

**EVALUATION OF CHARACTERISTICS AND ENERGY POTENTIAL OF
SELECTED AGRICULTURAL WASTES IN NIGER STATE**

BY

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MATRIC NO: 2005/21654EA

**DEPARTMENT OF AGRICULTURAL & BIORESOURCES ENGINEERING,
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA**

DECEMBER, 2010.

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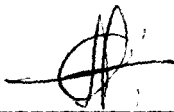
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**BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN
AGRICULTURAL & BIORESOURCES ENGINEERING, FEDERAL
UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.**

DECEMBER, 2010.

DECLARATION

I hereby declare that this project work is a record of research work that was undertaken and written by me. It has never been presented elsewhere for the award of any degree or diploma or certificate in any university or institution. Information derived from personal communication, published and unpublished work were duly referenced in the text, and also hereby relinquish the copyright to the Federal University of Technology, Minna.



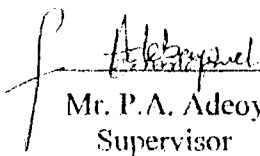
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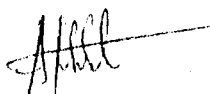
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CERTIFICATION

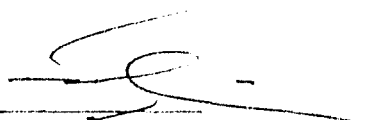
This is to certify that the project entitled "Evaluation of characteristic and Energy potentials of some selected agricultural waste (crop residues) in Niger State", (Yam peel, Cassava peel, Rice husk, Guineacorn husk, Cowpea shell and Groundnut shell.) by Olaleye Taofiq Idowu meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG) of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.


Mr. P.A. Adeoye
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03/02/2011
Date


External Examiner

8/12/2010
Date

DEDICATION

I fondly dedicate this project to my parents Mr. & Mrs. L.O. OLALEYE and my siblings for their support and prayers in my quest for knowledge.

ACKNOWLEDGEMENTS

I wish to thank Almighty ALLAH who made everything possible for me through his divine guidance to complete this work successfully.

My gratitude goes to my amiable supervisor Mr. P.A. Adeoye for his utmost attention during the course of doing this work from his busy schedules still had the time to scrutinizes , criticize and advice the work and also to Mr. Boulus for his guidance and assistance in the Laboratory work..

I also want to acknowledge the head of Department Engr. Dr. A. A. Balami, the project coordinator Engr. Dr. O. Chukwu, and my level adviser Mr. John Musa Jiya and all the academic staff in the department for the knowledge impacted by them in one way or the other, I say thank you all.

My sincere gratitude goes to my beloved parents Mr. & Mrs. L.O. OLALEYE for their immeasurable contributions morally, spiritually and otherwise.

I will also not forget my wonderful uncle Alhaji Abdulbari Yoosuph (Chief Imam O.C.C. Mosque, Lagos) and my darling aunty Mrs. Olaide Adigun, my brother Senator Ken Olaleye, my siblings and all my well wishers.

Also to Olaleye Taiwo, Ogunkoya adebowale, Jimoh Saheed, Makanjuola Tirimisyu, Oguche felix, I say thank you all for the guidance and support received, you contributed to this project and your support and encouragement was vital for the success of the project and to all the graduating students of 2010 I am grateful.

ABSTRACT

With a view to knowing the energy potential of some crop wastes generated in Niger State. Six agricultural residues were selected from Minna metropolis, Lapai, Agaie and Bida Local Government Areas of Niger State in Nigeria were subjected to Ultimate and Proximate analysis to determine their energy content using the method of Association of Official Analytical Chemists in the Water Aquaculture and Fisheries Laboratory of Federal University of Technology, Minna.

The samples are Cassava peel, Yam peel, Rice Husk, Guineacorn husk, Cowpea shell and Groundnut shell. Two of each samples were selected and the results of their calorific contents were 2256KJ/g and 2292KJ/g for Cassava peel, 2738KJ/g and 2678KJ/g for yam peel, 982KJ/g and 1980KJ/g for Rice husk, 1667.5KJ/g and 1436KJ/g for Guineacorn husk, 1828.5KJ/g and 1870.5KJ/g for Cowpea shell and 2358KJ/g and 1970KJ/g for Groundnut shell respectively. All samples considered have heat values greater than some well known biomass fuels and fall within the limit of production of steam in electricity generation. As a result of this, it is envisaged that Government should turn attention to the use of these agricultural waste to generate alternate energy source for the Nation to add to yet fully untapped solar power and this would at the same time solve waste problem in Niger State.

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CHAPTER ONE

1.1 INTRODUCTION

Crop residues are invariably fibrous, of low digestibility and low in Nitrogen. They are produced on the farm and widely spread geographically. These crop residues are only available only after the harvest of the crops. On small farms in Niger State, they form the principal feed of ruminant livestock during dry season which is paramount, most agricultural residues burnt as fuel are used in their natural state with some pretreatment like drying, cutting and compacting in some occasions.

Crop residues are characterized by its seasonal availability and have characteristic that differ from other soil fuels such as wood, charcoal. The main differences are the high content of volatile matter, lower density and burning time. The characteristics would therefore be based on each residues percentage in volatility, fixed carbon, Ash, and also density percentage.

The importance to farmers of crop residues for feeding ruminant livestock has long been neglected, if not falsely maligned, by scientists who define their success only in terms of grain yield per hectare. The error in this neglect is proven when a farmer rejects an "improved" cultivar because of its clearly inferior straw quality (Doyle et al, 1986).

Crop residue, traditionally considered as "trash" or agricultural waste, is increasingly being viewed as a valuable resource. Corn stalks, corn cobs, wheat straw and other leftovers from grain production are now being viewed as a resource with economic value. If the current trend continues, crop residue will be a "co-product" of grain production where both the grain and the residue have significant value.

Crop residues in this area or region are bulky and expensive or impossible to transport (e.g. stubbles). These materials are always cheapest in the places where they are produced. The demand for their use as livestock feeds is derived from the demand for animal products and the other reasons farmers maintain livestock. The existence of abundant crop residues can create an economic niche for ruminant livestock in the area.

The somewhat derogatory terms, "crop residue" and "agricultural waste" must have originated in the temperate climates of northern Europe and the British Isles. In a review of alternative practical methods for exploiting cereal straws, as fuel, feed and fertilizer, (Staniforth 1982, p. 1) stated that: the use and disposal of a huge and growing surplus of straw presents agriculture in developing countries with one of its most serious problems.

The emergence of crop residue as a valuable resource has evolved to the point where there are competing uses for it. There is even competition between use of crop residues for livestock versus their use to maintain soil organic matter balances and stabilize crop productivity, particularly where soil erosion is a threat.

CATEGORIES OF CROP RESIDUE

It is convenient, when establishing the characteristic and energy potentials for evaluating crop residues or by products as; residues high in fibre and low nitrogen which includes the most important crop residues, namely rice-stalks, cereal stalks and straws, legume haulus and straws, and N content from the plant; Crop residues high in fibre and high in nitrogen also regarded as animal by products; Crop residues low in fibre and high in Nitrogen includes products from processing, they include pineapple pulps, groundnut shell, reject bananas; and

crop residues low in fibre and high in Nitrogen comprises mostly oil seed cakes and slaughter offal.

These categories will be used to determine the characteristics. In study of energy potential, combustible gas production from shell biomass materials such as the crop residues (sample) can be experimentally investigated at 800⁰C using gastification technique by a downdraft gasifier.

The calorific value of the producer gas for various crop residues would be found and this would vary in each of the residues showing high presence of energy potential or low energy potential.

1.2 STATEMENT OF THE PROBLEM

It is discovered that the production of Arable crops such as cowpea, Yam, groundnut, rice, and millet are enormous in Niger State. These crop residues are dump as agricultural waste and are underutilized. Except for ruminant animals and nomadic farmers that go about feeding on these crop residues, they are not properly disposed. In other words, these crop residues have enormous uses due to its characteristic and the energy potentials readily available in them because they are energy supplements/serve as food to human.

The group at risk from the unscientific disposal of agricultural waste or crop residues and solid waste include – the population in areas where there is no proper waste disposal method, especially the pre-school children; waste workers; and workers in facilities producing toxic and infectious material. Other high-risk group includes population living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or leakage

from landfill sites. Some studies have detected excesses of cancer in residents exposed to hazardous waste. Many studies have been carried out in various parts of the world to establish a connection between health and hazardous waste.

1.3 OBJECTIVES OF THE STUDY

(1) The objective of this work is to evaluate the characteristic of selected crop residues, they include: Cassava peel, Yam peel, Rice husk, Guineacorn husk, Cowpea shell and Groundnut shell; and

(2) To determine the energy potentials of these crop residues.

1.4 SCOPE OF THE STUDY.

Agriculture biomass resources in Niger State are estimated to be around 25 million tonnes (dry matter) per year. Fifty percent of the biomass is used as fuel in rural areas by direct combustion in low efficiency traditional furnaces. The traditional furnaces are primitive mud stoves and ovens that produce large quantities of air pollution and are extremely energy inefficient. The agriculture biomass waste (resources) consists mainly of millet husk / straw, guinea-corn husk, rice straw, maize husks etc. Moreover, the traditional storage systems for plant residues on farms, on the roves of buildings, allow insects and diseases to grow and reproduce. In addition they pose a fire hazard.

CHAPTER TWO

2.0 LITERATURE REVIEW

The importance to farmers of crop residues for feeding ruminant livestock has long been neglected, if not falsely maligned, by scientists who define their success only in terms of grain yield per hectare. The error in this neglect is proven when a farmer rejects an "improved" cultivar because of its clearly inferior straw quality (Anderson, 1978).

High-quality crop residues are in short supply in this region. Well-directed plant breeding, in collaboration with animal nutritionists, may be the surest and most economical path to enhance these important feed resources: new cultivars which, from the farmers' viewpoint, are truly "improved". The main problem facing rural villages in developing countries are agricultural waste, sewage and municipal solid waste. However several studies have been conducted on the utilization of agricultural waste for composting or animal fodder (Sarma, 1986).

Most of the proposed solutions have not been implemented because they did not meet the basic element of sustainability; social progression, technical and technological improvements, environmental protection and economic developments (Sarma, 1986).

2.1 Bran as a Crop Residue

Bran is the hard outer layer of grain and consists of combined aleurone and pericarp. Along with germ, it is an integral part of whole grains, and is often produced as a by-product of milling in the production of refined grains. When bran is removed from grains, the latter lose a portion of their nutritional value. Bran is present in and may be milled from any cereal grain, including rice, corn (maize), wheat, oats, barley, and millet. Bran should not be confused with

chaff, which is coarser scaly material surrounding the grain, but not forming part of the grain itself (Heli Roy et al, 2005).

Bran is particularly rich in dietary fibre and omegas and contains significant quantities of starch, protein, vitamins, and dietary minerals.

Rice bran is a by-product of the rice milling process (the conversion of brown rice to white rice), and it contains various antioxidants that impart beneficial effects on human health. A major rice bran fraction contains 12%-13% oil and highly unsaponifiable components (4.3%) This fraction contains tocotrienols (a form of vitamin E), gamma-oryzanol, and beta-sitosterol; all these constituents may contribute to the lowering of the plasma levels of the various parameters of the lipid profile. Rice bran also contains a high level of dietary fibres (beta-glucan, pectin, and gum). In addition, it also contains 4-hydroxy-3-methoxycinnamic acid (ferulic acid), which is also a component of the structure of non-lignified cell walls. However, some research suggests that there are levels of inorganic arsenic (a toxin and carcinogen) present in rice bran. One study found the levels to be 20% higher than in drinking water.^[1] Other types of bran (derived from wheat, oat or barley) contain less arsenic than rice bran, but not necessarily the same health benefits (Heli Roy et al, 2005)..

The high oil content of bran makes it subject to rancidification, one of the reasons that are often separated from the grain before storage or further processing. The bran itself can be heat-treated to increase its longevity (Online Encyclopedia, 2010 Edition).

2.2 Sources of Crop Residue

Crop residues encompasses all agricultural wastes such as straw, stem, stalk, leaves, husk, shell, peel, lint, stones, pulp, stubble, etc. which come from cereals (rice, wheat, maize or corn, sorghum, barley, millet), cotton, groundnut, jute, legumes (tomato, bean, soy) coffee, cacao, olive, tea, fruits (banana, mango, coco, cashew) and palm oil.

Table 2.1: Sources of Crop Residues

Crops	Crop wastes	Residues production
Rice	Straw, husk, bran	1.5t of straw and 0.2t of husk from 1t of rice
Guinea-corn Husk	Straw, husk, bran	2t of residues from 1t of wheat seed
Maize	Stalk, leaves	6t of waste from 1t of maize (leaves + stalks 4t)
Sorghum	Straw, bran	2.5t of residues from 1t of sorghum seed
Barley	Straw, bran	1.5t of straw from 1t of barley
Millet	Straw, bran, husk	2t of residue from 1t of millet produced
Cowpea	Stalk, lint, hull	0.2t of waste from 1t of cotton seed
Groundnut	Shell, stalk, leaves	25% of shell weight from non husked
Coffee	Pulp, husk	3.6t of waste from 1t of green coffee
Coco	Hull, fibre	0.9t of waste from 1t of coconut
Palm oil	Shell, fibre,	75% waste from weight of fruit bunch
Yam	Peel	

Sources: Memento de l'agronome: quatrième (2005)

2.3 Potential Uses of Crop Residue

The rural families in the local village area in the state who own agricultural land use their own agricultural residue which varies throughout the year. They use it as a household fuel for cooking, heating water and for space heating during colder climates. Agricultural wastes are directly burnt to meet the need of cooking. Crop residues are yet used to light wood and charcoal.

Potters in some areas in Agaie and Bida, in Niger State burn a large amount of agricultural residues in their traditional pottery pit in order to produce their canaris, ceramic stoves and other pottery (Ministry of Agriculture, Minna) In the part of the world faced by the scarcity of wood-fuel and the cost-effective fuel substitutes, agricultural waste (owing to its high potentiality) may play a major role on sustainable energy.

However the traditional use of crop residues and the lack of information on modern technologies such as briquetting, pelleting, and bioconversion, limit the development of large scale use which leads to increase the value of agricultural output (Akinbami et al, 2001).

Crop residues have traditionally been used for animal feed. In many parts of the country, beef cows are placed in corn fields after harvest to graze on the residue and any grain remaining in the field. Also, crop residues are harvested, stored and fed to livestock during the dry season. Crop residues, especially straw from small grains, are used for livestock bedding (Anderson 1978).

A variety of commercial uses for crop residues are in various stages of development. Crop residues can be a feedstock for composite products such as fiberboard, paper, liquid fuels and others. Several straw-to-fiberboard business ventures have emerged in recent years with mixed success. Likewise, crops residues have been investigated as a feedstock for pulp for making paper. Conservative estimates indicate that there are enough crop residues to expand the supply of papermaking fiber by up to 40 percent (Heli Roy et al, 2005).

Crop residues can be used as a feedstock in the gasification (thermo-chemical) process for

Crop residues can be used as a feedstock in the gasification (thermo-chemical) process for making syngas (synthetic gas) which contains carbon monoxide (CO) and hydrogen (H₂). Syngas can be used for several purposes including producing electricity, producing certain chemicals and making ethanol, gasoline and diesel (McCarthy and Shrum, 1994).



Plate1: Rice stalk before harvest

Biomass can be used in the production of biogas, which is composed mainly of methane (CH₄) and carbon dioxide (CO₂). Biogas can be used in many parts of the world for low-cost heating and cooking. It can also be used to generate mechanical or electrical power. Biogas can be compressed, much like natural gas, and used to power motor vehicles.

Crop residues can also be burned directly to produce heat and steam. The investigation of alternative uses for crop residues to make commercial products will continue to grow as traditional feedstocks become limited and the need for renewable sources of feedstocks expands.

2.3.1 Crop Residue for Erosion Control

Crop residues remaining in fields after harvest offer great benefit for erosion control. Tillage practices such as minimum tillage or no till have become more widely accepted in the last few years and contribute to reduction of soil erosion and retention of moisture. Field residues provide a multitude of benefits to the soil such as: surface protection from wind and water erosion; nutrients; increased “cation” exchange capacity and thus increased retention of anions found in fertilizers such as nitrates; reduction of bulk density; increased moisture infiltration and retention; and energy for activity of microorganisms. Although field residues provide nutrients to growing crops, residues often do not provide sufficient nutrients for high yields of many crops such as corn. Commercial fertilizers are necessary for most field crops (Nordblom and Halimeh, 1982).

The benefits of crop residues have both short term and cumulative impacts. The advantages of surface protection, cation exchange capacity, bulk density, and moisture are most apparent over longer periods of time. Since it can take more than fifty years for an inch of soil to form, precautions should be taken to prevent soil loss and to improve soil characteristics (Nordblom and Halimeh, 1982).

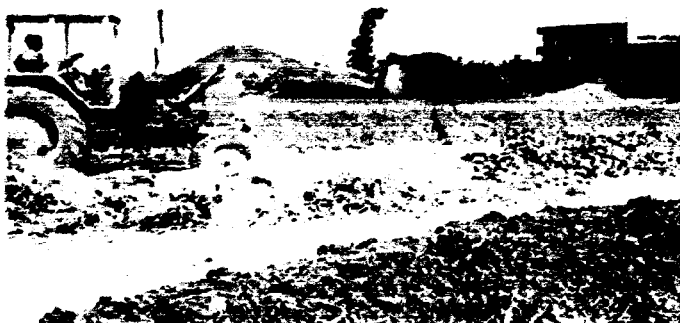


Plate 1: Hips of crop residues being scattered for erosion control

2.3.2 Nutritional "Value" of Crop Residues

"Value" is put in quotes to emphasize its commercial rather than biological significance. In other words, how much money is a certain waste material worth in a specific application as feed? Obviously, this value is determined not only by strictly nutritional characteristics such as nutrient composition, digestibility, presence of anti-nutritional factors, palatability, and tolerance, but also by usage characteristics such as convenience, stability, effect of the feed on the acceptability of the final product (e.g., effect on colour of egg yolk or on the flavour of milk, etc.), aesthetic barriers, or plain traditionalism. For these and other reasons, the value of wastes as feed is often considerably less than the value that would be assigned to them by a computer programmed for least-cost feed formulation (Heli Roy et al, 2005)..

2.4 Evaluation of Waste Characterization

To evaluate the characteristic of crop residues, the table below gives definitions and descriptions of waste characterization terms. It includes abbreviations, methods of measurement, and other considerations for the physical and chemical properties of farm waste, and crop residues.

Table 2.1 Physical Characteristic of Crop Residues

Term	Definition	Method of Measurement	Comment
Weight (lb)	Quantity or mass.	Scale or Balance	
Volume (Ft ³ or gal)	Space occupied in cubic units	Place in or compare to container of known volume; calculate from Dimensions of containment facility.	
Moisture Content (%)	That part of a waste material removed by evaporation and oven drying at 217°F (103°C).	Evaporate free water on steam table and dry in oven at 217°F for 24 hours or until constant weight	Moisture content (%) plus total solids (%) equals 100%.
Total Solids (%) (% w.b.) (% d.w.)	Residue remaining after water is removed from waste material by evaporation, dry matter	Evaporate free water on steam table and dry in oven at 217°F for 24 hours or until constant weight.	Total of volatile and Fixed solids; total of suspended & dissolved solids.
Volatile Solids (%) (% w.b.) (% d.w.)	That part of total solids driven off by volatile (Combustible) when heated to 1112°F (600°C) organic matter.	Place total solids residue in furnace at 1112°F for at least 1 hour.	Volatile solids determined from difference of fixed and total solids.
Fixed Solids (%) (% w.b.)	That part of total solids remaining after volatile gases	Determine weight (mass) of residue after volatile solids have	Fixed solids equal total solids deducted

(% d.w.)	have driven off at 1112 °F (600°C).	been removed as combustible gases when heated at 1112°F for at least 1 hour	from volatile solids
Dissolved Solids (%) (% w.b.) (% d.w.)	That part of total solids passing through the filter in a filtration procedure	Pass a measured quantity of waste material through 0.45 micron filter using appropriate procedure; evaporate filtrate and dry residue to constant weight at 217 °F.	Total dissolved solids (TDS) may be further analyzed for volatile solids and fixed dissolved solids parts.
Suspended Solids (%) (% w.b.) (% d.w.)	That part of total solids removed by filtration procedure.	May be determined by difference between total solids and suspended solids.	Total suspended solids may be further analyzed for volatile and fixed suspended solids parts.

Source: Barth, 1985.

N.B: Definitions and descriptions of waste characterization terms (% w.b. is percent measured on a wet basis, and % d.b. is percent measured on a dry basis)

Table 2.2 Chemical Characteristic of Crop Residues

Term	Definition	Method of Measurement	Comment
Ammoniacal Nitrogen (Total ammonia) (mg/L)	Both NH_3 and NH_4 Nitrogen compounds.	Common laboratory procedure uses digestion, oxidation, and reduction to convert all or selected nitrogen forms to ammonium that is released	Volatile and mobile nutrients; may be a limiting nutrient in land spreading of waste and eutrophication.
Ammonium Nitrogen (mg/L)	The positively ionized (cation) form of ammoniacal nitrogen.	and measured as ammonia.	Can become attached to the soil or used up by plants or microbes.
Total Kjeldahl Nitrogen (mg/L)	The sum of organic Nitrogen and ammoniacal Nitrogen.		
Nitrate Nitrogen (mg/L)	The negatively ionized (anion) form of nitrogen that is highly mobile.		Nitrogen in this form can be lost by denitrification, percolation, runoff, and plant microbial

			utilization.
Total Nitrogen (%; lb)	The summation of Nitrogen from all the various nitrogen compounds listed above.		Macro-nutrient for plants.
Phosphorus (%; lb)	Acid-forming element that combines readily with oxygen to form the oxide P_2O_5 . As a plant nutrient it promotes rapid growth, hastens maturity, and stimulates flower, seed and fruit production	Laboratory procedure uses digestion, and/or reduction to convert phosphorus to a colored complex; result measured by spectrophotometer.	Critical in water pollution control; may be a limiting nutrient in eutrophication and in spreading of waste etc.
Potassium (%; lb)	As a plant nutrient, available potassium stimulates the growth of strong stems, imparts resistance to disease, increases the yield of tubers and seed, and is	Laboratory digestion procedure followed by flame photometric analysis to determine elemental concentration.	

	necessary to form starch, sugar, and oil and transfer them through plants.		
5 Day Bio-chemical Oxygen Demand (lb of O ₂)	That quantity of oxygen needed to satisfy bio-chemical oxidation of organic matter in waste sample in 5 days at 68 °F (20 °C).	Extensive laboratory procedure of incubating waste sample in oxygenated water for 5 days and measuring amount of dissolved oxygen consumed.	Standard test for measuring pollution potential of waste material that could be discharged to surface water.
Chemical Oxygen Demand (lb of O ₂)	Measure of oxygen consuming capacity of organic and some inorganic components of waste material.	Relatively rapid laboratory procedure using chemical oxidants and heat to fully oxidized the organic components of the waste.	Estimate of total oxygen that could be consumed in oxidation of waste material.

Source: Barth, 1985.

The first four physical properties—weight (Wt), volume (Vol), total solids (TS), and moisture content (MC) are important to agricultural producers and facility planners and designers. They describe the amount and consistency of the material to be dealt with by equipment and in treatment and storage facilities. The first three of the chemical constituents—nitrogen (N), phosphorus (P), and potassium (K) are also of great value to waste systems planners, producers, and designers. Land application of agricultural waste is the primary waste

utilization procedure, and N, P, and K are the principal components considered in development of an agricultural waste management plan (Barth, C.L. 1985)

Total solids and the fractions of the total solids that are volatile solids (VS) and fixed solids (FS) are presented. Volatile solids and fixed solids are sometimes referred to, respectively, as total volatile solids (TVS) and total fixed solids (TFS). Characterization of these solids gives evidence of the origin of the waste, its age and previous treatment, its compatibility with certain biological treatment procedures, and its possible adaptation to mechanical handling alternatives.

Waste that has very high water content may be characterized according to the amounts of solids that are dissolved and/or suspended. Dissolved solids (DS) or total dissolved solids (TDS) are in solution (Barth, C.L. 1985).

2.5 Nuisance Caused by Crop Residue

About one third of the total amount of harvested crops is dumped on the farm as crop residues or wastes. These residues dumped on site causes hindrances to other crops which are yet to be harvested. These same high confinements of residues attract some farm animals for consumption and thereby destroying other crops that are yet to be harvested or in their germination period in the process. (FAO, 1998)

Also, the dumping of these crop residues in wrong places or across metropolitan areas of the state causes various environmental health hazards; these includes dust, odour, flies which can

result from difficulty in managing large residue quantities produced which would also result to bacteria and other diseases causing organisms.

Another major concern is the nitrogen and phosphorus of these residues may get into the surface or sub-surface water supply to the public and in some cases other compounds may degrade water by adding to its load of salt. Uncollected solid waste can also obstruct storm water runoff, resulting in the forming of stagnant water bodies that become the breeding ground of disease. Waste dumped near a water source also causes contamination of the water body or the ground water source. (Source - Adapted from UNEP report, 1996)

2.6 Main Practices of Urban Organic Waste Reuse in Niger State

There is a simple proverb: "waste is food." In traditional settlements in many parts of the state, the age-old habit of returning household wastes to the food chain persists. Kitchen peelings and food leftovers are fed to animals, selected organics are fed into fish ponds, and wastes are composted for home gardens. Where there is intensive farming in peri-urban areas, areas that typically receive municipal solid waste, the farmers frequently exploit the products of MSW decomposition in various ways. In addition to old practices, others, such as community vermin-composting (composting through worm culture), are growing in the urban areas like Lagos.

Kitchen and yard wastes, yard wastes from community households, old garbage dumps site, fruit seeds from garbage dumps are different types of solid waste in urban areas of Niger state and the major materials of these solid wastes includes raw peelings and stems, rotten fresh fruits and left-over cooked foods, garden trimmings and grass cuttings. Agricultural wastes /

crop residues which are predominantly residues produced by farming, twigs, grass, leaves, branches and cow dung (Ledward et al, 2003).

The main practices of these solid waste by the urbanites in the state includes collection of cow dung from pastures or roads and these are made into patties or dried on stick to be used as fuel or fertilizer or as binding ingredients in plaster made of mud; when twigs, leaves and branches are gathered, they are used as fuel or animal fodder; “garbage farming” is other form of practices and this is referred to as the practice of converting old garbage dump site to farm plots; and lastly commonest practice is the feeding animals within the house and neighborhood with food wastes and left-over cooked food (McCarthy and Shrum, 1994).

Compared to other developed cities of the world, these practices can be encouraged and improved upon to reduce the nuisance accrued from these waste.

Ledward et al (2003) concluded that directly feeding of household livestock with residues is probably rather low-risked and should be encouraged; in some areas, these wastes are taken by the municipal authority directly to a compost plant but the complete diversion deprives poor residents of alternate fuel and fodder.

2.7 Methods of Evaluating Energy Potential of Crop Residues

2.7.1 Briquetting System

The briquetting process is the conversion of agricultural waste into uniformly shaped briquettes that are easy to use, transport and store. The idea of briquetting is to use materials that are otherwise not usable due to a lack of density, compressing them into a solid fuel of a convenient shape that can be burned like wood or charcoal. The briquettes have better physical

and combustion characteristics than the initial waste. Briquettes will improve the combustion efficiency of existing traditional furnaces. In addition to killing all insects and diseases they reduce the risk of fire in the countryside. The idea of briquetting is to use materials that are not otherwise usable due to a lack of density, compressing them into a solid fuel of a convenient shape that can be burned like wood or charcoal. Briquettes were discovered to be an important source of energy during the First and Second World Wars for heat and electricity production using simple technologies. One of the recommended technologies is lever operating press (mechanical or hydraulic press). Briquetting allows ease of transportation and safe storage of wastes as they have a uniform shape and are free of insects and disease carriers. The advantages of briquetting are:

- gets rid of insects
- decreases the volume of waste
- efficient solid fuel of high thermal value
- low energy consumption for production
- protects the environment
- provides job opportunities
- less hazardous.

Raw materials suitable for briquetting are rice straws, wheat straws, cotton-stalks, corn stalks, sugar cane waste (baggas), and fruit branches. The briquetting process starts with the collection of wastes followed by size reduction, drying and compaction by extruder or press.

2.7.2 Gasification Process to Determine Energy Potential

The essence of gasification process is the conversion of solid carbon fuels into carbon monoxide by thermo-chemical process. The gasification of solid fuel is accomplished in air sealed, closed chamber, under slight suction or pressure relative to ambient pressure (Khater et al, 1992).

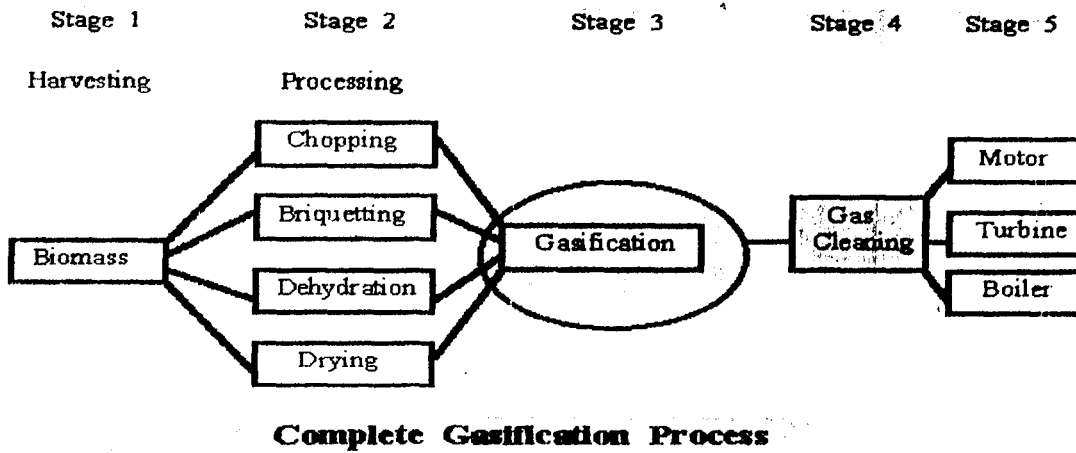


Figure 2.1: Complete gasification process

Gasification is quite complex thermochemical process. Splitting of the gasifier into strictly separate zones is not realistic, but nevertheless conceptually essential. A gasification stage occurs at the same time in different parts of gasifier (Adnan Midilli et al, 2001)

Crop residues can also be regarded as biomass or agricultural waste and it is at this point that the residues are being converted into useful energy such as gas. (Adnan Midilli et al, 2001)

Drying

Biomass fuels consist of moisture ranging from 5 to 35%. At the temperature above 100 °C, the water is removed and converted into steam. In the drying, fuels do not experience any kind of decomposition. (Adnan Midilli et al, 2001)

Pyrolysis

Pyrolysis is the thermal decomposition of biomass fuels in the absence of oxygen. Pyrolysis involves release of three kinds of products: solid, liquid and gases. The ratio of products is influenced by the chemical composition of biomass fuels and the operating conditions. The heating value of gas produced during the pyrolysis process is low (3.5 - 8.9 MJ/m³). Khater et al, 1999

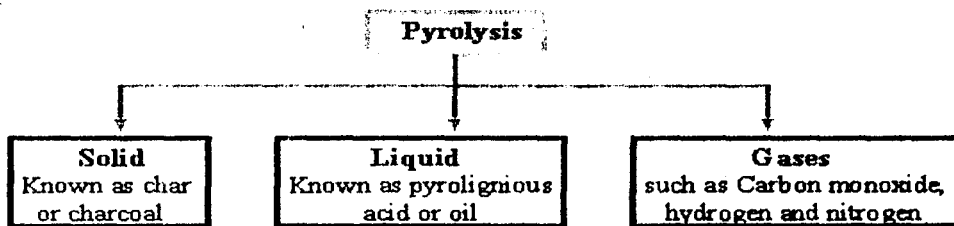


Figure 2.2 Products released during pyrolysis

It is noted that no matter how gasifier is built, there will always be a low temperature zone, where pyrolysis takes place, generating condensable hydrocarbon. (Khater, Khattab, and Hamad, 1999)

2.7.3 Composting

Composting is the aerobic decomposition of organic materials by micro-organisms under controlled conditions. Liebig (1876), a German chemist calculated that North African lands that were supplying two thirds of the grains consumed in Rome were becoming less fertile and losing their quality and productivity. He found, on conducting research, the reason behind this phenomenon: when crops are exported from North Africa to Europe, their wastes do not go back to North Africa but are flushed into the Mediterranean. Agricultural waste is rich in organic matter. This matter is derived from the soil and the soil needs it back in order to continue producing healthy crops. However, this was not the case and, in Liebig's opinion, was a breaking of the natural loop that gives the land back its nutrients. He called this phenomenon the "direct flow". The German scientist proposed artificial fertilizers, which were meant to compensate the soil for loss of organic matter, but they were not the same as natural fertilizers.

Composting is one of the best known recycling processes for organic waste to close the natural loop. The major factors affecting the decomposition of organic matter by micro-organisms are oxygen and moisture. Temperature, which is a result of microbial activity, is also an important factor. The other variables affecting the process of composting are nutrients (carbon and nitrogen), pH, time and the physical characteristics of the raw material (porosity, structure, texture and particle size) (Gale and Cambadella, 2000).

The quality and decomposition rate depends on the selection and mixing of raw materials. Aeration is required to recharge the oxygen supply for the micro-organisms. The passive composting method is the recommended technique for the Egyptian environment for technical and economic reasons. The main advantages of composting is the improvement of soil

structure by adding organic matter and pathogens structure as well as utilizing agricultural waste that can cause high levels of pollution if burned. Because compost materials usually contain some biological resistant compounds, a complete stabilization (maturation) during composting may not be achieved. The time required for maturation depends on environmental factors within and around the composting pile. Some traditional indicators can be used to measure the degree of stabilization such as decline in temperature, absence of odour, and lack of attraction of insects in the final products (Gale and Cambadella, 2000).

2.8 Renewable Energy Potentials in Nigeria

2.8.1 Wind Energy Potentials

Globally, Nigeria is located within low to moderate wind energy zone.

Ojosu and Salawu, (1989) carried out the most comprehensive nationwide study on wind energy availability and potential in Nigeria. The study uses Data on Wind speeds and directions for 22 meteorological Stations from the Nigerian Meteorological office, Oshodi near Lagos. The meteorological data are based on the 3-hourly records of wind for periods ranging from (1979 – 1989)

The isovents at 10m heights are drawn and four different wind zones/regimes are identified as shown in. The wind energy potential for wind energy utilization in Nigeria is broadly appraised (Ojosu and Salawu, 1989).

2.8.2 Solar Energy Resources in Nigeria

According to (Bala et al, 2000), Nigeria is endowed with an annual Average daily sunshine of 6.25 hours, ranging between about 3.5 hours at the coastal areas and 9.0 hours at the far northern boundary. Similarly, it has an annual average daily solar radiation of about 5.25

$\text{KW/m}^2/\text{day}$, varying between about $3.5 \text{ kWm}^2/\text{day}$ at the coastal Area and $7.0 \text{ kW/m}^2/\text{day}$ at the northern boundary (World Online Encyclopedia, 2009 edition). Nigeria receives about 4.851×10^{12} KWh of energy per day from the sun. This is equivalent to about 1.082 million tons of oil Equivalent (mtoe) per day, and is about 4 thousand times the current daily crude oil reduction, and about 13 thousand times that of natural gas daily production based on energy unit. This huge energy resource from the sun is available for about 26% only of the day. The country is also characterized with some cold and dusty atmosphere during the harmattan, in its northern part, for a period of about four months (November-February) annually. The dust has an attenuating effect on the solar radiation intensity (Bala, et al, 2001)

Based on the land area of $924 \times 10^3 \text{ km}^2$ for the country and an average of $5.535 \text{ kWh/m}^2/\text{day}$, Nigeria has an average of 1.804×10^{15} kWh of incident solar energy annually. This annual solar energy insolation value is about 27 times the nation total conventional energy resources in energy units and is over 117,000 times the amount of electric power generated in the country in 1998

2.8.3 Biomass and Biogas Energy Resources: An Alternate to Other Energy Resources

The biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal as waste arising from forestry, agricultural, municipal and industrial activities, as well as, Aquatic biomass. The biomass resources of the nation have been estimated to be about 8×10^2 M.J. Plant biomass can be utilized as fuel for small-scale industries. It could also be fermented by anaerobic bacteria to produce a very versatile and cheap Fuel Gas i.e. biogas (Garba and Bashir, 2002).

practice the accurate determination is complicated by number of factors which vary considerably from one sample to another.

Among the factors are the relative amounts of water available and the ease with which the moisture can be removed. Methods that are based upon the removal of water from the sample and its measurement by loss of weight or the amount of water separated. Air or vacuum oven drying at 70 – 80⁰C are considered to be reliable methods provided that there is no chemical decomposition of the sample and water is the only volatile constituent removed. Sample should be dried to a constant weight.

Procedure

1. Weight a clean and well labeled dish that has been oven dried (W_1)
2. Add enough sample in to the dish and weigh (W_2)
3. Transfer the dish and content to the thermo setting oven at about 105⁰C for about 24 hours.
4. Transfer dish from oven to desiccators. Cool for about one hour and weight, Repeat step 4 to constant weight W_3
5. Calculate % moisture content
6. In the case of hygroscopic substances a dish with a cover must be used.
7. Experiment must be performed at least in duplicate.

$$\% \text{ Moisture} = \frac{\text{Loss in Weight}}{\text{Weight of Sample before drying}} \times 100$$

$$= \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Terms

- a) 'Moisture' is mostly used for powder where the amount present is comparatively small as in the harvested grains.
- b) 'Water' is more common when the amount present is rather higher as with fresh fruits such as oranges.
- c) 'Total Solids' used for liquids such as milk.

3.2.2 Total Ash

The ash of biological materials is analytical term for the inorganic residue that remains after the organic matter has burnt off. The ash is not usually the same as the inorganic matter present in the original material since there may be losses due to the volatilization or chemical interaction between the constituents. The importance of the ash content is that it gives an idea of the amount of mineral elements present and the content of organic matter in the sample. The organic matter accounts for quantitative constituents of proteins, lipid or fat, carbohydrate, plus nucleic acid. Sample rich in organic matter can be preheated on the flame or hot plate.

Procedure

- a) Place silica dish or crucible in muffle furnace for about 15 minutes at 350°C.
- b) Remove the dish or crucible, cool in a desiccator for about one hour or cool to room temperature, weigh the crucible (W_1).
- c) Add enough sample into the crucible (0.5 – 2g the quantity will depend on texture and source of sample) and weigh content (W_2).
- d) If sample is wet or fresh plant sample it should be pre-dry.

- c) Place the crucible inside the muffle furnace, and slowly increase the temperature from 200⁰C – 450⁰C this is to avoid incomplete ashing. Ash sample until it become whitish in colour. If ashing is incomplete (evidence of black particles, within a reasonable period remove crucible, cool, moisten with few drops of distilled water, dry on water bath and return to the furnace.
- f) Remove from furnace to dessicator and allow to cool to room temperature.
- g) Reweigh the crucible and content (W₂).

Calculation:

$$\% \text{ Ash} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

3.2.3 Lipid (Fat) Extraction

Soxhlet Extraction Method

By definition, fats are mixtures of various glyceride of fatty acids, which are soluble in certain organic solvents. Extraction is carried out with Soxhlet apparatus with either or petroleum ether in a convenient extractor (Soxhlet extractor). The other extraction method is based on the principle that non-polar components of the sample are easily extracted into organic solvents. Direct extraction gives the proportion of free fat but gives no clue to the particular fatty acids. The Soxhlet extractor is mostly suitable for dried samples.

Procedure

1. Weight thimble previously dried (W_1) it should be fat free.
2. Add enough sample into the thimble and weigh again (W_2).
3. Weight the 500ml round bottom flask (fat free) W_3 .
4. Fill the flask with petroleum ether up to 2/3 of the 500ml flask.
5. Fit up the Soxhlet extractor with a reflux condenser as shown above. Adjust the heat source so that the solvent boils gently, leave it to siphon over several hours (5 – 8 hours).
6. Finally wait until the petroleum ether has just siphoned over the barrel. Detach the condenser and remove the thimble or filter paper. Distill petroleum ether from the flask.
7. Dry the flask containing the fat residue in an air oven at 100°C for 5 minutes or on water bath. Cool in a desiccators and weigh (W_4).
8. Place the thimble in the beaker in an oven at 50°C and dry to constant weight with sample. Cool in desiccators and weigh (W_5). The % of extracted lipid can be given by either.

- i. Weight of lipid in the flask after extraction

$$\% \text{ Fat} = \frac{W_4 - W_3}{W_2 - W_1} \times 100$$

- ii. From the thimble by weight loss in the sample

$$\% \text{ Fat} = \frac{W_2 - W_5}{W_2 - W_1} \times 100$$

3.2.4 Crude Fibre

Crude fibre is that portion of the plant material which is not ash or dissolves in boiling solution of 1.25% H_2SO_4 or 1.25% $NaOH$. Crude fibre was originally thought to be indigestible portion of any main food. It is known however that fibre consists of cellulose which can be digested to a considerable extent by both ruminants and non-ruminants. The interest in fibre in food and feed has increased, based on the noticed number of serious illnesses associated with diet low in fibre. Fibres swell and form gelatinous mass with high water retention capacity with the digestive system. Findings show that fibre products can absorb cholesterol, toxic agents and raise the excretion of bile acids and sterols.

Determination of fibre content of plant tissue is relatively simple. The method is essentially conventional, and it rigidly adhered to will provide a distinction between the most digestible and least digestible carbohydrate.

The starch and the protein are dissolved by boiling the sample with acid and then with $NaOH$. The residue of cellulose and lignin is washed, dried and weighed. The residue is ashed and the weight of the ash subtracted from the weight of the residue.

Procedure

1. Transfer about 3.5 – 5g defatened sample into 500ml conical flask.
2. Add 200ml of boiling 1.25% H_2SO_4 and bring to boiling within one minute and allow boiling gently for 30 minutes exactly using cooling finger to maintain constant volume.
3. Filter through poplin cloth or filter paper by suction using bunched funnel, rinse well with hot distilled water, and separate material back into flask with spatula.

4. Add 200ml of boiling 1.25% NaOH and few drops of antifoaming agent, bring to boiling within one minute and boil gently for 30 minutes using cooling finger (KOH can be used in the place of NaOH) and vegetable oil as antifoaming agent.
5. Filter through poplin cloth and wash with hot distilled water. Rinse four times with hot distilled water, and once with 10% HCl, four times again with hot water, twice with methylated spirit and three times with petroleum ether (where methylated spirit is not available). Ethanol could be used as a substitute for methylated spirit.
6. Servage the residue into crucible after drain, dry in the oven at 105⁰C, cool in desiccators and weigh W₂.
7. Place in muffle furnace at about 300⁰C for about 30 minutes.
8. Remove into desiccators and allow to cool to room temperature, weight again W₂.

$$\% \text{ Crude fibre} = \frac{W_2 - W_3}{W_1} \times 100$$

3.2.5 Nitrogen Determination

The accepted standard method for the determination of nitrogen in any sample involves complete digestion of sample in hot concentrated acid, and in the presence of an appropriate catalyst. The catalyst is to convert all nitrogen in the nitrogenous materials in the sample into ammonium ion.

Upon The addition of alkali to the digest, ammonia is released which may then either be distilled out of the sample and determined by simple acid-base titration, or the ammonia can react with an appropriate reagent such as phenol and sodium hypochlorite, to give a coloured derivative which can be measured with calorimeter or spectrophotometer.

The Kjeldahi digestion is usually performed by heating the sample with H_2SO_4 – containing substances which promote oxidation of organic matter by increasing the boiling appoint of the acid (K_2SO_4 or NaSO_4) and Se or Cu which increase the state of oxidation of organic matter. These reagents here is referred to as a digestion catalyst.

It is necessary to digest the sample for certain period until you obtain a clear solution to ensure accurate result.

Procedure

Digestion (State 1)

- a) Weigh about 2g wet sample into 50ml Kjeldahi flask, add 20 ml conc. H_2SO_4 with one Kjeldahi catalyst table:
- b) Weight about 0.5g dry sample into 50ml micro Kjeldahi flask, and 5ml conc. H_2SO_4 with half Kheldahi catalyst tablet. Let the weight be (W_1).
 - i. Heat on a heater start with a low heat for about 15 minutes, increase to medium heat for about 30 minutes again and finally at high heating until digested. Rotate the flask at intervals until the digest is clear (light green or grey white) continue heating for few minutes after that to ascertain complete digestion.
 - ii. Allow to cool, wash sample residue if any and filter, make up the digest up to 50, 100 ml or as appropriate (V_1).

Note: Catalyst can be formulated when tablet is not available 100g K_2SO_4 + 10g $\text{CUSO}_4 \cdot 5\text{H}_2\text{O}$ 1g sellinium or 60g K_2SO_4 + 6.5g H_2O .

Titration and Calculation (Stage Iii)

Titrate the distillate with standard mineral acid (0.01M HCl or 0.025M H₂SO₄). Titrate a blank with the acid as well.

Sample titre T₁

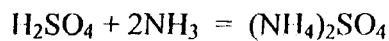
Blank Titre T₂

$$\text{Control Titre} = T_1 - T_2 = t$$

And molarity of Acid = M

Reactions

Digestion



Nitrogen converted to ammonia and reacted with H₂SO₄ to form (NH₄)₂SO₄.

3.2.6 Crude Protein

The amount of crude protein contained in the seed, roots, tubers and other stuff can be obtained by multiplying the nitrogen content of the food by 6.25, the factor 6.25 owes its origin to the assumption that all food protein contains 16% nitrogen, and that all nitrogen in a feed is present as protein. Although these assumptions are not entirely valid. The protein contained in plant tissue or feed may vary in terms of nitrogen content from 13 – 18%, In many cases, a factor other than 6.25 would be more valid.

Table 3.1: Protein conversion factor of some products.

PRODUCT	FACTOR	PRODUCT	FACTOR
Egg Whole	6.25	Oil Seed	5.4
Egg Albumin	6.38	Wheat	6.70
Egg Vitelin	6.22	Rice and Rice Flour	5.70
Egg Casein	6.40	Oats	5.85
Milk and Milk Product	6.39	Millet	6.30
Animal and fish	6.25	Legume	6.25
Cereals	5.90	Sorghum	6.25
Plant Leaf Protein	6.6	Groundnut	5.46
Soya Bean	5.70		

3.2.7 Carbohydrate (Nfe Or C₆H₁₂O₆) Determination

The term carbohydrate embraces a broad spectrum of compounds ranging from simple mono-saccharides to complex polysaccharides. The most common approach to the determination of carbohydrate content of foods or in plants is by difference (subtraction of the sum of the Moisture, Ash, Protein, Crude fibre and Fat from the total weight).

$$\% \text{ soluble carbohydrate} = 100 - (\% \text{ Moisture} + \text{Ash} + \text{Protein} + \text{Fibre} + \text{Fat}).$$

There are a number of objections to this approach. It is vulnerable to the inaccuracies associated with the determination of the other constituents. It does not take into account other

minor compounds such as lignin which may be present. The objections can be overcome to a useful degree by the Clegg Anthrone Method (Ibitoye A.A. 2005)

3.2.8 Determination of Energy Content

Calorific Value / Food Energy

This measures the chemical energy inherent in the bonds of the organic components of food such as the proteins, carbohydrates, fats, as well as minor constituents such as organic acids. These are two methods of evaluating food energy which includes the use of bomb calorimeter or the calculations of energy from the results of the proximate analysis of the food.

Bomb Calorimetric method involves igniting the food in adiabatic oxygen bomb calorimeter. (under a high pressure of oxygen usually a 25 atm). These will bring about the oxidation of organic constituents of water, CO₂ and oxides of some elements such as Nitrogen, Sulphur and Phosphorus with the resultants released to the bomb and the subsequent increase in temperature of the water that is used + estimate the energy value of the food.

The problem with this method is that it measures the energy of food constituents that may not necessarily be oxidized by human body (mainly the dietary fibre) and therefore over estimate the energy value of the food (James, 1996).

Procedure:

- Pellet 2g of the food sample
- Burn pelleted food sample in pure Adiabatic oxygen bomb calorimeter
- The heat of the combustion of the sample is calculated as gross energy

$$\text{Gross Energy} = \frac{W \times t - 2.3L - Y}{g}$$

Where

W = energy equivalent of calorimeter or water equivalent

t = temperature

2.3 = constant heat of combustion of wire

L = length of burnt wire

V = Titre value

g = weight of sample in grams

In the calculation method, the energy value (calorific value) of a food is given by

Energy value of food (in KJ per 100g) = [(% available in carbohydrate x 17) + (% Protein x 17) + (% Fat x 37)]. Or

$$(4(\text{CP \%}) + 4(\text{NFE \%}) + 9(\text{EE \%})) \times 10$$

(Source: Food Analysis and Instrumentation Theory and Practice, Gregory I. Onwuka, Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike).s

CHAPTER 4

DISCUSSION OF RESULTS

After carrying out the analysis, the following results were obtained:

4.1 CRUDE PROTEIN

Table 4.1: Crude protein tests on sample type I

Sample	Weight of Sample	Titre Value	% C. P.
Cassava peel I	0.50	0.80	7.0
Yam peel I	0.50	0.95	8.31
Rice Husk I	0.50	0.75	6.56
Guineacorn Husk I	0.50	0.60	5.25
Cowpea shell I	0.50	1.20	10.50
G/Nut shell I	0.50	0.90	7.88

Table 4.2: Crude protein tests on sample type II

Sample	Weight of Sample	Titre Value	% C. P.
Cassava peel II	0.50	0.90	7.88
Yam peel II	0.50	1.15	10.06
Rice Husk II	0.50	0.95	8.31
Guineacorn Husk II	0.50	0.75	6.56
Cowpea shell II	0.50	1.25	10.94
G/Nut shell II	0.50	1.15	7.88

Table 4.3: comparison of nitrogen contents for both samples

Sample	Nitrogen Content	% Crude Protein
Cassava peel I	1.12	7.0
Cassava peel II	1.26	7.88
Yam peel I	1.33	8.31
Yam peel II	1.61	10.06
Rice Husk I	1.05	6.56
Rice Husk II	1.33	8.31
Guineacorn Husk I	0.84	5.25
Guineacorn Husk II	1.05	6.56
Cowpea shell I	1.68	10.58
Cowpea shell II	1.75	10.94
G/Nut shell I	1.26	7.88
G/Nut shell IIs	1.26	7.88

4.2 ASH

Table 4.4: Ash tests on sample type I

Sample	Wt of Crucible		+ Crucible Sample hatch C	+ % Ash after
	Crucible A	Sample B		
Cassava peel I	14.67	16.67	14.78	5.50
Yam peel I	11.70	13.70	11.89	9.50
Rice Husk I	31.30	33.30	31.60	15.00
Guineacorn Husk I	14.87	16.87	15.01	7.00
Cowpea shell I	12.10	19.10	12.20	5.00
G/Nut shell I	26.99	28.99	27.02	1.50

Table 4.5: Ash tests on sample type II

Sample	Wt of Crucible		Crucible Sample hatch C	+ % Ash after
	Crucible A	Sample B		
Cassava peel II	16.67	18.67	16.78	5.50
Yam peel II	12.70	14.70	12.79	10.50
Rice Husk II	30.30	32.30	30.60	14.50
Guineacorn Husk II	15.87	17.87	15.01	9.00
Cowpea shell II	11.10	13.10	12.20	3.70
G/Nut shell II	28.99	30.99	27.02	3.50

4.3 LIPID (ETHER EXTRACT)

Table 4.6: Ether extract tests on sample type I

Sample	P (W ₁)	P + S (W ₂)	Wt after (W ₃)	% Lipid
Cassava peel I	0.90	1.90	1.88	2.00
Yam peel I	0.84	1.84	1.83	1.00
Rice Husk I	0.77	1.77	1.76	1.00
Guineacorn Husk I	0.73	1.73	1.29	1.75
Cowpea shell I	0.92	1.50	1.48	3.45
G/Nut shell I	0.74	1.74	1.73	1.00

Table 4.7: Ether extract tests on sample type II

Sample	P (W ₁)	P + S (W ₂)	Wt after (W ₃)	% Lipid
Cassava peel I	1.90	2.90	2.82	8
Yam peel II	1.84	2.84	2.77	7
Rice Husk II	1.77	2.77	2.73	4
Guineacorn Husk II	1.73	2.73	2.26	4
Cowpea shell II	1.92	2.50	2.47	5.17
G/Nut shell II	1.74	2.74	2.71	3

Using 1g of sample

$$\% \text{ Lipid} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

4.4 Moisture Content

Table 4.8: Moisture Content Determination of Sample Type I

Sample	P (W ₁)	P + S (W ₂)	Wt after (W ₃)	% M C
Cassava peel I	32.16	37.16	35.98	23.60
Yam peel I	45.04	50.04	49.15	17.80
Rice Husk I	41.20	46.20	45.69	10.2
Guineacorn Husk I	30.13	35.13	34.88	5.00
Cowpea shell I	31.27	36.21	35.29	19.60
G/Nut shell I	27.40	32.40	31.96	8.80

Table 4.9: Moisture Content Determination of Sample Type II

Sample	P (W ₁)	P + S (W ₂)	Wt after (W ₃)	% M C
Cassava peel II	33.19	38.19	36.78	28.20
Yam peel II	46.06	51.06	49.77	25.80
Rice Husk II	42.24	47.24	46.59	13
Guineacorn Husk II	32.11	37.11	36.48	12.60
Cowpea shell II	32.17	37.17	36.22	19
G/Nut shell II	29.44	34.44	33.59	17

Table 4.10: Comparison between Moisture Content and Dry Matter of Both Samples

Sample	% M. C.	% Dry Matter
Cassava peel I	23.6	76.4
Cassava peel II	28.2	71.8
Yam peel I	17.8	82.2
Yam peel II	25.8	74.2
Rice Husk I	10.2	89.8
Rice Husk II	13	87
Guineacorn Husk I	5.0	95.0
Guineacorn Husk II	12.6	87.4
Cowpea shell I	19.60	80.4
Cowpea shell II	19	81
G/Nut shell I	8.8	91.2
G/Nut shell II	17	83

4.5 CRUDE FIBRE

Table 4.11: Crude Fibre Tests on Sample Type I

Sample	Wt of crucible (W ₁)	Wt of Sample (W ₂)	Wt after (W ₃)	% C. F.
Cassava peel I	14.65	2	14.99	17.00
Yam peel I	22.10	2	22.21	5.50
Rice Husk I	10.59	2	11.12	26.50
Guineacorn Husk I	11.70	2	12.67	48.50
Cowpea shell I	10.49	2	11.17	34.00
G/Nut shell I	15.67	2	16.31	32.00

Table 4.12: Crude Fibre Tests on Sample Type II

Sample	Wt of crucible (W ₁)	Wt of Sample (W ₂)	Wt after (W ₃)	% C. F.
Cassava peel II	16.65	2	16.74	19.00
Yam peel II	22.10	2	22.21	5.50
Rice Husk II	14.59	2	13.52	28.50
Guineacorn Husk II	10.70	2	11.88	47.50
Cowpea shell II	12.49	2	13.47	37.00
G/Nut shell II	16.67	2	17.91	34.00

4.6 Ultimate Analysis

Table 4.13: Ultimate Analysis Comparison for Both Samples

Sample	% N	% P	% S	% C	% H	% O2
Cassava peel I	1.12	0.19	0.014	1.9	0.18	0.024
Cassava peel II	1.26	0.14	0.011	1.7	0.23	0.028
Yam peel I	1.33	0.43	0.080	4.3	0.12	0.030
Yam peel II	1.61	0.8	0.018	4.5	0.18	0.037
Rice Husk I	1.05	0.37	0.124	3.7	0.21	0.180
Rice Husk II	1.33	0.46	0.090	4.0	0.27	0.170
Guineacorn Husk I	0.84	0.17	0.003	1.7	0.15	0.130
Guineacorn Husk II	1.05	0.16	0.002	1.9	0.16	0.120
Cowpea shell I	1.68	0.56	0.012	1.56	0.12	0.140
Cowpea shell II	1.75	0.43	0.008	1.65	0.13	0.160
G/Nut shell I	1.26	0.18	0.100	2.2	0.14	0.160
G/Nut shell II	1.26	0.18	0.090	2.1	0.16	0.180

4.7 Carbohydrate and Calorific Value (Energy content)

Table 4.14: Summary Showing Carbohydrate Content Sample I

Description of Sample	% Dry Matter	% Moisture Content	% Crude Protein	% Lipid or Ether Extract	% Crude Fibre	% Ash	CH ₀ or NFE
Cassava peel	76.4	23.6	7.0	2.0	17.0	5.5	44.9
Yam peel	82.2	17.8	8.31	1.0	5.5	9.5	57.89
Rice Husk	89.8	10.2	6.56	1.0	26.5	15.0	40.74
Guineacorn Husk	95.0	5.0	5.25	1.75	48.5	7.0	32.5
Cowpea shell	80.4	19.6	10.5	3.45	34.0	5.0	27.45
G/Nut shell	91.2	8.8	7.88	1.0	32.0	1.5	48.82

Table 4.15: Summary Showing Carbohydrate Content Of Sample II

Description of Sample	% Dry Matter	% Moisture Content	% Crude Protein	% Lipid or Ether Extract	% Crude Fibre	% Ash	CH ₀ or NFE
Cassava peel	71.8	28.2	7.88	8.0	19.0	5.5	31.42
Yam peel	74.2	25.8	10.06	7.0	5.5	10.5	41.14
Rice Husk	87	13	8.31	4.0	28.5	14.0	32.19

Guineacorn	87.4	12.6	6.56	4.0	47.5	9.0	20.34
Husk							
Cowpea shell	81	19	10.94	5.17	37.0	3.7	24.19
G/Nut shell	83	17	7.88	3.0	34.0	3.5	34.62

Table 4.15: Comparison in Calorific Value of Both Samples (KJ/g)

Sample	Calorific Value (KJ/g)
Cassava peel I	2256
Cassava peel II	2292
Yam peel I	2738
Yam peel II	2678
Rice Husk I	1982
Rice Husk II	1980
Guineacorn Husk I	1667.5
Guineacorn Husk II	1436
Cowpea shell I	1828.5
Cowpea shell II	1870.5
G/Nut shell I	2358
G/Nut shell II	1970

Akinbami et al (2001)'s assessment indicated that in Nigeria, identified feedstock substrate for an economically feasible biogas programme includes water lettuce, water hyacinth, dung, cassava leave, urban refuse, solid (including industrial) waste, agricultural residues and sewage. Akinbami et al (2001)'s views include the following; Nigeria produces about 227,500 tons of fresh animal wastes daily. Since 1 kilogram (kg) of fresh animal wastes produces about 0.03 m³ gas, then Nigeria can produce about 6.8 million m³ of biogas every day. In addition to all these, 20kg of municipal solid wastes (MSW) per capital has been estimated to be generated in the country annually. By the 1991 census figure of 88.5 million inhabitants, the total generated MSW will be at least 1.77 million tones every year. With increasing urbanization and industrialization, the annual municipal solid waste (MSW) generated will continue to increase. Biogas production may therefore be a profitable means of reducing or even eliminating the menace and nuisance of urban wastes in many cities by recycling them.

2.9 Agricultural Residues for Carbonization

Agricultural residues attract interest as carbonization raw materials because they are often available in large quantities around processing plants and appear difficult to utilize except as fuel. The use of these residues however is not without disadvantages for agriculture since using them this way removes organic and inorganic materials from the soil leading to impoverishment of farmlands and increasing the need for costly artificial fertilizers (Gale and Cambadella, 2000).

Except for nut shells agricultural residues are not a preferred raw material for charcoal making. Rather they are used because making them into charcoal seems to offer a method of realizing a profit on an otherwise useless waste material (Andrews, 2006).

The list of agricultural residues which can be considered for carbonization is long but the level of commercial success is limited to a few special cases. As mentioned the only attractive raw materials are the nut shells because of the high priced charcoal which they can produce (Gale and Cambadella, 2000).

The following list gives an idea of some of the various agricultural residues which have been considered as possible charcoal making materials.

- Nut shells and husks
- Residues from farm crop processing and canning
- Bamboo, scrub and cactus
- Garbage wastes
- Straw and reeds
- Processing residues from coffee, cotton and fruit canning

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials Preparation

3.1.1 Preparation for Sampling

One of the factors that can invalidate or make chemical analysis dependable is how representative the plant tissue collected is. Poor sampling could be misleading and result to incorrect diagnosis.

To obtain a representative plant tissue for analysis is very essential and at the same time, a complex task that requires skill. Therefore, the roles of sampling should be followed closely. They include:

3.1.2 Method Used to Collect Materials

All measurement was recorded by one person (Researcher). This was done to standardize the result. Sampling plan and collection involves both researcher and subject matter experts that analyzed the sample. The researcher and analyst agreed on the information that is needed and the intended use. This help the analyst to develop possible approaches for collecting the necessary data to fulfill the problem objectives and determine the economic consequences or risks associated with the sampling effort.

3.1.3 Material Collected for Sampling Analysis

The following materials were collected from different areas of Minna metropolis, Lapai, Agaie and Bida where agricultural cereals are produced. The waste materials of these agricultural cereals which are referred to as crop residues were collected for sampling. These crop residues includes thus:

Cassava Peel	Type I:	<i>Manihot palmata</i> (Sweet cassava)
	Type II:	<i>Manihot utilisima</i> (Bitter cassava)
Yam Peel	Type I:	<i>Dioscorea cavanensis</i> (Yellow yam)
	Type II:	<i>Dioscorea rotundata</i> (White yam)
Rice Husk	Type I:	<i>Oryza sativa</i> (Asian rice)
	Type II:	<i>Oryza glaberrima</i> (West African rice)
Guineacorn Husk	Type I:	<i>Sorghum bicolor</i> (Red)
	Type II:	<i>Sorghum bicolor</i> (White)
Cowpea Shell	Type I:	<i>Vigna unguiculata</i> (Ife Brown)
	Type II:	<i>Vigna unguiculata</i> (TVX)
Groundnut Shell	Type I:	<i>Arachis hypogea</i> (Running)
	Type II:	<i>Arachis hypogea</i> (Erect / Bunchy)

3.1.4 Sample Preparation for Analysis

Handling procedures after sample collection is noted to be greatly influenced by the type of analysis required, the nature of material contamination on the surface, distance of collection and the environment. Since biochemical analysis is required, hence there was the need to prevent or reduce biochemical activities of the tissue which are still alive and respiring.



Plate 3: Cowpea shell after drying to 19% M.C.

Samples on collection may require aerated containers or placed in water to keep the cells alive. The shorter the lapse of time between sample collection and analysis, the more reliable the analytical results. Samples collected for chemical analysis undergo the following major preparatory steps before analysis:

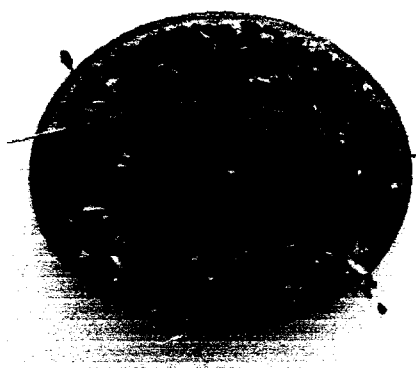


Plate 4: Guineacorn husk after drying to 12% M.C.

3.2 Methods

The samples were subjected to method of Association of Official Analytical Chemists (A.O.A.C. 1984).

3.2.1 Drying

Most chemical analysis are expressed on dry matter bases, therefore after washing, plant samples collected was dried as quickly as possible, this reduced further chemical or biological changes. Drying at 65⁰C is considered ideal to stop enzyme reactions but temperature up to 80⁰C was employed.



Plate 5: Groundnut shell milled after drying to 19% M.C.

The sample is placed in hot air oven and dries until the mass is constant. The period required depend on the nature and quantity of plant tissue. Low temperature of 65 – 80⁰C has minimal effect on loss of volatile nutrients such as nitrogen. High temperature can cause volatilization

and result to complexing of carbohydrates and protein into lignin. Very low temperature may not stop reaction of enzymes immediately.



Plate 6: Milled cassava peel after drying to 24% M.C.

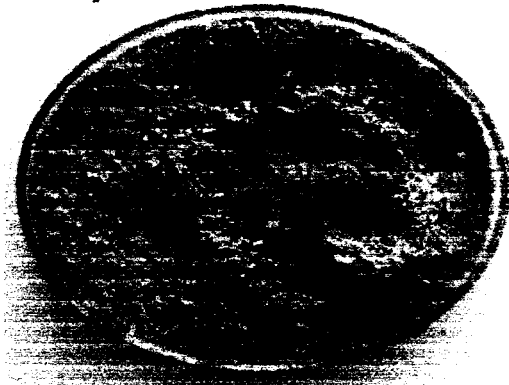


Plate 7: Rice husk after drying to 19% M.C.

3.2.1 MOISTURE CONTENT

The determination of moisture content is one of the most important and widely used measurements in samples that absorb and retain water. Chemical analysis are normally made on dry matter basis. Moisture content determination look very simple in concept, but in

4.8 Proximate Analysis

The results obtained for crude protein of both samples are presented in Tables 4.1 and 4.2 respectively. Table 4.3 presents the comparison of the Nitrogen contents of both sample type I and II. In Nitrogen analysis of type I, Guineacorn husk has the lowest Nitrogen of 0.8 and Cowpea shell has the highest of 1.68 and the same is observed for type II both values of 1.05 and 1.75 respectively.

The percentage Ash is presented in Tables 4.4 and 4.5 respectively; while the result for the percentage Lipid (i.e. Ether Extract or Crude Fat) are presented in Tables 4.6 and 4.7 for sample type I and type II respectively.

Tables 4.8 and 4.9 presents the moisture content as received by all the waste samples and was revealed that Cassava peel has the highest moisture content of 23.6% and 28.2% for both types, while Guineacorn has the lowest of 5% and 12.6% respectively. The moisture content of others are 17.8%, 10.2%, 19.6% and 8.8% in type I and 25.8%, 13%, 19%, and 17% in type II for Yam peel, Rice Husk, Cowpea shell, and Groundnut shell respectively. Table 4.10 presents the comparison between moisture content and Dry matter of both wastes samples. These compare well with the typical proximate analysis of fruits and other agricultural wastes that have been reported in Literatures (Kranzler and Davis 1981, Ledward et al, 1983). The comparative high moisture content in these biomass indicated that they would have to be dried so that they could easily burn off when used as sources of heat

The crude fibre of the waste specimen varied in both types from 48.5% and 47.5% for Guineacorn Husk exhibiting the highest and 5.5% for Yam peel in both samples having the lowest. Other results are 17% and 19% for Cassava peel, 26.5% and 28.5% for Rice Husk

34% and 37% for Cowpea shell, while that of Groundnut shell are 32% and 34% respectively as presented in Tables 4.11 and 4.12

4.9 Ultimate Analysis

The Nitrogen contents as presented in Table 4.3 varies between 1.12 and 1.26 for Cassava peel, 1.33 and 1.61 for Yam peel, 1.05 and 1.33 for Rice husk, 0.84 and 1.05 for Guineacorn husk, 1.68 and 1.75 for Cowpea shell and; 1.26 for both types in Groundnut shell.

The Sulphur content for types was observed to fall below 1% in all the samples analyzed which mitigates the emission of Sulphur dioxide (SO₂) into the atmosphere. Sulphur content are way too low than the energy content which I referred to as the Energy content of the wastes samples.

The Phosphorus content of the two types of six specimens varied between 0.19% and 0.14% for Cassava peel, 0.43% and 0.38% for Yam peel, 0.37% and 0.42% for Rice husk, 0.17% and 0.16% for Guineacorn husk, 0.56% and 0.43% for Cowpea shell, and while that of Groundnut shell are 0.18% and 0.17% respectively.

The Carbon content of the waste samples also varied between 1.9% and 1.7% for Cassava peel, 4.3% and 4.5% for Yam peel, 3.7% and 4.0% for Rice husk, 1.7% and 1.9% for Guineacorn husk, 1.56% and 1.65% for Cowpea shell, and lastly Groundnut shell have 2.2% and 2.1% respectively.

The Hydrogen content is observed to fall below 1% in all samples. The variations visible include 0.18% and 0.23% for Cassava peel to that of Groundnut shell to be 0.14% and 0.16%.

Finally, from the Ultimate Analysis presented in Table 4.13, the Oxygen (O₂) content is observed also to fall very low than 1% in all the waste samples analyzed.

4.10 Carbohydrate and Calorific Value

The carbohydrate content is presented in both Tables 4.14 and 4.15 respectively for both types. It varies from 44.9% and 31.42% for Cassava peel, 57.89% and 41.14% for Yam peel, 40.74% and 32.19% for Rice husk, 32.5% and 20.34% for Guineacorn husk, 27.45% and 24.19% for Cowpea shell, while 48.82% and 34.64% were observed for Groundnut shell.

The Energy potential in all the waste samples observed is presented in Table 4.15. With Yam peel having the highest heat content of 2738KJ/kg and 2678KJ/kg. Guineacorn husk produced the lowest heat content having 1667.5KJ/kg and 1436KJ/kg respectively for both types of samples. Others include 2256KJ/kg and 2292KJ/kg for Cassava peel, 1982KJ/kg and 1980KJ/kg for Rice husk. 1828.5KJ/kg and 18705KJ/kg were obtained for Cowpea shell while finally Groundnut shell have 2358KJ/kg and 1970KJ/kg respectively.

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Study shows that agricultural wastes (crop residues) are strategic component material in energy production and other use which include animal feeding, construction material, cooking fuel and mulch remaining in the field (sometimes burnt).

In the evaluation all these agricultural wastes (crop residues), Sulphur content of all the samples fall below 1% and this is good for combustion since good fuel are known to exhibit low Sulphur content characteristics.

All wastes samples considered have heat values greater than some well known biomass fuels and falls within the limit for the production of steam in electricity generation which can be greater advantage to the country at large.

Recent interest in bio-fuel production exacerbates further the pressure on biomass production system. The tradeoffs between different uses of crop residues could be observed which include variation between leaving the crop residues on the field to improve soil productivity (nutrient balance, erosion control, and soil health) and production of bio-fuels, bio-ethanol, energy production (i.e. generation of electricity), feeding to animals, and consumption by humans.

Finally, the low composition of Nitrogen in virtually all the samples analyzed will result in low emission of oxides of Nitrogen into the atmosphere and there may not be the need for equipment for the removal of Nitrogen oxides in the design equipment for the conversion of this crop residues to energy in and around of Minna Niger State.

5.2 Recommendation

The following are to be considered for action

1. Local agriculturist should be encouraged to develop a habit of producing these agricultural wastes and transporting it to where they can be used or converted for further use
2. State government should be advised to turn attention to this opportunity of converting wastes into further use and thereby establishing industries in respect to energy production from wastes as supplement to their power generation capacity since the State is popularly know as "Power State".
3. Support should be provided by the Federal government to enable the establishment of the industry in a very large scale with respect to power generation from agricultural waste as this is done I the developed world.

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APPENDIX

1. Calculating for % Crude Protein

% C. P. = Nitrogen x Protein Conversion factor;

$$\text{And Nitrogen} = \left[\frac{\text{TV} \times \text{NCF} \times \text{MA} \times \text{DF} \times 100}{\text{Wt of Sample}} \right] \times \text{PCF}$$

Where:

T.V. = Titre value,

NCF = Nitrogen Conversion

Factor

M.A. = Molarity of Acid used;

D.F. = Dilution Factor

Wt of sample = Weight of sample.

N.B: NCF = 0.014; AND PCF = 6.25

2. % Ash is calculated as

$$= \frac{\text{Crucible+Sample after hatching} - (\text{wt of crucible})}{(\text{Crucible+Sample}) - (\text{wt of crucible})}$$

$$= \left(\frac{C-A}{B-A} \right) \times 100 \quad \text{Weight of sample being 2g used.}$$

3. Using 5g of sample

% Moisture content is given as follows

$$\begin{aligned} \% \text{ M. C.} &= \frac{(P.d.+Sample)-(wt \text{ after})}{(P.d.+Sample)-(wt \text{ of P.d})} \times 100 \\ &= \frac{W_2-W_3}{W_2-W_1} \end{aligned}$$

Where

W_1 = Weight of P.d.

W_2 = Weight of P.d. + Sample

W_3 = Weight of P.d. after

P.d. = Wt of filter paper

4. % Crude Fibre is given as

$$\% \text{ C. F.} = \frac{W_w - W_1}{W_2} \times 100$$

5. Carbohydrate ($C_6H_{12}O_6$ or N. F. E.) is determined by adding % Moisture Content, % Crude Protein, % Lipid or Ether Extract, % Crude Fibre and % Ash all together and subtracting from 100.

$$C_6H_{12}O_6 = 100 - (\%M.C. + \% C.P. + \% \text{ Lipid} + \% C.F. + \% \text{ Ash})$$