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Palm Oil Mill Wastes Utilization; Sustainability in the Malaysian Context

Asha Embrandiri*, Mahamad H. Ibrahim*, Rajeev P. Singh**

* Environmental Technology Division, School of Industrial Technology, Universiti Sains Malaysia, 11800 Penang, Malaysia.

** Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi-221005, India

Abstract- Palm oil contributes about 19% of worldwide vegetable oil production with Malaysia accounting for over 50% of total production. Due to the global rise in crude oil prices, scientists have been forced to look for cheaper alternatives and palm oil has provided the right platform. This in turn led to an increase in the oil plantations and production in countries such as Malaysia, Indonesia and Thailand. Palm oil contains a number of vitamins, carotenes, fatty acids, sterols, pigments, and some other components enabling its wide application in the chemical, food and pharmaceutical industries. Palm oil production is an integrated process with several stages starting from good cultivation practices for fruits of high oil content followed by a number of integrated processes for maximal separation and utilization of each oil fraction. The various processing phases generate several by-products which if not dealt with in a scientific manner could lead to deterioration in the ecosystem. In this paper we shall discuss the various on- going researches regarding the use of Palm mill wastes and suggestions on uses of this valuable crop and its by-products as a future to agriculture and a sustainable environment in Malaysia.

Index Terms- Sustainability; Composting; Vermicomposting; POMW; “Crop for the future”

INTRODUCTION

12% of the Malaysian GDP is contributed by Agriculture and has also provided employment opportunities for 16% of the people. The Colonialists acquired extensive land areas and introduced commercial crops such as rubber, palm oil and cocoa. Since then, these crops have been leading agricultural exports in Malaysia. Local farmers cultivate a variety of fruits and vegetables for the domestic market, such as bananas, coconuts, durian, pineapples, rice, rambutan and a few others. In 1998, the production of rice was about 1.94 million metric tons. In 1999, Malaysia produced 10.55 million metric tons of palm oil out of which 8.8 million metric tons was exported and since then has remained one of the world's largest producers. They are also one of the world's leading suppliers of rubber (767,000 metric tons in 1999). Logging in the tropical rainforest is an important export revenue earner in East Malaysia and in the northern states of Peninsular Malaysia. In 2000, 21.94 million cubic meters of sawed logs was produced earning US$450 million from exports. In spite of efforts at regulating felling and reforestation in the early 1990s, logging companies destroyed the ecosystem. Condemnation from various nature activists and environmentalist groups led to the ban on the direct export of timber. (Encyclopedia of the Nations 2010)[1]

Oil palm

Oil palm was introduced to Malaysia from Nigeria by the British colonialists in 1917 and has fast become a major contributor to the nations GDP with around $7million per annum. Latest figures indicate that over 89 million tonnes of fresh fruit bunch (FFB) is produced per year in Malaysia (Singh et al., 2010)[2]. Eleais guineesis Jacq is the most commercially efficient oil producer among the other species in the palmae family. Oil palm plantation has increased from 2.03 million hectares to 4.49 million hectares from 1990 to 2009, an increase of 121.2%, in Malaysia (Embrandiri et al., 2011)[3]. It is a very versatile crop which can produce effectively for over 20 years if maintained properly.

Palm oil has a wide range of uses from deep frying to margarine and shortening for cakes, snacks, instant noodles etc. It is also being used in cosmetics, soaps and synthetic detergents. Due to the rises in crude oil globally, palm oil has become a much sought after fuel alternative. It could be regarded as the "*Crop for the future*" considering its numerous uses. With this increase in demand, environmental management in the palm oil industry is an issue of major concern today. The mills are most often located in the plantations and the prevailing practice is collecting the waste and dumping in the most unscientific manner as excess nutrients may be harmful to both the growing plants and the ecology on the whole. Oil losses due to process instabilities and leakage result in increased oil concentration in the mill's effluent. A total oil loss of 10 - 15 kg/t FFB has been reported (Chavalparit et al., 2006)[4]. In addition, inefficient equipment, defective machinery, leakage (by break down or overflow of tanks) may often be the reason for extra oil losses.

Utilization of wastes from Oil Processing.

The process of palm oil production involves a number of stages from the sterilization of the FFB to the digestion, threshing and clarification of the oil. At each processing phase a different form of waste is produced. Figure 1 summarizes the processes in the extraction of oil palm and the various wastes obtained. In general all wastes from the palm industry are termed as Palm Oil Mill Wastes (POMW). The milling process and plantation activities generate a large amount of solid waste consisting of trunks, fronds, leaves from the plantation and empty fruit bunch (EFB), palm oil mill sludge (POMS), palm kernel cake (PKC), decanter cake, fibre and shells from processing. Palm kernel cake is a by-product of oil extraction from palm kernel seeds. Chavalparit et al (2006)[4] reported that average values of waste generation rate per ton FFB from palm oil mill in Thailand were 140 Kg of fiber, 60 Kg of shells, 240 kg of empty fruit bunch (EFB) and 42 kg of decanter cake. The liquid waste comes from oil extraction and processing and is referred to as Palm Oil Mill Effluents (POME). It has been estimated that one tonne of crude palm oil production requires 5-7.5 tonnes of water in which about 50% ends up as POME(Ma, 1999)[5].

Malaysia produced an average of about 53 million m^3 POME per annum obtained from 14.8 million tonnes of palm oil production in 2005 (Lorestani, 2006)[6]. POME contains cellulosic material, fat, oil and grease (Agamuthu, 1995)[7]. It has a very high Biochemical Oxygen Demand (BOD) (25,000 mgL-1) and Chemical Oxygen Demand (COD) (50,000 mgL-1) which is 100 times more than the domestic sewage. Although it is non toxic as no chemical is added during the oil extraction process, the effluent is considered as one of the major sources of aquatic pollution in Malaysia. The effluents from palm oil mill can cause considerable environmental problems if discharged untreated (Singh et al., 2010)[2]. However, it also contains appreciable amounts of N, P, K, Mg and Ca which are the vital nutrient elements for plant growth. This has led to the open dumping of the wastes and occasional disposing beneath the palm trees. Similarly, the POME is discharged into the fields. Table 1 shows a summary of the wastes produced and its uses in various industries.

Sustainable Management of POMW

Even though several researches have been carried out for alternative sustainable management, there is still much work to be done as the quantities being produced on a daily basis exceeds its use. Environmental- friendly approaches are required right from the harvesting to operation of the mills such as zero burning, waste minimization and recycling or re-use of the wastes. Less or total avoidance of inorganic fertilizers .The sending back of EFB to the plantation areas is considered good but due to its highly organic nature, it reaches a threshold after which is considered harmful to the plants and ecosystem. Composting is considered as one of the sustainable ways to

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minimize the waste from the industries. It is a microbial practice used in stabilization of organic wastes. During the composting process, aerobic microorganisms decompose the substrate and most of the biodegradable organic compounds are broken down to chemically stabilized composted material. Composting reduces the volume of the wastes and to improve the process of composting, degradation rate has to be increased thus quality of final compost too is enhanced. Several modifications have been carried out to enhance this degradation process such as addition of biodegradable waste to reach the optimum C/N ratio of about 30 (Rupani et al., 2010)[8]. This is known as co- composting. Yaser et al., 2007[9] carried out co-composting process using palm sludge with saw dust. The mixture prevents air pollution and improves the efficiency of the composting process.

To facilitate the composting process in order to obtain good quality fertilizer, earthworms can also been introduced, this is known as vermicomposting. Vermicomposting is the process in which earthworms are used to convert organic materials into humus-like material known as vermicompost or earthworm compost. Through the vermicomposting process, physical, chemical and biological reactions take place breaking down the organic matter into simpler forms. The resultant product (vermicast) is much more fragmented, porous and microbially active (Edwards and Bohlen, 1996)[10]. Moreover the earthworm can further be processed as a source of animal feed. Longsdon (1994)[11] reported that during the vermicomposting process important plant nutrients such as nitrogen, phosphorus, potassium, etc. present in the waste are converted into many soluble and available forms to plants. As a result it increases the plant nutrients as compared to the simple composting [12]. Table 2 shows a comparison of the composition of nutrients present in vermicompost and backyard manure [13].

CONCLUSIONS AND RECOMMENDATION

In the Palm Oil production process there is an overall surplus of by-products and the utilisation rate of these by-products is low especially for POME, EFB and Decanter cake. As the bio-based economy develops and markets for carbon neutral products grow those by-products should be seen as resources. The increased nutrient recycling will improve soil fertility and sustainability of palm oil production. Systems that minimise the removal of nutrients and carbon from the system should be preferred. Still not all carbon and nutrients have to be re-cycled. What the optimum is between biomass utilisation and recycling varies according to soil and climate. Composting, Co-composting and Vermi composting techniques although are in practice have not been utilized in full as large amounts of palm waste can be decomposed in shorter lengths of time. The end products can not only be applied to palm plantations but to other crops as well. This will in turn eradicate the use of chemical fertilizers and prevent heavy metal leaching problems. However unscientific land application of this compost can also be harmful to plant growth and soil properties. Thus more funds should be given to Research and Development of the palm and its residues. Scientific bodies and Universities should dedicate more to eco- friendly management of these resources more than development of new products. As in the coming years, Malaysia could become a self sustainable nation

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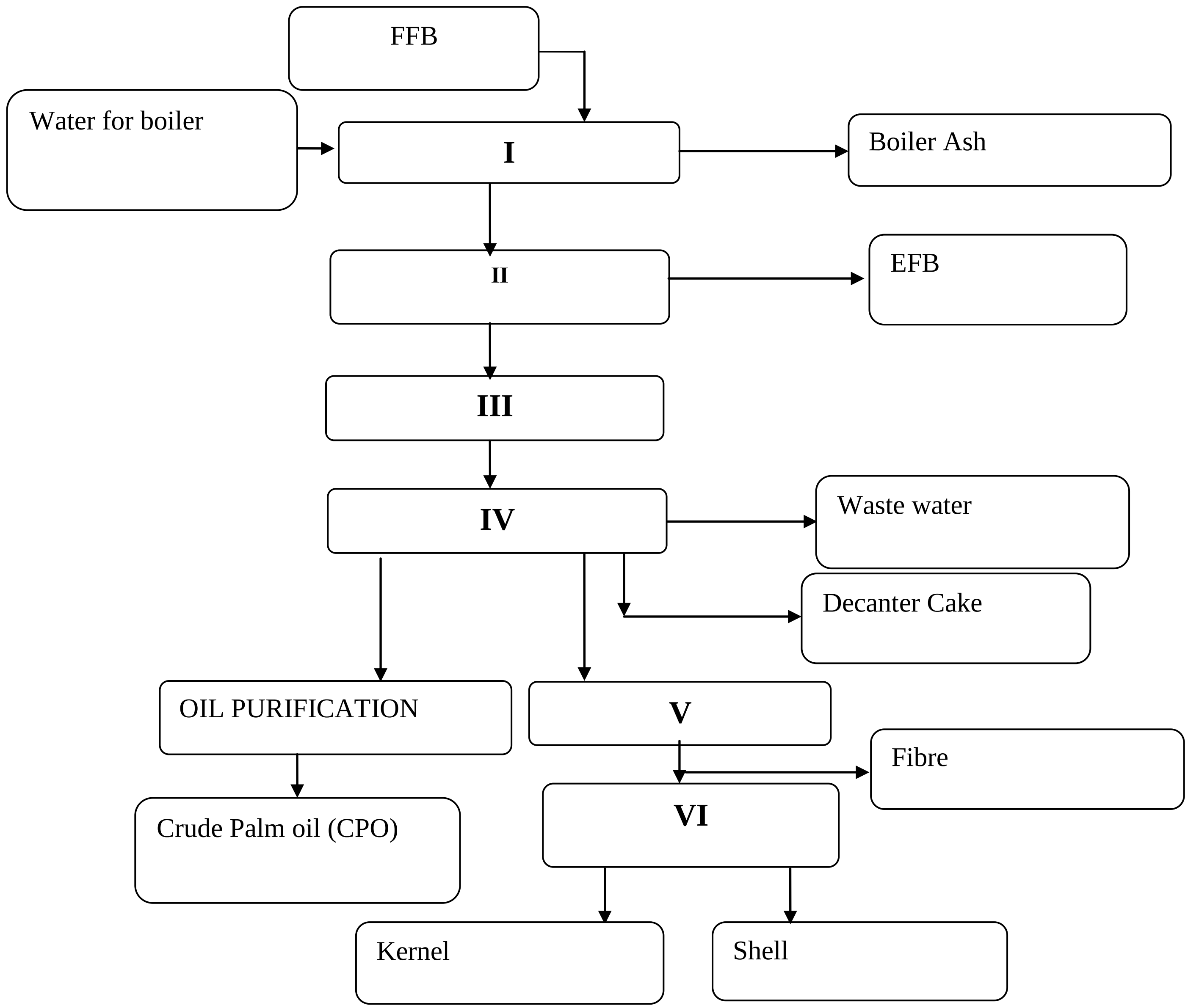
AUTHORS

First Author – Asha Embrandiri MSc, PhD. Student at the Environmental Technology Division, School of Industrial Technology, Universiti Sains Malaysia, 11800 Penang, ashanty66@gmail.com.

Second Author – Mahamad Hakimi Ibrahim, PhD. Associate Professor at the Environmental Technology Division, School of Industrial Technology, Universiti Sains Malaysia, 11800 Penang.(Supervisor)

Third Author – Rajeev Pratap Singh, PhD., Assistant Professor, Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi-221005, India (Field Supervisor)

Correspondence Author – Asha Embrandiri. As above.



Source: Modified from *Oil recovery from palm oil solid wastes*- [13].

Figure1: Chart showing the stages in production of palm oil, the type of waste produced.

I-STERILIZATION II- STRIPPING III- DIGESTION IV- EXTRACTION V – NUT AND FIBRE SEPARATION VI – NUT CRACKING

Table 1: Various palm mill wastes and their common uses

No	**TYPE OF WASTE RESIDUE**	**USES**
1	FRONDS,TRUNKS & LEAVES	• Used as mulching material in the fields which helps in moisture retention. • Also used as roofing material and some are processed as furniture.
2	Empty Fruit Bunch(EFB)	• Earlier used for generating steam for the mills and ash residues used as fertilizer. A major cause of environmental pollution so done on low key. • As raw material for products such as paneling, composites, fine chemicals, pulp and paper as well as compost and bio-fertilizer [14] • Main substrate for the cultivation of *Pleurotus ostreatus* (oyster mushroom) (Tabi et al., 2008)[15] • Most of it is just disposed off back into the fields as the above uses are not in large scale.
3	Palm Press Fibre(PPF)	• Fuel for the mills • Used as a substrate for animal feed in addition to soymeal, fishmeal. • Used for making fibre boards. • Polymeric composites for building materials referred to as AGROLUMBER for products like wall panels, sub-floors, doors and furniture parts. (MPOB 2009)[14] • Used as potting material for ornamental plants • Currently trials are on-going utilizing fibre+ Pome for vermicompositing.
4	Decanter cake	• Used as animal feed • Used in combination with inorganic fertilizer to improve soil quality (Haron and Mohammed, 2008)[17] • Currently on going work using dried, powdered form of DC as biofertilizer for vegetable gardening.[18]
5	Palm Kernel Cake(PKC)	• Suitable as feedstock because it has 48% carbohydrate and 19% protein (Kolade et al., 2005).[19]
6	Shells	• Used mainly for fuel. • Converted into activated carbon for water purification purposes.
7	POME	• Mainly used for Irrigation purposes but due to its acidic nature is quite toxic to flora and hence needs to be treated. • Carotenes are extracted from POME by pharmaceutical industries

Table 2: Nutrient composition of vermicompost and Backyard compost

Type of Compost	OC	N	P	K	Ca	Mg	Na	Zn	Cu	Fe
Vermicompost	9.8-13.4	0.51-1.61	0.19-1.02	0.15-0.79	1.18-7.61	0.0093-0.568	0.058-0.158	0.0042-0.110	0.0026-0.0048	0.2050-1.3313
Backyard compost	12.2	0.8	0.38	0.48	2.27	0.57	<0.01	0.0012	0.0017	1.1690

Source:(Nagavallemma et al., 2004)[13]