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Assessment of Waste Management Techniques from Palm Oil Producing Industry: A Case Study of Nigerian Institute for Oil Palm Research (Nifor) Benin City

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***Abstract*- Oil palm (Elaeisguineensis) is one of the most important economic oil crops in Nigeria. As of early 1900, Nigeria was producing all palm oil sold in the world market. Nigerian Institute for Oil Palm Research (NIFOR) is an International Center of Excellence in Palms and Shea Research and Development. It is a common sight to see decayed and overflowing solid and liquid waste dumps all over most palm oil producing industries. The objective of this study is to assess the technique for waste management in NIFOR. Primary data through interview and secondary data from literatures and periodicals were used. The survey reveals that most wastes generated are converted into useful means. The POME (Palm oil mill effluent) is converted into organic fertilizer through the process of composting, the EFB (Empty fruit bunch) is used for erosion control and for increasing soil water retention capacity, and the PKS (Palm kernel shell) is used as a source of fuel for boilers and sterilizers. It is therefore recommended that the government and management of NIFOR should increase environment awareness programme for all staff to save cost and create less environmental degradation while vigorously involving the people in all facets of environmental management.**

***Keywords:-* PEPSA, Solid waste, Dumpsites, Disposal, Municipal, Human health, Waste collection.**

I. INTRODUCTION

Oil palm (Elaeisguineensis) is one of the most important economic oil crops in Nigeria. According to World Rain forest Movement, oil palm is indigenous to the Nigerian coastal plain though it has migrated inland as a staple crop. Cultivation of oil palm serves as a means of livelihood for many rural families and indeed the farming culture of millions of people in the country. Oil palm is made of essential components, namely; the fronds, the leaves, the trunk and the roots which are used for several purposes ranging from palm oil, palm kernel oil, palm wine, broom, and palm kernel cake (PIND, 2012).

As of early 1900, Nigeria was producing all palm oil sold in the world market and it was considered a dominant source of foreign exchange. Up until the 1960s, Nigeria was the world’s largest producer of palm oil accounting for 43% of global palm oil production. Over-reliance on traditional production methods, excessive tapping of palm trees for palm wine and the civil war between 1967-1970 are factors that contributed to Nigeria’s inability to meet up with the global rise in demand for palm oil. The Nigerian oil palm belt covers twenty-four states, including all nine states of the Niger Delta (AkwaIbom, Abia, Rivers, Edo, Imo, Ondo, Bayelsa, Cross River and Delta). Within the oil palm belt in Nigeria, 80% of production comes from dispersed smallholders who harvest semi-wild plants and use manual processing techniques. Several million smallholders are spread over an estimated area ranging from 1.65 million hectares to 2.4 million hectares and to a maximum of 3 million hectares. The estimate for oil palm plantations in Nigeria ranges from 169,000 hectares (72,000 ha of estate plantations and 97,000 ha of smallholder plantations) to 360,000 ha of plantations. Many of these plantations mentioned above are the result of past attempts by the Nigerian government to establish large scale plantations, most of which resulted in complete failures. Examples of such failed efforts are the Cross River State project in 60's and of the European Union funded "Oil palm Belt Rural Development Programme" in the 90's. This effort included the ambitious plantation of 6,750 hectares of oil palm within an area thought to be one of the largest remnants of tropical rainforest in Nigeria under the management of Risonpalm Ltd, partly owned by the government. (PIND, 2012).

Nigerian Institute for Oil Palm Research (NIFOR), was formerly known as West African Institute for Oil Palm Research (WAIFOR). NIFOR is an International Center of Excellence in Palms and Shea Research and Development. The Institute has varied and enormous infrastructure and has made a considerable impact over the years since its establishment in 1939, through Research, Development, and Extension Support for the Nigerian palms industry. NIFOR enjoys substantial international standing as a major world centre in oil palm research. The Institute's achievements and reputation derive from its highly trained scientific staff, a well-established experimental station infrastructure with functional facilities, and a tradition of scholarship and relevant research. Having such credential among oil palm producing factory over the years, one should expect large mass of solid and liquid wastes that are generated during the processing and handling operations which might pose a great treat to the health of the staff and indwellers of the research institute.

Wastes can be defined as substances produced in our daily activities which are unwanted and no longer useful to man. These substances must be handled and disposed with care, so that they do not constitute danger to public health. Waste however could be said to be relative especially in the manufacturing and production sectors. What is regarded as waste to certain group may be regarded as raw material to another group. The system of waste salvaging, reclaiming or recycling though objectionable and often economically unsound, is fast gaining ground in most cities today (Bisong and Ajake, 2001).Waste can be classified according to their origin or source, chemical composition, appearance, texture or location. Conventionally, however waste can be grouped into two major categories: Solid and Liquid waste (Osinem, 2005). Waste generation and its management has become a major issues in urban areas because of the increasing gap between the prolific level of generation and the limited technology and capacity of evacuation (Bisong and Ajake, 2001).

Waste management is the collection, transport, processing, recycling or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is also carried out to recover resources from it. Waste management can involve solid, liquid, gaseous or radioactive substances, with different methods and fields of expertise for each. Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator (Osinem, 2005).

The import of waste management is its consequences for public health and wellbeing, the quality and sustainability of the urban environment and the efficiency and productivity of the urban economy. Most Nigerian cities are not able to provide and efficient waste management system for its population. A large percentage of the urban population do not have access to waste collection services and only a fraction of generated wastes in these cities is actually managed in real terms. Where these exist, collection is haphazard in terms of space, time and frequency of collection.

A flow chart for oil palm processing is shown in figure 1.1 This comprises sterilization stripping, digestion and pressing, clarification, purification, drying and storage.

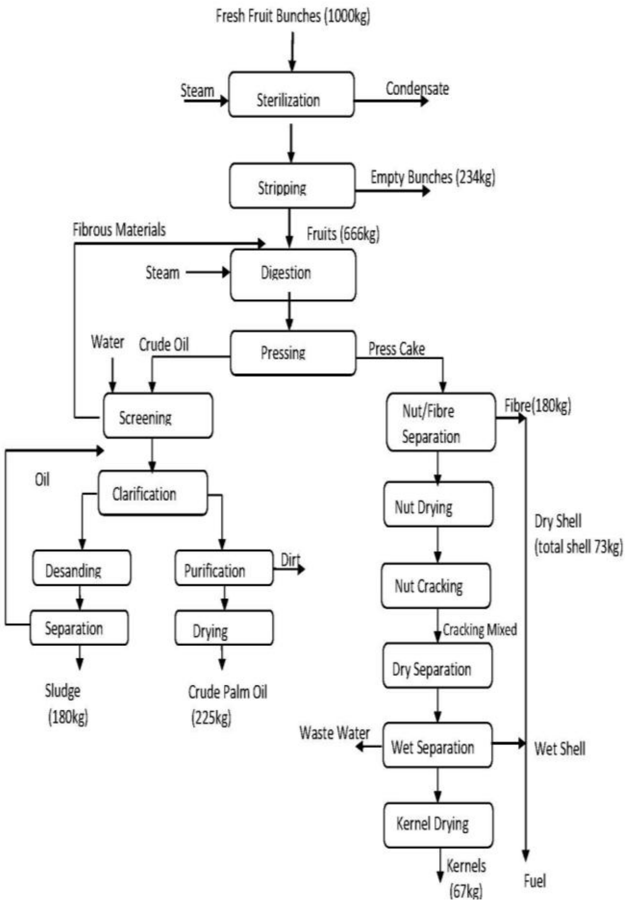

Fig 1. Flow Chart for Oil Palm processing
(Source: Sivasothy, 2006).

NIFOR remains one of the largest palm oil producers in Nigeria. It is a common sight to see decayed and overflowing solid and liquid waste dumps all over most palm oil producing industries. This study therefore seeks to understand the techniques of waste management in NIFOR and to make recommendations and suggestions for future waste management and control. The objectives of this study is to assess the technique for waste management in NIFOR.To explore ways waste management can be turned into lucrative venture and be made more attractive.Cleanliness according to the popular adage is next to godliness. Most of the diseases people in our society suffer today are as a result of dirty environment which often is as a result of improper refuse disposal.

Hence the significance of a study like this cannot be overstressed. The study of waste management in NIFOR will yield information which to achieve a safe working environment free of toxic and harmful substance capable of polluting the air, surface and ground water and also the farm lands NIFOR. The public and individuals will benefit from the study because the study will reveal their role in maintaining clean and healthy environment.

II. MATERIALS AND METHODS

1. Study Area:

Nigeria Institute for Oil Palm Research (NIFOR) is the major oil palm plantation in Nigeria, with its main station consisting about 1735 ha land area located near Benin City about 29km from the city centre, off Benin-Akure Road as shown in figure 1. NIFOR is located on the southern part of Nigeria, with its coordinates of 6.56017o N and 5.62372o E. It's located at the outskirt of Benin City (along the Benin-Akure road). Edo state (6o38N, 5o30E) in the rain forest belt of the humid tropics, the topography of the location is partly flat with few hills to the east and north-east, about 400-450 m above sea level. The climate of the region is characterised with daily temperature which ranges from 26oC to 32oC and annual rainfall of about 80 120 cm for most part of the year. Weather information from metrological report reveals the weather conditions does not conform to any regular annual regime. However, there are two distinct seasons in this region; the rainy season and the dry season lasting from April - September and October - March respectively (Ugbah and Nwawe, 2008).

Fig 2. Google Image of NIFOR.
Source: www.googleearth.com

2. Method of Data Collection:

The method for the collection of data for this research work are primary through interview with ten (10) staff of NIFOR comprising of 5 management staff and 5 technicians. Other information was obtained from already published works which are duly acknowledged in this articles. Both are extensively used for the purpose of drawing an empirical conclusion on analysis of data so as to come up with fairly objective findings.

3. Methods of Data Analysis:

Subsequent upon the acquisition of relevant information about waste management, disposal and control in NIFOR, the information obtained was used to draw conclusion and discussion about the extent of waste management in NIFOR and the possible improvements needed.

4. Theoretical Framework:

By way of analyzing the statement of the problem in (section 1.2 of chapter one) this study makes use of industrial ecology theory according to Pongracz (2006). This theory is a unified body of knowledge about waste and waste management and itis founded on the expectation that waste management is to prevent waste from causing harm to human health and environment and promote resource optimization. Industrial ecology theory when applied in manufacturing involves the design of industrial processes and products from dual perspectives of products competitiveness and environmental interaction.

It is a system oriented vision built on the principle that industrial design and manufacturing process are to be considered in operatorship with the environment.This is what sustainable waste management needs to grow into. Embracing the principle of Industrial Ecology, Waste Management Theory will be instrumental in optimizing resource use.

III. RESULTS AND DISCUSSIONS

1. Findings from Field Survey

Any palm oil processing industry striving for relevance and sustainability must face and address the challenges of proper waste disposal/management techniques in its operations to avert harm to the environment and health of the community hosting the palm oil mill (POM) Mahzadet al., (2009).

From field survey it was gathered that NIFOR produces two major products from the processing of Fresh Fruit Bunches (FFB) namely Crude Palm Oil (CPO) and Crude Palm Kernel Oil (CPKO). CPO is obtained from the mesocarp and CPKO is obtained from the endosperm (kernel). The production of these primary products generates waste by-products.These wastes constitute about 70-75% of the FFB and are mainly in the form of the Empty Fruit Bunches (EFB), Oil Palm Shell (OPS), Palm Fibre, Palm Oil Mill Effluent (POME) and sterilizer condensate. Waste management in NIFOR involves the collection, transport, processing, recycling or disposal and monitoring of waste by-product with an ever increasing concern about reducing the negative impact of human activities on the environment. The following are the wastes generated from NIFOR and the techniques for managing them:

2. Palm Oil Mill Effluent (POME):

The process of FFB into CPO produces a large amount of organic slurry waste called palm oil mill Effluent (POME) shown in Plate1. It is the largest Palm Oil industry by product, a colloidal suspension containing 95-96% water, 0.6-0.7% of oil and grease and 4-5% of total solids. It is thick, brownish in colour, liquid with a discharged temperature of between 80-90oC, being fairly acidic with a PH value of 4.0-5.0.POME is rich in energy and nutrients. In NIFOR the nutrients are excellent substitutes for inorganic fertilizers. They are recycled as manure. One technique known as Complete Stirred Tank Reactor (CSTR). The equipment uses microorganisms to digest the organic substance in POME in an airless environment.

Fig 3. Plate 1: Palm Oil Mill Effluent.
(Source: Field Survey 2016)

The POME in NIFOR is converted into organic fertilizer through the process of composting, the composting pit shown in plate 2 are used for the anaerobic digestion before they are transferred to the field and mixed with soil to provide nutrients and to serve as soil conditioner.

Fig 4. Plate 4.2: Palm Oil Mill Effluent
(Source: Oviasogieet al., 2013)

The use of organic fertilizers will provide an environmentally friendly, naturally sustainable, safe and affordable means for maintaining soil fertility and increasing crop production. It will also lower the cost on the importation of inorganic fertilizers. This will ensure food security and improve the standard of living of Nigerians.

3. Empty Fruit Bunches, EFB:
Empty Fruit Bunch shown in Plate 3 is one of the by products in processing of FFB in NIFOR. EFB besides being rich in plant nutrients, also improve soil physical and chemical properties in these ways;

- Increases soil organic matter content.
- Improve soil structure.
- Increase infiltration and aeration.
- Reduces run-off.
- Improve - soil water – retention.
- ncreases soil fauna micro-activities.

There are three approaches to managing EFB in NIFOR

- Composition
- Incineration
- Dumped or land filled.

Fig 5. Plate 3: Empty Fruit Bunches (EFB)
(Source: Field Survey 2016)

4. Oil Palm Shell (OPS):
The palm kernel shell shown in plate 4 is also used as a source of fuel for boilers in NIFOR. Unfortunately, the shell contains silicate that form a scale in the boilers if too much shell is fed to the furnace, thus limiting the amount of shell utilized in the boilers. Residual shell is disposed of as gravel for road maintenance and erosion control. According to information gathered from staff of NIFOR Blacksmiths also buy shells to use as fuel material in casting and forging operations. OPS have also been used in the construction industry to develop light weight concrete. Research shows that concrete using Oil Palm

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Shell (OPS) as coarse aggregate has been found useful as structural concrete.

Fig 6. Plate 4: Palm Kernel Shell
(Source: Field Survey 2016)

5. Fibre:
The fibre recovered from the nut/fibre separation is a good combustible material and finds uses as boiler fuels. Palm fibre constitutes bulk material used to fire large boilers to generate superheated steam to drive turbines for electrical power generation in large scale plants. The ash from burnt fibre is recycled as fertilizer and factory floor cleaning agent whereby the potash in the ashes reacts with oil to form weak potash soap washed away with water. The fibre is used as biomass for the boiler/sterilizer shown in Plate 5.

Fig 7. Plate 5: Boiler/Sterilizer
(Source: Field Survey 2016)

6. Processes Being Used to Turn Waste into Energy:
In a very basic sense, biomass energy generation takes what we don't want—by-products from various sources including timber, sugarcane, woody plants, algae, agricultural residue and even municipal and industrial waste—and turns it into something we DO want; energy. The recovery of energy from waste has developed over the years from the simple incineration of waste in an uncontrolled environment to the controlled combustion of waste.

Conversion technologies range from releasing energy directly, in the form of heat or electricity, or conversion to another form like liquid biofuel or combustible biogas. Figure2 The flow chart below high lights the major biomass conversion technologies, their range of feedstock, and major fuel products for power and heat utilization.

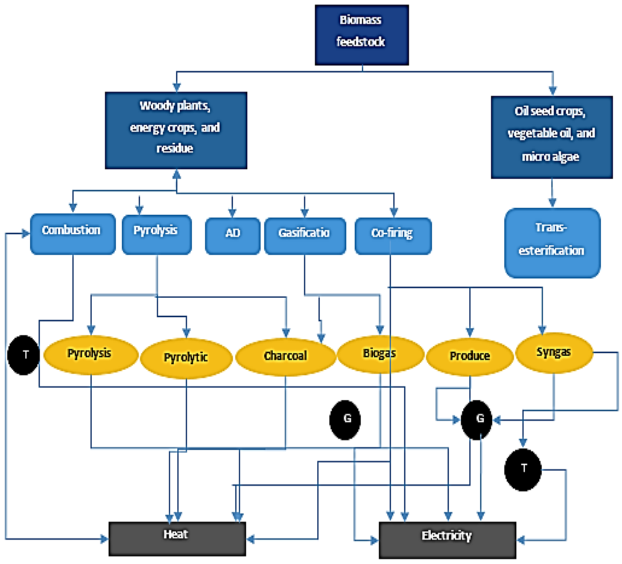

Fig 8. The major biomass conversion technologies.
Source: http://www.technavio.com

7. Five emerging biomass technologies:
There are a number of different techniques and techno logies involved in turning waste into usable energy.

7.1 Direct combustion:
Direct combustion is the simplest and the most traditional way of generating electricity from biomass.It works by burning biomass in boilers, which produces high-pressure steam. This steam rotates the turbine connected to the generator and ultimately produces electricity. Most biomass power plants use direct combustion to generate electricity, and the steam from the plants is also captured to heat water and buildings, which are commonly known as co-generation facilities. Direct combustion systems normally achieve thermal efficiencies of around 20%. These efficiencies can be increased through co-generation.

7.2 Co-firing:
Co-firing includes the burning of biomass along with coal in traditional power plant boilers. This technology is one of the most economical ways to produce electricity from biomass because existing power plant equipment can be used without major alterations. Some coal-fired power plants in North America use co firing to reduce coal consumption and lower carbon dioxide, sulphur dioxide, and nitrogen oxide emissions. Co-firing allows biomass to be converted to electricity at a higher thermal efficiency ranging from 33% to 37%.

7.3 Gasification:

Thanks to the development of new technologies, biomass can now be gasified to produce an energy source. This works by heating solid biomass at high temperatures in the absence of oxygen to produce a fuel gas that contains one fifth to half the heat content of natural gas. Fuel gas can be used to drive combined cycle systems to generate electricity.This process is twice as efficient as burning biomass directly and results in fewer particulate matter emission and greenhouse gases. Gasification systems can also be combined with fuel cell systems, which convert hydrogen gas to electricity and heat.

7.4 Pyrolysis:

Pyrolysis is a part of gasification systems. In this process, the partial combustion takes place at a temperature of 842F-1112F, which results in the formation of a liquid bio-oil as well as gaseous and solid products.The pyrolysis oil can be used as a fuel to produce electricity, and the remaining solid is a charcoal-like residue known as char. The bio-oil can then be burned like petroleum to generate electricity while the char can be used for heating.

7.5 Anaerobic digestion:

Anaerobic digestion transforms biomass feedstock with a relatively high moisture content into biogas. The process relies on certain kinds of bacteria to break down organic material in the absence of oxygen and produce biogas as a waste product. Anaerobic digestion is a naturally occurring procedure and can be harnessed to treat organic material such as energy crops, residues, and wastes from industrial and agricultural processes and municipal waste streams. These materials, when buried, are digested by bacteria, resulting in biogas (landfill gas) rich in methane. This gas is collected and used to heat buildings, run engines, and generate electricity.

Table1.Below gives a comparative analysis of the different technologies for biomass power generation considering various parameters.

Biomass to power conversion technology comparison

Parameter	Combustion	Anaerobic Digestion	Gasification	Pyrolysis
Resource	Mainly solid biomass	Wet biomass	Mainly solid biomass	Mainly solid biomass
Raw materials	Wood logs and chips, agricultural residues, and energy crops	Manure and sewage sludge	Wood chips and pellets and agricultural residues	Wood chips and pellets and agricultural residues
Technology status	Commercial	Commercial	Commercial	Demonstration
Temperature (°F)	1292-2552	Not applicable	932-2372	716-986
Pressure (MPa)	> 0.1		> 0.1	0.1 - 0.5
Drying	Not essential, but may help	Not essential	Necessary	Necessary
Advantages		A very effective method of treating organic wastes with high moisture content. This is very useful for waste management with biogas as a valuable by-product.	This technology can have electrical efficiency up to 50% with 25% efficiency small-scale applications. Gasification technology is more useful for small-scale applications as there is no available efficient technology for solid biomass for power production.	The main product of this technology is a liquid with high energy content and easy to store and transport. This can be used for different purposes

Source: http://www.technavio.com.

IV. CONCLUSIONS

The survey reveals that the staff of NIFOR understands the need to have a clean environment as well as the challenges that might occur if the opposite were the case. The collection and final disposal of waste is fast overwhelming. Steady increase in waste variety and quantity coupled with their present waste management system calls for encouragement and praise for the staff of NIFOR.A comprehensive assessment approach is essential towards improving the existing strategy, establish the performance of present strategy and improve the knowledge base through provision of information to stake holders and creating a platform for discourse. Virtually all wastes both solid and liquid generated are converted into other useful products, the liquid wastes mixed with other substrates becomes bio-fertilizer for crop production and the solid waste is used as either biomass or for erosion control around the environment.

V. RECOMMENDATIONS

Based on information obtained from the field survey and interview. The following recommendations will go a long way to help maintain or improve the management of solid and liquid wastes in NIFOR.

1. Government should provide affordable and sustainable technology for proper recycling solid and liquid wastes in NIFOR.
2. Waste recycling plant should be established in NIFOR, this will go a long way to encourage the conversion of all the wastes into useful end products.

3. There should be a total implementation of laws for production of waste minimization products by agro allied and other industries.
4. The management of NIFOR should increase envir onment awareness programme for all staff which is a great avenue to save cost and create less environ mental degradation through attitudinal change while vigorously involving the people in all facets of envi ronmental planning and management.

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