OH^-_{(aq)}$$
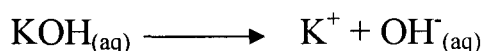
It is a typical base, neutralizing all acids.

$$2KOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow K_2SO_4(aq) + 2H_2O_{(l)}$$
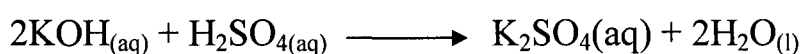
Potassium hydroxide reacts with acidic oxides to form potassium salts

$$2KOH_{(aq)} + SO_{2(aq)} \longrightarrow K_2SO_4(aq) + H_2O_{(l)}$$
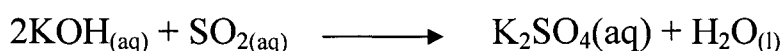
(2) *Saponification reaction*:- The alkaline hydrolysis of fats and oil is termed saponification. KOH reacts with fats and oils as follows to produce soap.
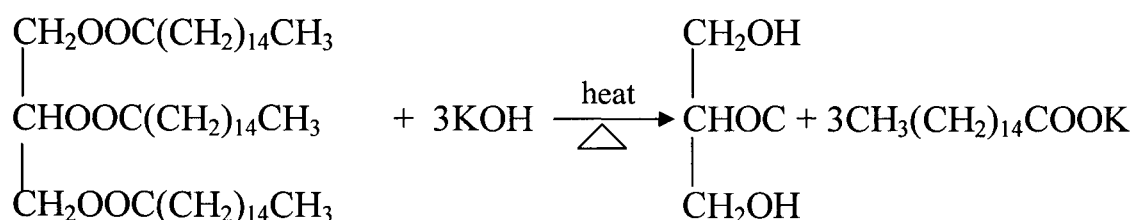
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\begin{array}{llll}
CH_2OOC(CH_2)_{14}CH_3 & & & CH_2OH \\
| & & & | \\
CHOOC(CH_2)_{14}CH_3 & + 3KOH & \xrightarrow{\text{heat}\,\triangle} & CHOC + 3CH_3(CH_2)_{14}COOK \\
| & & & | \\
CH_2OOC(CH_2)_{14}CH_3 & & & CH_2OH \\
\text{Steric acid} & \text{Potassium Hydroxide} & & \text{Soap}
\end{array}
$$

(3) *Reaction with organic acid*: All organic acids also react with KOH to form soluble salt. However, reaction with esters will form the corresponding salts of the organic acid and alcohol of greater industrial use or importance.

$$CH_3COOC_2H_{5(L)} + KOH_{(aq)} \rightleftharpoons CH_3COOK_{(aq)} + C_2H_5OH_{(aq)}$$

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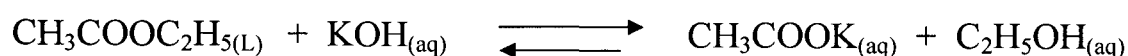
(4) *Reaction with non-metals*:- KOH reacts with a variety of non-metals like halogens, sulphur, phosphoric and silicon to form potassium salts.

1.4 IMPORTANCE OF CAUSTIC POTASH

Today in Nigeria, many industries are using Caustic potash as their major raw materials, this include industries like;

(i) **Soap and creams industries**:- Potassium hydroxide (KOH), is used in the manufacture of liquid soap, soft soap, detergent, shampoo and sometimes with an acid to produce a salt which is electrically neutral.

(ii) **Fertilizer industries**: KOH is used here for the production of potassium compounds such as potassium chloride (Pcl), potassium sulphate (K_2SO_4) and potassium nitrate (KNO_3), which are essential ingredient in the production of in organic fertilizers. Fertilizers are essential chemical substance used to replenish the soil due to their cations exchange capacities, thereby increasing agricultural industries production as a result of abundant agricultural produce now available as raw materials.

(iii) **Petrochemical industries**:- Caustic potash is used in petroleum industries for the refining of oil.

(iv) **In matches industries**:- Caustic potash is an important chemical for the production of explosive such as matches. Matches producing companies use KOH in its converted form i.e. potassium nitrate (KNO_3) and potassium chloride (Kcl_3) as oxidizing agent in the manufacture of matches.

Other general uses of Caustic potash

(v) Used in fibres and plastic industries

(vi) Used in pulp and paper industries

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(vii)   Used in glass manufacturing industries

(viii) Used in explosive solvent and other chemicals

(ix)   Used for the bleaching of cotton textile e.g NaOH

(x)   Used in the manufacture of rayon and other textile.

(xi)   Used as a base to neutralize the acidic content of the soil.

(xii)   Used as an electrolyte.

Used in volumetric analysis in chemical laboratory.

1.5   PROBLEM OF ECONOMIC DEVELOPMENT

The Federal Government has not given attention to caustic potash producing plants in Nigeria and as a result, the manufacturers of caustic potash have been of great importance in economic and industrial development of many nations.

Today, in Nigeria, the caustic potash has made contribution to industries, domestic and laboratory use. Based on commercial production, the problems encounter by an economically viable company in designing a plant suitable for the recovery of at least 80 tonnes per day of caustic potash in Nigeria, are product specification, all normal services needed at the site, in particular, 415v 3-phase, 50Hz power supply, cooling water at medium temperature of 22^0c, steam and 40 bar with 20^0c of super heater. But for this particular project, the problem encountered may not be much since the caustic potash required, is only in small quantity.

1.6 MOTIVATION TOWARDS THIS PROJECT

(i) To utilize most agricultural waste products available, whose disposal is a big problem in the production of some useful chemical compound in our industries.

(ii) To satisfy the increasing used of caustic potash in the industries.

(iii) To reduce the cost of obtaining caustic potash product by using improvised instruments to produce it locally in the industries.

1.7 AIMS AND OBJECTIVES

This project is aimed at establishing the possibility of utilizing various agricultural wastes which constitute a waste to the environment in the recovery of caustic potash which have been found to have wide spread of industrial application. This aim can be actualize through the realization of the following objectives.

1. The production of caustic potash from agricultural waste.

2. Determination of caustic potash content in each of the agricultural waste.

3. Determination and studying the effect in the overall yield of caustic potash.

4. By varying leaching time to determine the optimum time.

5. Finally, by analyzing the caustic potash content using classical method of titration analysis.

1.8 SCOPE OF THE RESEARCH WORK

The research project is based on the possibility of producing caustic potash from various agricultural wastes available, and also to determine the caustic content in each of the agricultural waste.

The recovery also focus on the variation of weight and studying the resulting effect in the overall yield of caustic potash and also varying leaching time to determine the optimum time.

The method of recovery also will be by the local method i.e. (batch method) via leaching. The analysis of the caustic potash content is based on classical method which is basically titration analysis.

CHAPTER TWO

2.0 LITERATURE REVIEW

Over the years, the recovery of caustic potash from agricultural waste has majorly been focused on ash from cocoa pod husk while little or no attention were focused on other valuable agricultural waste products. From previous analysis, it has been shown that plant ash contains cation e.g potassium, sodium, magnesium and anion e.g carbonate, hydroxide, chloride. It was then shown that percentage yield of caustic potash from cocoa pod husk was found to be 6.2% in 1994 according to Peter Jeremiah. It was also found that the purity of caustic potash obtained increased with ashing time, at constant temperature of 300^0C

Therefore, this research work attempt to look at the recovery of caustic potash from other sources, with increased ashing time and analyse the caustic potash content.

2.1 MAIZE (ZEA MAIZE)

2.1.1 THE ORIGIN OF MAIZE

Maize was first found in Central America and was carried back to Europe by the Spaniards. Maize has been introduced into all the countries of the world that have suitable climatic condition. It was then found growing in North America by the first settler. It is the biggest crop of the continent. The United States grows half the world's crop which uses about 80 to 90 percent to feed livestock.

The origin of maize is still unsettled but the most widely held hypothesis assumes that maize developed from its wild relative teosinte (z. mexicana) through a combination of favourable mutations, recognized and selectively propagated by early humans.

2.1.2 CULTIVATION OF MAIZE

Maize are normally cultivated annually in Nigeria. They are mostly grown in the northern part of the country. It grows under a wide range of climates and temperature with planting date which depend on the temperature and soil condition. Planting rates are influenced by water supply, soil type, fertility and by the maturity characteristics of the hybrid grown. The use of Nitrogen fertilizer is very important in the cultivation of maize in that rich product are finally grown and harvested. Harvesting of maize began when the moisture content of the grain had been reduced by natural drying to 20-24 percent. The mechanical picker supplanted hand harvesting may be employed.

2.1.3 CHEMICAL COMPOSITION OF MAIZE COB

The various elements that have entered into the composition of maize plant body have been determined by chemical analysis. The approximate chemical composition of maize cob are as follows; hydrogen 3.2%, carbon 54.8%, oxygen 37.0%, Nitrogen 0.8%, sulphur 0.1%, ash 4.2%.

2.1.4 IMPORTANCE OF MAIZE

Maize is used for different variety. It is used for animal feed, food for human consumption e.g corn meal, syrup, starch and alcohol.

2.2 RICE (ORYZA SATIVA)

2.2.1 ORIGIN OF RICE

The origin of rice probably originated in Southern India, where it has been grown for thousands of years. From there it spread Eastward into China more than 5,000 years ago. Soon afterward, it spread westward into Persia (Iran) and Egypt.

Rice was not taken to North America until the 1600's. Today, the leading rice producers are China, India, Indonesia, Bangladesh, Thailand and Myanmar.

2.2.2 CULTIVATION OF RICE

In Asia and other parts of the world, rice seed is sown in seedbeds by hand. When the plants are linches (18cm) high or more, they are pulled from the bed, trimmed and transplanted to a muddy field. The fields then are flooded and world's rice is harvested by hard, using sickles and knives. The grains are knocked free from the straw by threshing. Threshing is done by machines that beat the rice hands on by animals that trample on them. In some countries rice is cut and threshed in one operation by machines. Today, in Nigeria, rice is cultivated mostly in Niger State, in a very large quantity and other part of the country like Kwara state, Benue state, Adamawa state, Kano state, Zaria in Kaduna State and middle belt.

2.2.3 CHEMICAL COMPOSITION OF RICE HUSK

The chemical composition are hydrogen 5.5%, carbon 39.4%, oxygen 36.0%, nitrogen 0.5%, sulphur 0.2% and Ash 18.4%.

2.2.4 IMPORTANCE OF RICE AND RICE HUSK

Rice is used as food i.e. boiled or baked or in the form of breakfast cereal, rice flour. Also a by-product of milling which is used to make bread, sugar, starch and glue. Wine can be made by fermenting rice. It is also used to make malt, an ingredient of beer. Hulls and bran from milled rice can be fed to farm animals. The husks are also used as bedding for farm and laboratory animals, as packaging around fragile items and as fuel. Rice straw is used to make paper and for mats, hats, basket and roof thatching.

2.3 BANANA (MUSA SPP)

2.3.1 The origin of Banana

The origin of bananas is traced back to the Malaysian jungles of Southeast Asia, where so many varieties and names for the banana are in that area. Some horticulturists suspect that the banana was the earth's first fruit. Banana plants have been in cultivation since the time of recorded history. One of the first records of bananas dates back to Alexander the Great's conquest of India where he first discovered bananas in 327 B.C. In some lands bananas were considered the principal food. Early travelers and settlers would carry the roots of the plant as they migrated to the Middle East and Africa. From there Portuguese traders carried banana roots to the Canary Islands, where bananas are still grown commercially. When Spanish explorers came to the New World, so did the banana. According to Spanish history, Friar Tomas de Berlanga brought the first banana root stocks to the Western Hemisphere.

In 1516, Friar Tomas sailed to the Caribbean bringing banana roots with him; and planted bananas in the rich, fertile soil of the tropics, thus beginning the banana's future in American life. Bananas were officially introduced to the American public at the 1876 Philadelphia Centennial Exhibition. Each banana was wrapped in foil and sold for 10 cents. Before that time, bananas came to America on the decks of sailing ships as sailors took a few stems home after traveling in the Caribbean. In the late 1870's, with the invention of the telegraph and the development of the Central American railroads, the banana industry finally took shape. Systematized growing fields and refrigerated steamships signaled the end of an era when bulky full stems of bananas were shipped on sailing vessels.

2.3.2 CULTIVATION OF BANANA

Banana can be cultivated for exportation, desirable commercial bunches of banana consists of (12) twelve hands or more, such bunches may be produced annually on one hectre of land, and about 2.5 million tonnes can be produced annually, in Nigeria.

Also, Banana can be cultivated using fertigation techniques i.e. (by the application of water soluble fertilizer through drip irrigation). This drip irrigation helps in getting uniform bunches of banana with even ripening, and in creating a good micro-climate. It saves as much as 50 percent water.

2.3.3 CHEMICAL COMPOSITION OF BANANA PEELS

Banana peels by analysis is said to have contained about 28.3% water, 0.6% fat, 40.8% ash, this has been found to consist of a high percentage of alkaline salts, 30% oxygen and 0.3% Nitrogen.

2.3.4 IMPORTANCE OF BANANA

Banana is used as food i.e. can be eaten freshly. Banana is used traditionally as a balanced and supplementary for babies from 4-10 months. The fully matured banana is chosen for this preparation. After peeling the banana, it is cut into thin, very fine pieces and dried under the sun, then ground well into fine powder. This power is thickened by boiling with milk and one pinch of sugar, and fed to the babies. This is a wonderful nutritious diet for easy digestion, and prevents diarrhea and worm trouble in babies. Generally, all the banana are good for the purification of blood, good digestion and for developing immunity.

2.4   GROUNDNUT (ARACHIS HYPOGEA)

2.4.1. THE ORIGIN OF GROUNDNUT

Groundnut is a group that belongs to the family of Leguminosease. It originates from Bolivia (probably its first home) a native of South America. India is one of the largest producers of groundnut in the world. On an average, India produces 7-8 million tonnes of groundnut (unshelled) every year. Indian shippers have the capability to prepare and supply edible peanuts conforming to highest standard. India offers both bold and java type groundnuts seeds and unshelled.

2.4.2 CULTIVATION OF GROUNDNUT

Groundnut is a plant which is cultivated and harvested within a year. The flower of the groundnut is borne above the ground and after it withers, the stalk elongates, bends down, and forces the ovary underground. When the seed is mature, the inner lining of the pods (called the seed coat) changes colour from white to a reddish brown. The entire plant, including moist of the roots, is. removed from the soil during harvesting.

The pods begin in the orange varied, yellow petaled, pea like flowers, which are borne in auxiliary clusters above ground. For self-pollination (Groundnut are complete in-breeders), the flowers fade the stalks at the bases of the ovaries, called pegs, elongate rapidly, and turn downward to bury the fruits several inches in the ground to complete their development. The pods act in nutrient absorption. The fruits have wrinkled shells that are constricted between the two-three seeds. The mature seeds resemble their legume seeds, such as beans, but they have paper-thin seed coats, as opposed to the usual, hard legume seed coats.

Groundnut groups best in light, sandy-loamy soil. They require five months of warm. Weather and an annual rainfall of 500 to 1000mm (20 to 40inch) or the

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equivalent in irrigation water. The pods ripen 120-150 days after the seeds are planted. If the crop is harvested too early, the pods will be unripe. If they are harvested late, the pods will snap off at the stalk, and will remain in the soil.

2.4.3 CHEMICAL COMPOSITION OF GROUNDNUT

The chemical compositions are hydrogen 4.9%, carbon 39.9%, oxygen 33.9%, nitrogen 1.2%, sulphur 0.3% and ash 19.7%

2.4.4 IMPORTANCE OF GROUNDNUT

Groundnuts are used for different purposes which are; salted peanut, shelled nuts, peanut butter (popular in sandwiches), peanut brittle, candy bars. Groundnuts are often eaten raw, or boled in salt water. Groundnut oil is often used in cooking, because it has a wild flavour and burns only at a relatively high temperature. Also used for garden bird feeding. It is also used industrially for paint, varnish, lubricating oil, leather dressing, furniture polish, insecticides and nitroglycerin. Soap is made from saponified oil, and many cosmetics contain peanut oil and its derivatives. The protein portion of the oil is used in the manufacture of some textile fibres. It can be used also in the manufacture of plastic, wallboard, abrasives and fuel. They are also used to make cellulose (used in rayon and paper) and mucilage (glue). Also used in plant tops to make hay. The protein cake (oil cake meal) residue from oil processing is utilized as an animal feed and as a soil fertilizer.

2.5 THEORY OF LEACHING

Leaching can simply be defined as the preferential separation of one or more constituents of a solid mixture by contact with a liquid solvent. The separation usually involves selective dissolution with or without diffusion, but in extreme

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case of simple washing. It consists merely of the displacement (with some mixing) of one interstitial liquid by another with which it is miscible. The soluble constituent may be solid or liquid and it may be incorporated within, chemically combined with, adsorbed upon, or held mechanically in the pore structure of the insoluble material. The insoluble use, cellular with selectively permeable cell walls or surface activated. This process may be used either for the production of a concentrated solution of a valuable solid material or in order to remove an insoluble solid from a soluble material with which it is contaminated. Leaching is also known as solid liquid extraction lixiviation, percolation, infusion, washing and decantation settling in chemical engineering practice. It is an industrial separation operation based on mass transfer.

In this project work, there are four main steps involved in leaching of the various ashed agricultural wastes.

These are as follows:-

1. Preparing of the agricultural waste for leaching, which are drying, picking away of impurities, ashing, grinding and weighing the ash of the various wastes.

2. Contact of liquid solvent with the solid to effect transfer of solvent from the solid to the solvents. This is mixing, this implies contact of water with the ground ashed materials.

3. Separation of the resulting solution from the residue (filtration).

4. Recovery of the solute from the solvent (evaporation).

2.5.1 FACTORS INFLUENCING RATE OF LEACHING

There are four factors influencing the rate of extraction in leaching:

1. *Particle size*:- The size of particles influences the rate of extraction in a numbers of ways: the finer the particle size, then chemical reactivity is greater. Also, the smaller the size, the greater the interfacial area between the solid and liquid and therefore the higher the rate of transfer of material and the smaller is the distance the solute must diffuse within the solid and helps each particle to have approximately the same time for extraction and to separate two constituents when one is dispersed in small isolated pockets.

2. *Solvent*:- The liquid chosen should be a good selective solvent and should have low toxicity and flammability, low density, low surface tension and its viscosity and vapour should be sufficiently low for it to circulate freely. Generally a relatively pure solvent will be used initially, but as extraction proceed the concentration of solute will increase and the rate of extraction will progressively decrease, first because the concentrate viscous.

3. *Temperature*: - In most cases, the solubility of the material which is being extracted will increase with temperature to give a higher rate of extraction. Further, the diffusion coefficient will be expected to increase with rise in temperature and this will improve the rate of extraction.

4. *Agitation of fluid*: - Agitation of solvent is important because this increases eddy diffusion and therefore increases the transfer of material from the surface of the particle to the bulk of the solution.

Also agitation of suspension of fine particles prevents sedimentation and more effectiveness is made of interfacial surface.

2.5.2 IMPORTANCE OF FACTORS INFLUENCING RATE OF LEACHING IN THIS WORK

In the course of the research work carried out, the various factors mentioned above were applied and controlled in some cases:

1. The sample size of the material was not taken into consideration but rather, different masses was used so that, the effect of mass change on the yield of caustic potash can be analysed.

2. Distilled water was chosen as the solvent for the leaching because among numerous solvent available, water has a very low viscosity and can circulated freely, thereby penetrating deep into the inner core of the sample.

3. The temperature of leaching was maintained at 100^0c for the entire leaching process so that distinction can be made on the differences in yield for the different weight employed.

4. And finally, the boiling liquid mixture was constantly agitated so that eddy diffusion can be increased which transfer the soluble part of the sample to the bulk of the solution.

2.5.3 MASS TRANSFER IN LEACHING OPERATION

Mass transfer rate within the porous residue are difficult to assess because it is impossible to define the shape of the channels through which transfer must take place. But it is impossible to obtain an approximate indication of the rate of transfer from the particle to the bulk of the liquid using the concept of a thin film as providing the resistance to transfer the equation for mass transfer may be written as follows:-

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$dm/dt = K'A (C_s - C)/b$

where

A – Area of solid-liquid interface

b- The effective thickness of the liquid film surrounding the particles.

c- The concentration of the solute in the bulk of the solution at time t.

C_s- The concentration of the saturated solution in contact with the particles.

M- Mass of solute transferred in time t

K'- The diffusion coefficient (constant)

The diffusion co-efficient approximately equal to the liquid phase diffusivity (D_2) and is usually assumed constant. For a batch process in which V assumed total volume of solution, is assumed to remain constant, then

$Dm = Vdc$

And $dc/dt = K'A (C_s-C)/bv$

The time t taken for the concentration of the solution to rice from its initial value to a value is found by integration on the assumption that both b and A remain constant, re-arranging, we have,

$\int_{c_o} (d_c/C_s-C) = K' (A/V_b) dt$

$\therefore \ln C_s-C_o = K'(A/V_b)t$

Pure solvent used initially, $C_o = 0$ and $1-C/C_s = e^{-(KA/V_b)t}$

$$or \ C = C_s(1-e^{-(KA/V_b)t})$$

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CHAPTER THREE

3.0   EXPERIMENTAL WORK

The various agricultural wastes used in this research project are:

1.   Maize cob   sample A

2.   Rice husk   sample B

3.   Banana peel   sample C

4.   Groundnut shell   sample D

3.1   TREATMENT PROCESSES

1.   *Drying of waste sample*:- Drying was carried out using ambient temperature by exposing various waste under sunlight. After sun-drying of the waste, a constant weight has been gained and it was easy to break (crispy), then the waste was ready for crushing.

2.   *Crushing of dried waste*:- Crushing is a process of breaking down materials into smaller particles. The dried wastes were broken down into smaller particles using a mortal and pestle.

3.   *Grinding of waste*:- A grinding machine was used to grind the crushed particles into finer particles. This further reduction in size was done in order to enhance better ashing by increasing the interfacial surface area of the reaction, thereby increasing rate of reaction.

4.   *Screening of the samples*:- The samples were screened on the basis of size. The application of the screens is the grading of particles into size ranges. Screen sizes use a mesh size number for small sizes and by the actual size of opening in the screen for the larger sizes. There are different standards in use for mesh size and it is important to quote the

particle size ranges by mesh size. For this project work, the particles size used ranges from (Aperture 500- 710μm) for the separation process.

5. ***Weighing of samples***: Weighing was carried out using an electric weighing machine. Four (4) samples of waste were weighed for ashing at different time.

6. ***Ashing of the samples***: Ashing is a process of complete burning of all combustible organic matter present in the samples at a controlled constant temperature of $600^{0}c$ at a time of 3 hours, the ashing remove the moisture remaining after drying in the oven and also convert organic matter such as carbohydrate, fat oil etc. into carbondioxide, water, SO_2 etc. The ash obtained was ash coloured and contained no charcoal.

3.2   EXPERIMENTAL EQUIPMENT, APPARATUS AND REAGENT

The equipment and apparatus used for the entire research work is written below:

1. Mortal and pestle (for crushing)

2. Grinding machine

3. Electronic weighing balance/machine

4. Sieving equipment

5. Electric furnace

6. Crucible

7. Oven

8. Hot plate with magnetic stirrer

9. Beakers

10. Thermometer

11. Burette and pipette

12. Electric heating mantle

13. Spatula (scraper)

14. Conical flask

15. PH meter

16. Retort stand

17. Funnel with filter paper

18. Measuring cylinder

19. Volumetric flask

20. sample bottles/containers

21. Standard solution of Hcl (0.1M)

22. Standard solution of sodium carbonate

23. Standard solution of sulphuric acid (0.1M)

3.3 LABORATORY WORK

3.3.1 EXPERIMENTAL PROCEDURE FOR LEACHING

1. Samples were dried under sunlight.

2. After drying, they were crushed and ground.

3. The samples were reduced to a size range of aperture (500- 710μm) by sieving them using a sieve vibrator.

4. Four (4) samples of the ground materials were weighed using an electric weighing machine. (A-390.01, B-465.66, C-378.50, D-370.63)g.

5. The four samples A, B, C and D were pre-heated and then placed in an electric furnace at a constant temperature of 600^0c for 3 hours.

6. 15g of the ashed sample of A was taken from the total mass ashed and kept in a beaker, 500ml of distilled water was added to it.

7. The mixture above was kept on an electronic hot plate with a magnetic stirrer. The mixture was heated at a temperature of 100^0c with magnetic follower in the mixture to aid agitation.

8. The process (7) was allowed to heat for 2hours and solution allowed to cool before filtration, using filter paper to obtain filtrate and solid residue.

9. Another fresh 500ml of distilled water was added to the residue obtained in (8) and process (7-8) was carried out on them.

10. Also, another fresh 500ml of distilled water was added to the residue obtained in 9 and process (7-8) was carried out on them.

11. The filtrate obtained from the three (3) extract were heated in a heating component leaving the solid substance which is the impure caustic potash (KOH)

12. (30, 45, 60)g of sample A were separately taken and operation (6-11) were performed on them.

13. Process (6-12) was performed for the ash of the remaining sample which include, sample B, C and D.

3.3.2 PROCEDURE FOR LEACHING BY VARYING LEACHING TIME

1. 15g of the ashed sample was taken and leached with a varying leaching time of (30, 60, 90, 120, 150, 180) minutes in a beaker. 500ml of distilled water was used as the solvent.

2. The mixture obtained after each leaching time was filtered using a filter paper to obtain the various extract for the different leaching time.

3. The filtrate obtained from (2) above was evaporated to get the impure extract of caustic potash after which the purity was carried as before.

4. Method (1-3) was repeated for masses of 30, 45 and 60g respectively.
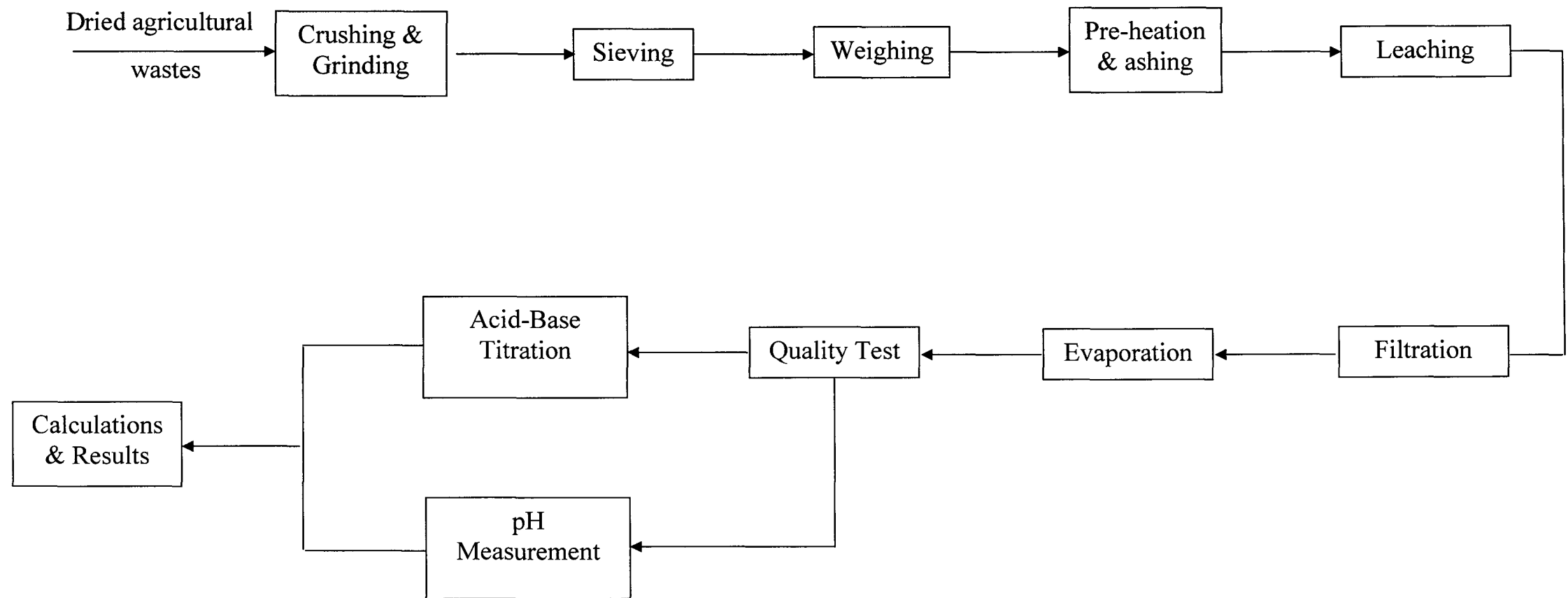
PROCESS INVOLVED IN PRODUCTION OF KOH FROM AGRICULTURAL WASTES

3.4 QUALITY ANALYSIS

A quality test was carried out on these extract to know their percentage purity. The test included are the pH measurement and volumetric analysis. 1.3g of impure KOH was dissolved in 250cm of distilled waster. 25cm^3 of solution was titrated against 0.1MHcl acid solution, using phenolphthalein indicator to detect the end point.

3.4.1 ACID-BASE TITRATION PROCEDURE

The impure caustic potash (KOH) obtained from each sample of ashed obtained at different masses for different runs was used to prepare a standard solution by dissolving 1.3g of KOH in 250ml of distilled water in a volumetric flask. 25cm^3 of the standard solution was measured and transferred into a conical flask using a pipette and titrated with 0.1MHcl standard solution in a burette using two drops of phenolphthalein indicator to detect the end point. PH meter was also used to monitor the titration of the solution.

3.4.2 PREPARATION OF STANDARD SODIUM CARBONATE SOLUTION

7g of anhydrous primary sodium carbonate was weighed to a platinum dish or crucible and dry at 250^{0}c for 5 hours in a desiccators and transfer it to a 500ml conical flask. 75ml of water was then added. It was shaken to dissolve and 3 drops of 0.1 percent modified methyl orange indicator solution (prepared by dissolving 0.1g or methyl orange and 0.14g of xylene dye in 100ml of water).

3.4.3 PREPARATION OF STANDARD HCL SOLUTION

85ml of concentrated Hcl in a graduated cylinder was measured and transferred to a 1 litre volumetric flask, dilute to volume. Alternatively, measure 30ml of concentrated H_2SO_4 in a graduated cylinder and slowly add it to a half the desired amount of water in a 600ml beaker, rinsed the cylinder into the beaker, mix, allow to cool and the mixture transferred to a 1litre volumetric flask and then, it was diluted to volume. The solution was then titrated against the sodium carbohydrate solution above. The temperature of the acid during titration was noted and recorded.

3.5   TOTAL ALKALINITY DETERMINATION

15g each of the ash was weighed and transferred into 100ml volumetric flask using distilled water shaked thoroughly and dilute to volume. 25ml of the supernatant was measured to conical flask and 2-3 drops of modified methyl orange indicator solution was added. It was titrated with standard 1M Hcl to a grey end point and record of the volume and temperature of acid used

CHAPTER FOUR

RESULTS AND DISCUSSION OF RESULTS

4.1 EXPERIMENTAL RESULTS

4.1.1 SCREENING RESULTS

The screening result is as shown below:

Particle size ranges from aperture 500-710µm

4.1.2 ASHING RESULTS

The ashing of the crushed samples was carried out at a temperature of 600^0c in an electric furnace for the period of 3hours for the four samples respectively.

Table 1

Samples	Initial weight	Final weight	Weight loss	Weight loss (%)
Maize cob	390.01	72.86	317.15	81.32
Rice husk	465.66	69.52	396.14	85.07
Banana peel	378.50	79.75	298.75	78.93
Groundnut shell	370.63	90.13	280.50	75.68

4.1.3 LEACHING RESULT

The leaching was performed on each sample by changing the masses and observing its effect on the yield at a leaching temperature of 100^0c for three runs for each of the four materials used.

Table 2

Maize Cob

Final weight of ashed Sample (g)	72.86			
Weight of ash (g)	15	30	45	60
1st E_1	2.39	2.85	3.29	4.03
2nd E_2	0.05	0.78	0.81	0.60
3rd E_3	09.02	0.03	0.04	0.02
Total impure KOH extract (g)	2.460	3.66	4.14	4.65
% impure of total extract	**16.40%**	**12.20%**	**9.2%**	**7.75%**

Table 3

Rice husk (Sample B)

Final weight of ashed Sample (g)	69.52			
Weight of ash (g)	15	30	45	60
1st E_1	2.39	2.85	3.29	4.03
2nd E_2	0.05	0.78	0.81	0.60
3rd E_3	0.02	0.03	0.04	0.02
Total impure KOH extract (g)	2.00	3.10	4.l01	4.65
% impure of total extract	**13.33%**	**10.33%**	**8.91%**	**7.75%**

Table 4

Banana peel (Sample C)

Final weight of ashed Sample (g)	79.75			
Weight of ash (g)	15	30	45	60
1st E_1	2.25	3.78	4.67	5.07
2nd E_2	0.75	1.25	2.63	3.78

$3^{rd} E_3$	0.05	0.08	0.20	1.64
Total impure KOH extract (g)	3.05	5.11	7.5	10.49
% impure of total extract	**20.33%**	**17.03%**	**16.67%**	**17.48%**

Table 5

Groundnut shell

Final weight of ashed Sample (g)	90.13			
Weight of ash (g)	15	30	45	60
1st E_1	2.42	3.79	4.50	5.19
2nd E_2	0.48	0.95	1.05	1.68
$3^{rd} E_3$	0.09	0.06	0.02	0.08
Total impure KOH extract (g)	2.99	4.80	5.57	6.95
% impure of total extract	**19.93%**	**16.00%**	**12.38%**	**11.58%**

Note: E_1, E_2 and E_3 stand for the first, second and third runs of the various extract.
Purity test result

The KOH extracted was analysed with 0.1M Hcl of standard solution of KOH which was prepared by dissolving 1.3g of KOH extract in 250cm^3 of distilled water. PH meter was used to know the pH of the solution.

Table 6

Sample A (Maize cob)

Mass (g)	Total impure KOH extract (g)	% impure extract	Vol. of acid (cm^3)	pH of KOH solution	Mass conc. of pure KOH (g/dm^3)	% purity	Amount of pure KOH (g)	% yield
15	2.46	16.40	14.10	11.62	3.164	60.85	1.497	9.98
30	3.66	12.20	13.50	11.54	3.029	58.26	2.132	7.11
45	4.14	9.20	12.90	10.92	2.895	55.67	2.305	5.12
60	4.65	7.75	11.60	10.20	2.603	50.06	2.328	3.88

Table 7

Rice husk (sample B)

Mass (g)	Total impure KOH extract (g)	% impure extract	Vol. of acid (cm3)	pH of KOH solution	Mass conc. of pure KOH (g/dm^3)	% purity	Amount of pure KOH (g)	% yield
15	2.00	13.33	11.90	11.65	2.670	51.35	1.027	6.85
30	3.10	10.33	11.40	11.42	2.558	49.20	1.525	5.08
45	4.01	8.91	10.50	11.15	2.356	45.31	1.817	4.04
60	4.65	7.75	9.30	10.94	2.087	40.13	1.866	3.11

Table 8

Banana peel (sample C)

Mass (g)	Total impure KOH extract (g)	% impure extract	Vol. of acid (cm3)	pH of KOH solution	Mass conc. of pure KOH (g/dm^3)	% purity	Amount of pure KOH (g)	% yield
15	3.05	20.33	15.00	12.05	3.366	64.73	1.974	13.16
30	5.11	17.03	14.10	11.92	3.164	60.85	3.109	10.36
45	7.50	16.67	12.90	11.59	2.895	55.67	4.175	9.27
60	10.49	17.48	11.60	11.99	2.612	50.23	5.269	8.78

Table 9

Groundnut shell (Sample D)

Mass (g)	Total impure KOH extract (g)	% impure extract	Vol. of acid (cm3)	pH of KOH solution	Mass conc. of pure KOH (g/dm^3)	% purity	Amount of pure KOH (g)	% yield
15	2.99	19.93	14.40	11.08	3.231	62.14	1.850	12.38
30	4.80	16.10	13.70	10.93	3.083	59.29	2.846	9.48
45	5.57	12.38	13.00	11.10	2.922	56.19	3.130	6.95
60	6.95	11.58	11.00	10.73	2.020	38.84	3.299	5.50

Table 10

Leaching result at varying time of leaching

|		Leaching time (minutes)					
	Mass (kg)	30	60	90	120	150	180
Maize cob	15	0.12	0.82	1.10	1.80	1.80	1.70
	30	0.23	0.95	1.34	1.85	1.92	1.90
	45	0.35	1.25	1.63	2.05	2.20	2.13
	60	0.51	1.34	1.95	2.43	2.40	2.34
Risk husk	15	0.12	0.32	0.68	1.48	1.50	1.47
	30	0.16	0.43	0.96	1.62	1.61	1.58
	45	0.28	0.75	1.24	1.72	1.72	1.71
	60	0.39	1.04	1.43	1.81	1.80	1.78
Banana peel	15	0.75	2.13	3.54	4.50	4.55	4.21
	30	1.14	2.41	3.83	4.80	4.81	4.44
	45	1.29	2.55	3.94	4.97	5.12	5.02
	60	1.62	3.26	4.65	5.63	5.64	5.13
Groundnut shell	15	0.32	0.50	1.55	2.63	2.61	2.75
	30	0.46	0.78	2.15	3.04	3.02	2.84
	45	0.68	1.36	2.52	3.18	3.17	3.06
	60	0.89	1.94	2.84	3.35	3.32	3.29

THE GRAPH FOR MAIZE COB
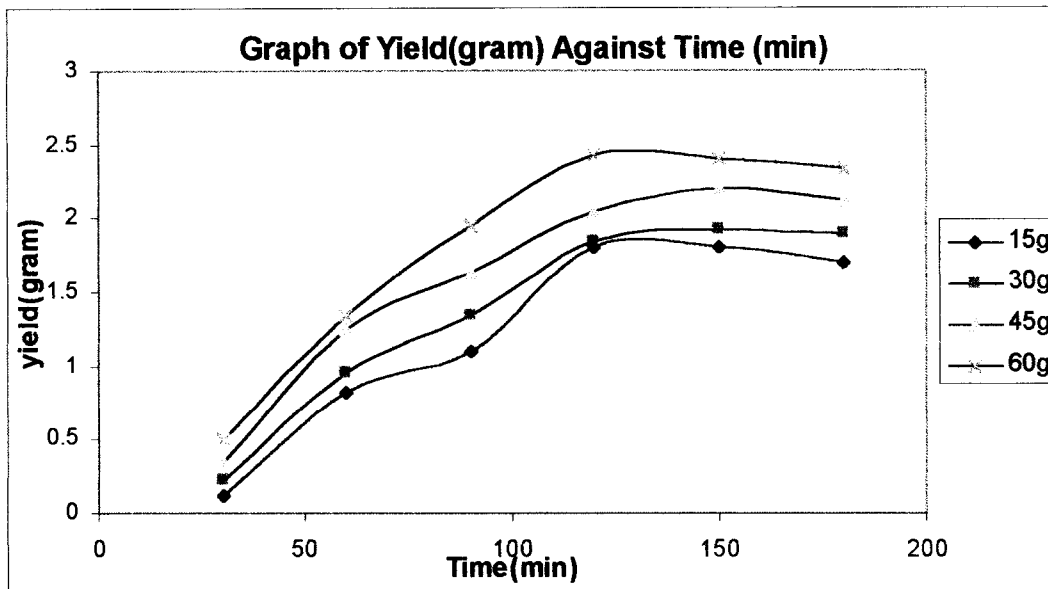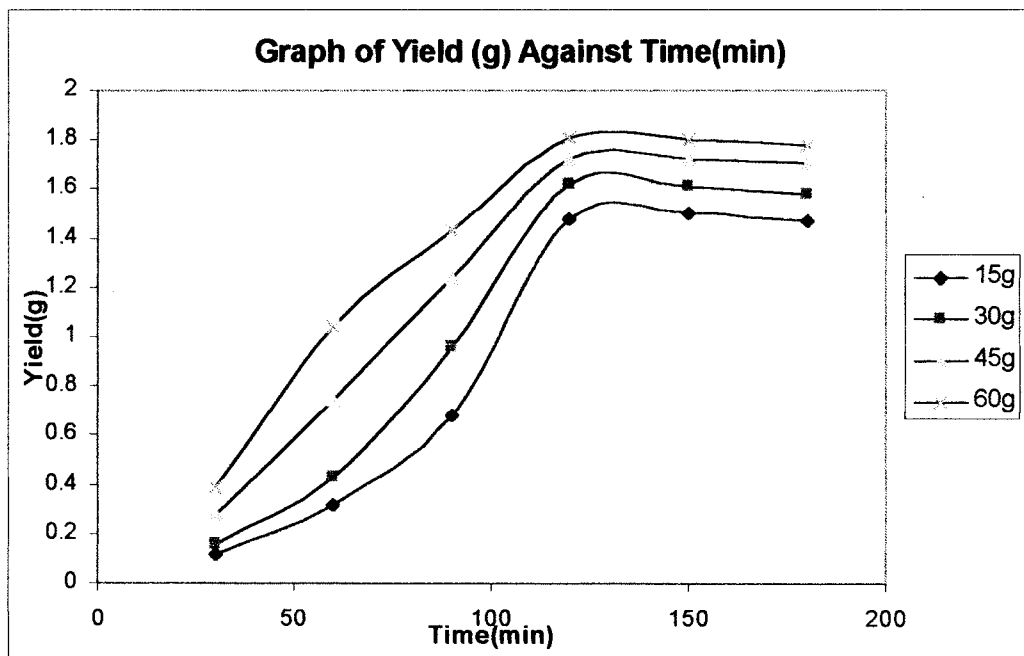

Fig.1

THE GRAPH FOR RICE HUSK

Fig. 2

THE GRAPH OF BANANA PEEL
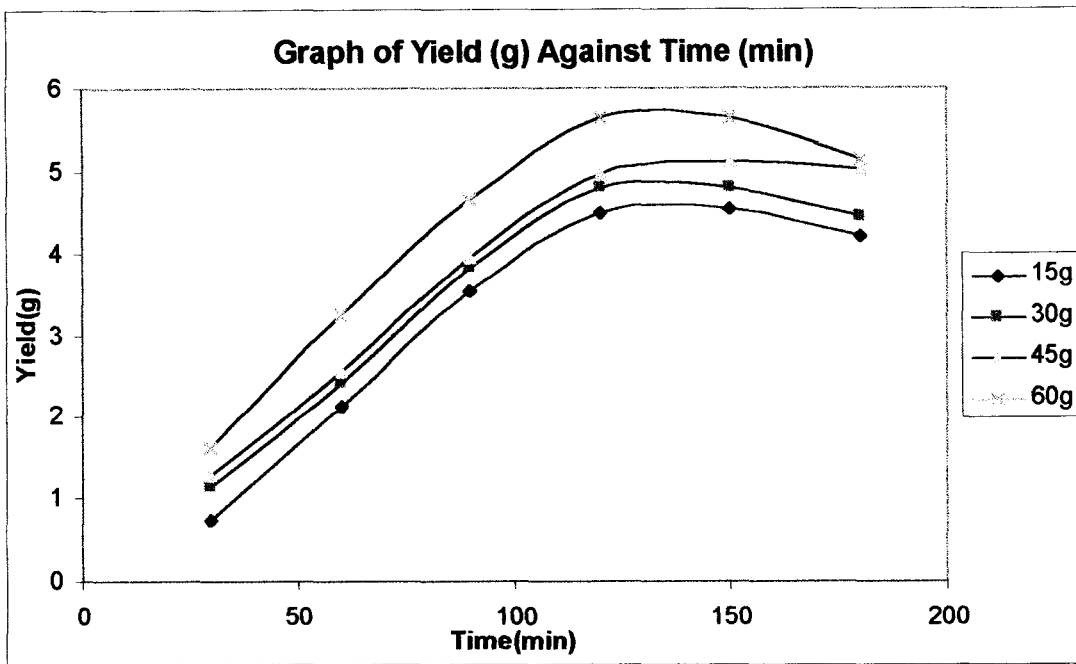
Fig. 3

THE GRAPH OF GROUNDNUT SHELL
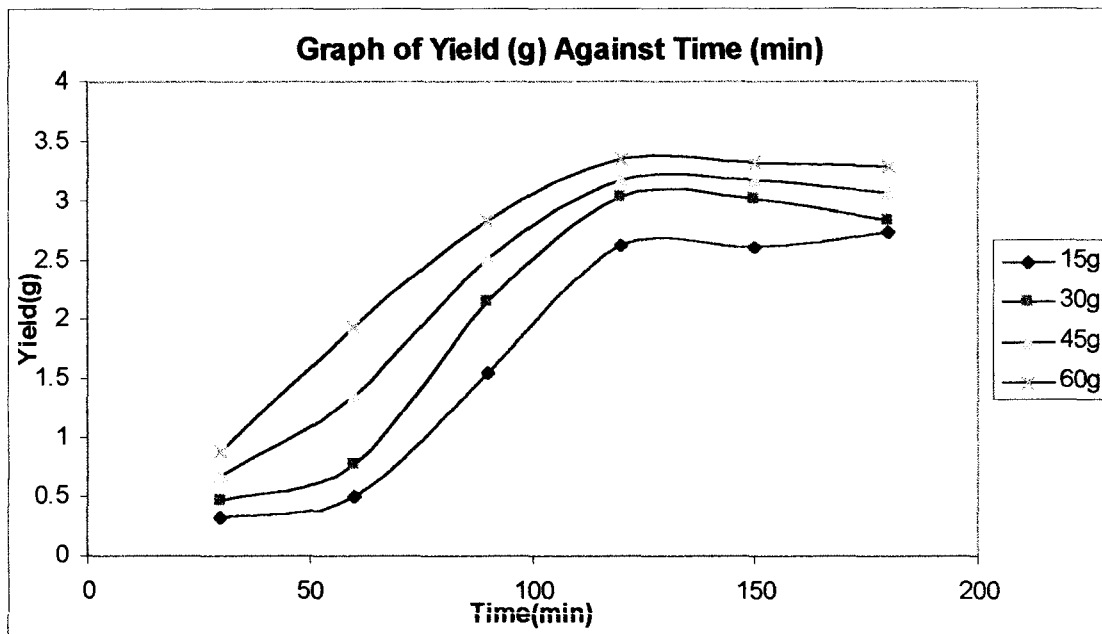
Fig. 4

Table 11

Caustic potash content results

	Maize		Rice husk		Banana peel		Groundnut shell	
Weight of sample ash (g)	15		15		15		15	
Volume of dissolution (ml)	100		100		100		100	
	Acid-Base Titration							
Burette reading	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Final reading	6.40	10.5	5.30	8.70	18.60	38.70	19.30	30.60
Initial reading	0.00	3.90	3.00	6.20	0.00	20.00	10.60	21.70
Titre value	6.40	6.60	2.30	2.50	18.60	18.70	8.70	8.90
% KOH	**27.38**		**10.11**		**78.55**		**37.07**	

4.2   DISCUSSION OF RESULTS

The following findings were noted from the result:

From the ashing result obtained in table 1, it can be seen or shown that weight loss result shows that substantial amount of organic matters were burnt off during ashing at constant 600^0c for 3 hours. The weight loss obtained for maize cob was 81.32% while that of rice husk was 85.07%, the remaining sample i.e. banana peels and groundnut shell has 78.93% and 75.68% respectively.

From table 2 to 5 of various samples, the total amount of impure extract obtained increases as the masses of sample increases i.e the yield is directly proportional to the weight of the sample taken, however the percentage yield of

caustic potash extract decreases as the mass of sample increases. Thus, the is due to the fact that the same volume of solvent (distilled water) was used for all the mass taken. As the mass increases the rate of penetration of the solvent into the interior or core of the sample to be leached out become difficult and hence percentage yield decreases with the mass of the sample used.

From the table 6 of the result, it shows that the amount og pure KOH i.e. yield, increases from 1.497g for mass of 15g to 2.328g for mass 60g. However, the percentage yield decreases from 9.98 for 15g to 3.88 for 60g. All other results from table 7 to 9 follow the same trend of increasing yield and decrease in percentage yield.

From the same table 7, the pH value obtained for all the extract produced is considerably high at an average pH value of 11. These show that the caustic potash produced is highly alkaline. All other samples follow the same trend by showing high alkalinity.

Also, from table 10, i.e, the leaching result, it can be seen that there is a relationship between the mass, leaching time and yield of caustic potash, therefore in order to get this relationship, the graph of yield versus the leaching time was plotted for the various masses used. The result obtained shows that for any mass leached which varies linearly with the yield obtained from the first experiment, an optimum leaching time of (120-150) minutes was obtained. This shows that irrespective of the weight of sample being leached, the leaching must be carried out between the ranges of 120 to 150 minutes, after which the yield begins to decrease.

CHAPTER FIVE

5.0   CONCLUSION AND RECOMMENDATIONS

5.1   CONCLUSION

It can be concluded from this research project that caustic potash (KOH) has been successfully produced from four different agricultural waste product by studying the relationship between the yield and the weight of ash chosen. Also, the caustic potash content has also been determined using classical titration method.

Also, the result obtained shows that amount of pure extract increases as the weight of the ash also increases. The result also shows that banana peel has the highest percentage of caustic potash content with 78.55% and followed by groundnut shell with 37.07% caustic potash in the same 15g. Also, maize cob and rice husk has caustic potash content of 27.38% and 10.11% respectively in all 15g ash.

5.2   RECOMMENDATIONS

With respect to this research project, and for economy viability of the production process:

1.   It is recommended that other factors be varied e.g factors like difference in sample size, temperature of leaching, volume of solvent.

2.   It is recommended that the temperature of ashing be further increased to at most 1000^0c and time of ashing also increase from 5-6hours in order to get a complete whitish caustic potash extract.

3.   It is also recommended that continuous method of leaching be used as contrasting to batch method used in this project work. This will definitely affect the yield positively.

4. Lastly, an entire chemical plant can be designed for the production of caustic potash from agricultural waste products which will serve as alternative source of caustic potash in the country rather than spending so much foreign exchange on the importation of the chemical into the country.

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APPENDIX A

PROPERTIES OF CAUSTIC POTASH (KOH)

Molecular weight   =   56.1

Colour   =   white crystalline solid

Crystal   =   Deliquescence

Specific gravity   = $2.044g/cm^3$

Melting point   = 380^0c

Boiling point   = 132^0c

Solubility in cold water   = 970^0c

Solubility in hot water   = 178^0c

APPENDIX B

CALCULATION OF RESULT

1. **Percentage of ash obtained**

   Given

   Initial weight $= (I_{wt})$

   Final weight $= (F_{wt})$

   Weight loss $\% = \dfrac{I_{wt} - F_{wt}}{I_{wt}} \times 100$

   Maize cob $= \dfrac{390.01 - 72.86}{390.01} \times 100$

   $= 81.32\%$

   Rice husk $= \dfrac{456.66 - 69.52}{456.66} \times 100$

   $= 85.07\%$

   Banana peel $= \dfrac{375.63 - 90.13}{370.63} \times 100$

   $= 75.68\%$

2. **Percentage yield of impure KOH**

   $\% \text{ yield} = \dfrac{\text{Weight of ash (g)}}{\text{Total impure KOH (g)}} \times 100$

   Maize cob $= \dfrac{15}{2.46} \times 100$ (At 15g weight)

   $= 16.40\%$

   $= \dfrac{30}{3.66} \times 100$ (At 30g weight)

$$= \quad 12.20\%$$

$$= \quad \frac{60}{4.65} \times 100 \qquad \text{(At 60g weight)}$$

$$= \quad 7.75\%$$

3. Preparation of standard solution of 0.1M Hcl

The following are provided with the concentration Hcl acid

(i)   Specific gravity = $1.18g/cm^3$

(ii)   Molecular weight = 36.48

(iii)   % purity = 35.4

From the specific gravity = $1.18g/cm^3$

$1 cm^3$ of solution contains 1.18g of Hcl

$1dm^3$ ($1000cm^3$) solution will contain

$$\frac{1.18}{1} \times 1000 \quad = 1180g/dm^3 \text{ Hcl}$$

Mass concentration of pure Hcl = % purity x mass in dm^3 Hcl

$$= \quad \frac{354 \times 1180}{100}$$

$$= \quad 417.729/dm^3$$

Molar Conc. of Hcl

$$= \quad \frac{\text{Conc. in g/dm}^3}{\text{Molecular weight}}$$

$$= \quad \frac{417.72}{36.46}$$

$$= \quad 11.457 moldm^{-3}$$

The initial concentration of the acid is 11.457moldm^{-3}

For the dilution to 0.1moldm^{-3} of Hcl using dilution formular, i.e.

$$C_1V_1 = C_2V_2$$

where;

C_1 = Initial conc. of Hcl = 11.46 moldm^{-3}

V_1 = Required vol. of Hcl = ?

C_2 = Final conc. of Hcl = 0.1moldm^{-3}

V_2 = Volume diluting to = 1000cm^3

Therefore on substituting

$$V_1 = \frac{C_2V_2}{C_1}$$

$$= \frac{0.1 \times 1000}{11.46}$$

$$V_1 = 8.73cm^3$$

Which means that 8.73cm^3 was taken and diluted for 1000cm^3

(4)   Preparation of Standard Solution of KOH (0.1M KOH)

1.3g of the impure KOH obtained was taken and dissolved in 250cm3 of distilled water.

Given that:

Molecular weight = 56.1

Then,

1cm^3 of distilled H$_2$O will contain

$$\frac{1.3}{250}$$

Mass conc. $= \dfrac{1.3g \ \times 1000cm^3}{250cm^3}$

$= 5.2g/dm^3$

Molar conc. $= \dfrac{Mass}{Molar \ mass}$

$= \dfrac{5.2}{56.1}$

$= 0.0927mol/dm^3$

5. Calculation conc. of solution prepared between the acid and base

Equation for reaction:

$KOH + HCL \longrightarrow Kcl + H_2O$
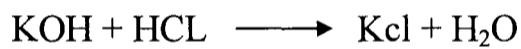
Molar ration of acid to base $= \dfrac{n_A}{n_B}$

$= \dfrac{1}{1}$

i.e. $C_A V_A = C_B V_B = 1$

$C_B = \dfrac{C_A V_A}{V_B}$ (Molar conc. of pure KOH)

where;

V_B = Volume of KOH pipetted $= 25cm^3$

C_A = Molar Conc. of Hcl $= 0.1moldm3$

43

C_B = Molar Conc. of KOH = ?

V_A = Volume of acid = Vol. of acid used for titration for different

sample

For the 1st experiment i.e. the titration with extract of weight 1.0g for maize

cob.

$V_A = 14.1 cm^3$

∴ On substitution

$C_B = \dfrac{0.1 \times 14.1}{25}$ $= 0.0564 mol/dm^3$

Mass Conc. of pure KOH in g/dm^3 = Molar x Molecular weight

$= 0.0564 \times 56.1$

$= 3.164 g/dm^3$

% purity of KOH $= \dfrac{Mass\ Conc.\ of\ pure\ KOH}{Mass\ conc.\ of\ impure\ KOH} \times 100\%$

$= \dfrac{0.0564 \times 100}{5.2}$

$= 60.85\%$

Amount of pure KOH = % purity x total amount of impure KOH obtained

$= \dfrac{60.85 \times 2.46}{100}$

$= 1.497g$

% yield $= \dfrac{Amount\ of\ pure\ KOH\ obtained}{Mass\ of\ ash} \times 100\%$

$$= \quad \underline{1.497} \quad \text{x} \quad 100 \quad = 9.98\%$$
$$15$$

The calculations for the other samples follow the same pattern.

APPENDIX C

Calculation of caustic potash content

$$\% \, KOH = \underline{V \, x \, C_A \, x \, M_w} \quad x \, W_s$$
$$2$$

where;

V_{Ave} = Average titre value

N_A = moles of acid

M_W = Molecular weight of KOH

W = weight of sample

For maize cob

By substituting in the above equation, we have

$$\% \, KOH = \underline{6.50 \, x \, 1 \, 56.1} \quad x \quad 15$$
$$2$$

$$\% \, KOH = 27.38$$

For Rice Husk

$$\% \, KOH = \underline{2.40 \, x \, 1 \, 56.1} \quad x \, 15$$
$$2$$

$$\% \, KOH = 10.11$$

For Banana peel

$$\% \text{ KOH} = \frac{18.65 \times 1\ 56.1}{2} \times 15$$

$$\% \text{ KOH} = 78.55$$

For Groundnut shell

$$\% \text{ KOH} = \frac{8.80 \times 1\ 56.1}{2} \times 15$$

$$\% \text{ KOH} = 37.07$$