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Sustainable Oil Palm Waste Management in Engineering Development

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Abstract
Managing wastes from oil palm industry encompasses environmental impacts of the palm oil manufacturing process and waste water generated; which are mainly decanter cake, empty fruit bunches, seed shells and fibre from mesocrap. Hence there is an urgent need for a sustainable waste management system to tackle this waste. As these wastes are organic in origin, they are rich in plants nutrients, Air pollution, climate change, liquid wastes as Crude Oil (CPO), Crude Palm Kernel Oil (CPKO), Palm Oil Mill Effluent (POME) and Solid Waste, Empty Fruit Bunches (EFB), Oil Palm Shells (OPS), Oil Palm Fibre (OPF) were studied. The specimens used were the waste by-products of the oil palm industry unto which the high technological waste-to-energy managements were carried out. The various ways the wastes can be put to use especially in terms of energy generation, fuel substitutes in the boilers environmental management systems with regards to Biological Oxygen Demand (BOD) and Suspended Solids (SS) were reviewed. The paper discussed problems posed by the waste-by-products, various aspects of waste management practices cum the impacts their-in.
Keywords: Managing Wastes, Oil Palm, Industry,Energy Generation,Climate change

INTRODUCTION

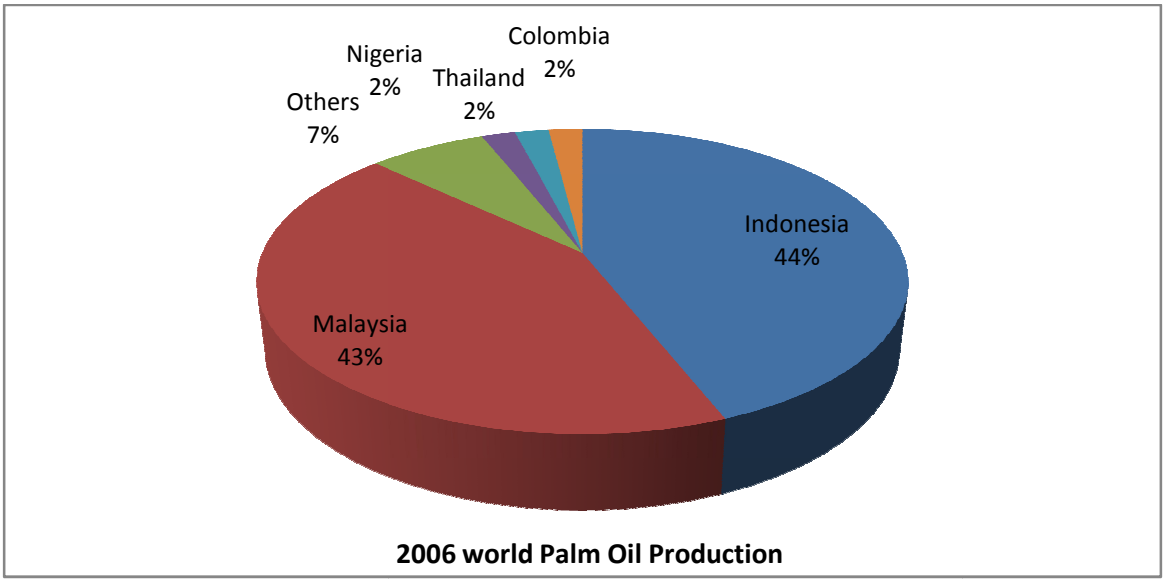
Any palm oil processing industry striving for relevance and sustainability must face and address the challenges of proper waste disposal/management techniques in its operations to avert harm to the environment and health of the community hosting the palm oil mill (POM)Mahzad et al (2009). The oil palm (Elais Guineensis) processing industry is no exception. The palm oil industry 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. A well engineered waste management scheme will enable the POMs if the waste is processed to generate energy or other useful products and above all reduce the release of harmful waste product to the environment Yusoff (2006).
The world's major dealers on palm oil industry are Malaysia and Indonesia, both contributing about 90% of the world total palm oil production together with the concomitant palm oil waste. Traditionally, these waste products have been disposed in water outlets, landfills or used as compost. The various management systems especially waste-to-energy as it pertains to palm oil will be reviewed and discussed Yusoff (2006).

PRODUCTION DATA

Prior to 1977, Nigeria was the world's largest producer and exporter of crude palm oil; however, following Malaysia government aggressive agricultural diversion programme in 1977, Malaysia became the largest producer and exporter of CPO. Nigeria became less of a player in the palm oil industry as the government focus changed from cash crop export to petroleum product export. Malaysia held this leading role in production and exportation of CPO until in 2006 when Indonesia surpassed Malaysia and became the world's largest producer of CPO. Indonesia is projected to maintain this position for quite a while UNDP (2006).

Figure 1: 2006 World Palm Oil Production Table

COUNTRY	%	TONS (000)
Indonesia	44	15900
Malaysia	43	15881
Others	7	2718
Thailand	2	820
Nigeria	2	815
Colombia	2	711



Data shows that Indonesia Palm Oil Production increased by over 400% between 1994-2004 and in 2006, it surpassed Malaysia as the top producer of palm oil. Indonesia CPO production has increased by almost 160% since 2000 to 18.1 million tones and Malaysia production has increased by more than 60% to 17.7 million tones World Growth (2009).

Forecast shows that the demand for palm oil will double reaching 40.5 million tons by 2020. This level of production can only be achieved by palnting 1.160 new square miles every year for the next 20 years. Majority of this production will take place in Indonesia, because Malaysia has already established palm plantations in much of its former rain forest. According to Indonesia's agriculture minister, Indonesia is planning to expand oil palm plantations to an additional 26,000 square miles largely taken from forests, compared to 2003 where 12000 square miles of Indonesia plantation were harvested WHO (2003).

From the above diagram, it can be seen that about 90% of the world palm oil production are produced in Malaysia and Indonesia combined. It is logical to claim that about 90% of the palm oil waste is generated in these two countries UNDP (2008).

PALM OIL INDUSTRY WASTES.

The processing of FFB results in the production of solid and liquid wastes that contaminate the soil and ground water and also in the emissions of harmful gases. POMs produce significant amount of biomass waste and generate large quantities of waste WHO(2003). Waste water can be categorized as a major problem, since the production requires a high amount of water in various processes and it produces high levels of Biological Oxygen Demand (BOD) and Suspended Solids (SS). For every 1tone of Fresh Fruit Bunch (FFB), it produces 1.5 /nm3 of Particulate Matter (PM). Hence, for a typical 500, 000 tones of CPO, it may require the burning of 17,5000, 000 tones of FF8. This may result in the production of pollutant of 1to 1.5 tonnes particulate matter to atmosphere per mill. The total amount of particles emitted by 309 palm oil mills in Malaysia is then about 154.500 tonnes in a day. Over an extended period of time, these levels of pollution will certainly threaten the lives of humans, animals, plant, and buildings, Mannah and Ganapathy (2004). Black smoke from palm oil mill contains various pollutant gases and materials such as Nitrogen Dioxide (N02). Carbon Monoxide (CO). Particulate Matter (PM) and Sulphur Dioxide (SO2), which gives various effect to humans and environment. Other side effects of black smoke include the interruption of air and sea transportation and traffic services. Air pollution also directly brings bad effects to the economy. It tends to raise the expenditure for health care and increases the cost needed to cover the work lost due to illness damage to agricultural crops, buildings, tourism industry and paints among others Sergeant(2001).

Table 1: Palm Oil Mill's Waste Water Characteristic Composition of fresh ripe fruit and mesocarp %-dry weight

Fruit	Dry weight	Mesocarp	%
Palm Oil	29	Palm Oil	46-50
Water	27	Palm Oil (Dry Basis)	77-81
Residue	8	Moisture	36-40
Shell	30	Non-fatty Solid	13-15
Kernel	6		

Availability of fresh and dry weight of EFB, Shell, fibre and effluent in tons per hectare per year after milling from 1 ha of mature palms.

Tons per Ha	1Ha of mature Palms Plantation	
	Fresh wt. (t/ha/yr)	Dry wt. (t/ha/yr)
FFB	20.08	10.60
EFB at 22% of FFB	4.42	1.55
Fibre 13.5% of FFB	2.71	1.63
Shell 5.5% of FFB	1.10	1.10
1. Sterilizer Condensate 12%of FFB	2.41	1.12
2. Clarification sludge 50% of FFB	10.04	0.50
3. Hydrocyclone washing 5% of FFB	1.00	0.05
TOTAL POME	**13.45**	**0.67**

PALM OIL INDUSTRY WASTE MANAGEMNENT

Waste management encompasses the totality of activities which involves 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. National and International leaders are putting policies in place to ensure that industrial activities does not affect the environment negativelyUNDP(2005). The palm oil processing industry produces a large amount 01' solid waste mostly, palm shells. fibre and kernels. All these wastes are biomass, which can be used as a fuel substance. The boilers can utilize palm shells and fibre as the source of fuel rather than fuel oil. Under anaerobic conditions, POME produces methane. Methane from waste can be captured to provide a renewable source of energy and in the process, help abate the green house effect that it would have caused if released to atmosphere or used as fertilizers Suhaimi and Ong (2001).

One of the systems used is the clean Development Mechanism (CDM) aimed at reducing green house gas emissions especially methane gas from palm oil mill effluent (POME) and transform it into renewable biogas used for combustion in gas engines or boilers, i.e the solid wastes are utilized as a fuel substitute in the boilers Mahad et al (2009).

POME

The process of FFB into CPO produces a large amount of organic slurry waste called palm oil mill Effluent (POME). 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 80-900C, being fairly acidic with a PH value of 4.0-5.0. POME is rich in energy and nutrients, traditionally discharged in water channels like lake, river etc; where the nutrients affect the water channels quality and under anaerobic condition releases methane a dangerous green house gas, into the environment causing global warming Suhaimi and Ong (2001)

Economically, viable technique of extracting methane and other nutritious content of POME have been used in industries like agriculture, medical and energy sector. 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. Resulting in a low level of BOD and methane, used in generating electricity.

EMPTY FRUIT BUNCHES, EFB

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

1. Increases soil organic matter content
2. Improve soil structure
3. Increase infiltration and aeration
4. Reduces run-off
5. Improve - soil water - retention
6. Increases soil fauna micro-activities

Where have three approaches to managing EFB

a. Composition
b. Incineration
c. Dumped or land filled.

Incineration currently is the cheapest and most widely used in waste management option for POME. Policies are made to ban the use of incineration by government at POM sites. EFB is transported back to the plantation for composting depending on the terrain; a bulldozer can work on a flat terrain. It can be spread manually if on a difficult terrain.

As part of the CDM project, efforts are made to generate energy from FFB, involving the construction of a 7.5mw turbine generator equipped with auxiliary facilities such as boilers, water demineralization plants, cooling tower, air pollution control device and EFB storage yard. The palm mesocarp fibre and palm kernel shells have a higher caloric value and lower moisture content. Palm oil mill effluent is derived from crude palm oil (CPO) extraction process Suhaimi and Ong(2001).

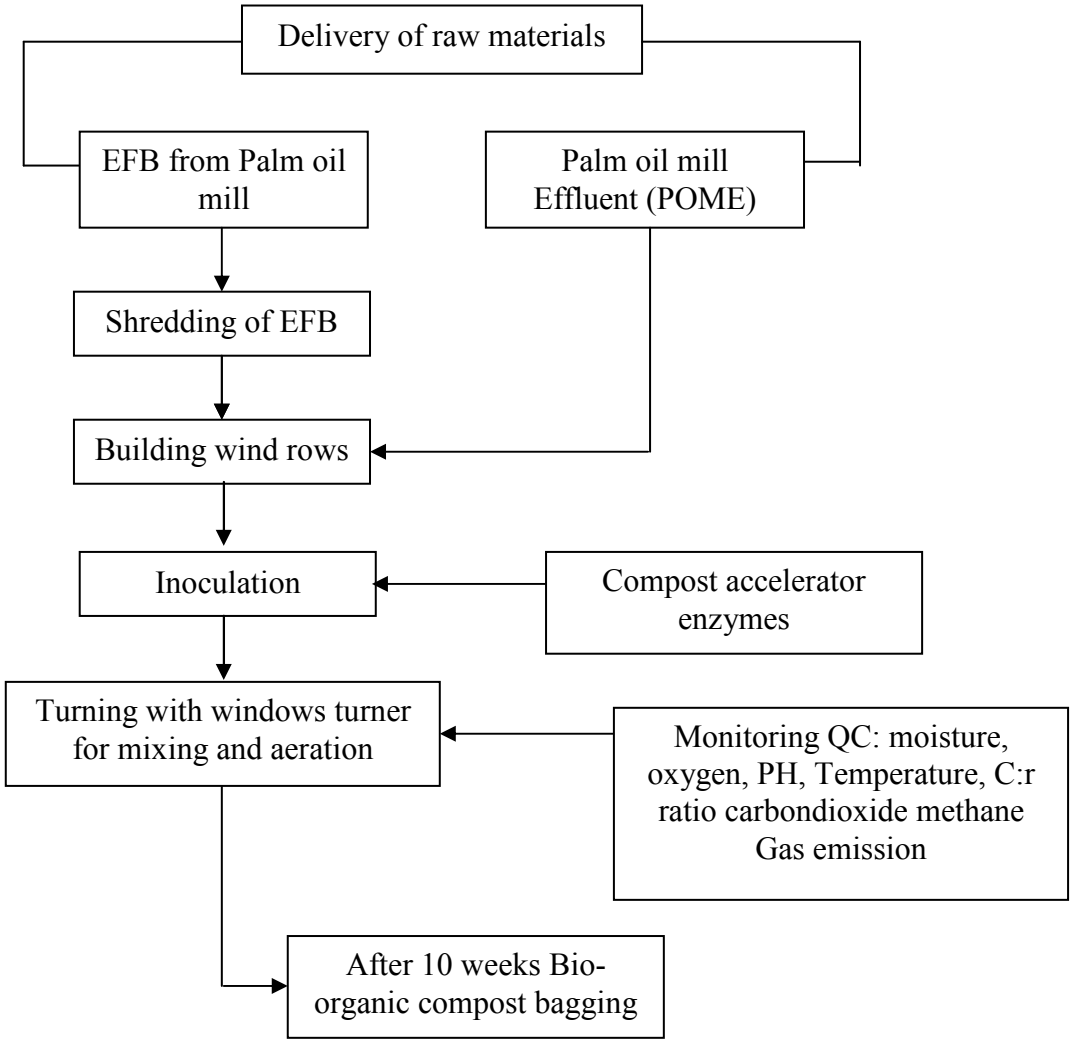


Figure 3: Composting process utilizing EFB and POME:

OIL PALM SHELL (OPS)

The palm kernel shell is also used as a source of fuel far boilers. Unfortunately, the shell contains 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. Blacksmiths also buy shells to use as fuel material in casting and forging operations Yusoff (2006).

OPS have also been used in the construction industry to develop light weight concrete. Research shows that concrete using Oil Palm Shell (OPS) as coarse aggregate has been round useful as structural concrete. As the bulk density is much less than stone aggregate. OPS concrete is a lightweight concrete of density, about 1850kg/m3. The comprehensive strengths of OPS concrete ranges from 20-24 N/mm2 for 28 days; this satisfies the strength requirement of structural lightweight concrete Mannah (2001)

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.

CONCLUSION

It is imperative that the waste generated by POMs be managed using technologically, economically and environmentally viable techniques at global demand for palm oil increases Mahzad et al (2009). The following problems associated with waste water management have been eliminated:-

- The problem of odour, the difficulties in acquiring waste water treatment sites, and the complaints from local communities.
- The cost of fuel has been reduced at the same time as solid wastes have been reduced and electricity is generated that is adequate for in-house consumption. Moreover, the company is already producing more biogas than is required for its own needs and surplus sold to Electricity Generating Authorities.
- Air pollution from fuel oil combustion has been reduced, with corresponding reduction in greenhouse gas emissions.
- The operating staff is now capable in terms of process control and environmental management.

RECOMMENDATION

With appropriate technology, certain types of waste generated in the production processes like agricultural wastes and other biomass form wastewater can be a potential fuel substitute

Waste to energy practices require intensive technology development high investment cost and operating personnel must be qualified to handle the system; It may be a barrier to adopting the practices. To counter this, the government is now providing support to palm oil manufacturers to make this technology economically viable UNDP (2005).

LIST OF ABBREVIATIONS

BOD	Biological Oxygen Demand
CPKO	Crude Palm Kernel Oil
CPO	Crude Palm Oil
CDM	Clean Development Mechanism
EFB	Empty Fruit Bunches
FFB	Fresh Fruit Bunches
POM	Palm Oil Mill
POME	Palm Oil Mill Effluent
OPS	Oil Palm Shell

REFERENCES

Mahzad H., Sa'arib M., Mohamme A., and Mohd S., (2009). Optimization of POME Anaerobic Pond, European Journal of Scientific Research ISSN 1450 – 216X Vol. 32 No.4, pp. 455-459.

Mannah M.A and Ganapathy C. (2004) Concrete from an Agriculture Waste Oil Palm Shell (OPS). Building and Environment, 39 (4), pp. 441-448.

Sergeant H., (2001) Vegetation Fires in Sumatra: Destruction or Development? Jakarta, Indonestia: Ministry of Forestry and the European Union Forest Fire Prevention and Control Project.

Suhaimi M. and Ong H. K., (2001). Composting empty Fruit Bunch of Oil Palm Malaysian Agricultural Research and development Institute Malaysia.

UNDP (2005) Clean Development Mechanism Simplified Project Design Document for Small – Scale Project Activities (SSC – CDM – PDD) Version 02.

UNDP (2006) Oil world. Oil world Annual Conference: Hamburg.

UNDP (2008) Oil world. Oil world Annual Conference: Hamburg.

WHO (2003) Utilization of Biogas General from the Anaerobic Treatment of Palm Oil Mills Effluent (POME) as Indigenous Energy Source for Rural Energy Supply and electrification. A Prefeasibility study Report.

World Growth (2009) Palm Oil – The Sustainable Oil. A Report by World Growth September 2009.

Yusoff S., (2006). Renewable Energy from Palm Oil-Innovation of Effective Utilization of Waste Journal of Cleaner Production, 14(1), pp. 87 – 93.

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