Status Evaluation of Palm Oil Waste Management Sustainability in Malaysia

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Abstract: Malaysia occupies a strategic position in palm oil production and export in the world. The palm oil industrial process is been characterized by huge waste generation both in the upstream and downstream sectors. In 2015, the solid biomass waste generated in the palm oil industry in Malaysia was rated about 75.61 million tons per annum while the palm oil mill effluent (POME) waste generated amounts to 65.35 million tons per year. The palm oil biomass waste and POME generation are projected at 85-110 million tons and 70-110 million tons per year by 2020. The growth in the waste generation poses environmental sustainability challenges in relation to the waste management and greenhouse gas generation from both the solid biomass and POME. The status of the palm oil waste management is important considering sustainability in the industry and the environment, thus this study is centred on analysing the different waste management processes and their input in waste reduction and sustainability. This study is conducted using statistical data from the Malaysian Palm Oil Board and secondary data from literatures. It was observed that the Malaysian Palm oil industry is fast growing and currently has a plantation of over 5.74 million hectares where about 87% are mature palm trees which contributes to the high volume of solid waste through pruning. The management of the solid waste has been mainly the use of the wastes as bio-fertilizer like mulching and composting. Researches and technological development on the conversion of the waste to energy like in the heat and power is fully developed where the palm oil mills generate about 300MW of electricity while targeting 800MW by 2020. Other conversion processes of the solid waste to renewable energy in the form of biofuels (gasification, and briquette production) are in their different developmental stages. Palm oil solid waste has also been useful as bio-composite materials like the production of plywood/particle boards, fibre-mats, bio-char and activated carbon. Similarly, bio-chemical conversions have been employed in the management of palm oil solid waste which include extraction of sugars/cellulose, lignin, vitamin E, and carotenes which are currently at the emerging stage. The conversion of the POME fermentation product (Methane)/biogas is still in a very early stage in Malaysia even though methane has high negative impact on the environment. The management of the palm oil mills effluent is one major area where the Malaysia palm oil industry is still lagging behind. Out of the 450 palm oil mills in the country, only 90 mills representing 20% has installed biogas capturing system. Currently, 360 palm oil mills representing 80% of the total palm oil mills treat their generated POME in open ponding, 52 mills representing 12% uses Digester Tank while 38 mills (8%) treat the POME in Covered Lagoon. The analysis of the 90 mills that are involved in biogas capture showed that 52 mills flare the captured gas while 12 mills use the gas for Combined Heat & Power generation, 24 mills use the gas for electricity generation, while 2 mills use the gas for package boiler. It was also found that out of the 24 mills that generates electricity; 19 are connected to the grid while the others are mainly for the mills activities. It can be concluded that there is progress in the growth of sustainability in the Malaysia palm oil industry. More monitoring and applications of the research findings in the industry are required for faster growth in sustainability in the industry.

Keywords: Oil Palm Waste, Palm Oil Mill Effluent, Sustainability, Waste Management, Waste to Energy

Introduction

The concept of environmental sustainability as presented by Goodland (1995) is described as maintenance of natural capital which connects social and economic sustainability to human daily activities. The above concept has also been employed as valid representation of sustainability by Morelli (2013) which the author further developed to portray environmental sustainability as the process of conducting human and industrial activities in the environment without compromising the health of ecosystems while meeting the needs of human and other creatures. Thus, environmental sustainability is a concept of maximizing the welfare of the environmental, enhancing the health of living creatures, increasing economic development for the future and societal development while meeting human needs. The indicators for environmental sustainability are described in the Environmental Sustainability Index benchmarks Esty et al. (2005) to include environmental systems, environmental stresses, vulnerability of human to environmental stresses, response to environmental challenges by the society, and global stewardship.

Environmental sustainability performance in palm oil industry has always focused on climate change with consideration on life cycle assessment, environmental management systems and eco-labeling. Hansen (2007) and Johnson (2014) identified some of the existing sustainability assessment methods in the Malaysian palm oil industry as Life Cycle Assessment, certification schemes and palm oil sustainability standards measurement (eco-labeling). Life cycle assessment is an environmental management tool employed in the assessment of resources usage and the environmental impacts of the totality of the product's life cycle (Finnveden et al. 2009, Tan 2010). Environmental Management Systems (EMS) is a formal documentation approach of waste management by industry or organization to improve environmental sustainability by integrating operational impact on the environmental into the overall management process of the organization, thus minimizing the negative impact of human activities on the environment in line with ISO 14000 (Remaud, Forbes, and De Silva 2012). Eco-labeling is an environmental sustainability measure designed to encourage consumers to develop cultural affinity to more resource and energy efficient products thereby redirecting the manufacturing industry into manufacturing sustainable products (Horne 2009). Considering the palm oil industry which has products employed in various domestic and industrial processes, there is requirement to sustainably preserve the environment for the health of the people.

In Malaysia, the palm oil industry is a major cash crop as it is in some tropical countries, thus contributes economically to Malaysia economy (Yoshizaki et al. 2013). The Malaysia palm oil industry was identified in 2011 to be the fourth largest contributor to the nation's economy contributing 6.4% of gross national income (Dayang Norwana et al. 2011, Lim and Biswas 2015). The Department of Statistics Malaysia (DOSM 2016) reported that agriculture contributed about 9% to Malaysia's Gross Domestic Product (GDP) in 2015 which also reported that over 46% of the contribution emanating from palm oil. Palm oil was reported to contribute to the socio-economic sustainability of Malaysia; the industry has been assessed by some international pressure groups, such as Rainforest Action Network, Greenpeace, and World Wildlife Fund (WWF) to be unsustainable in the production practices which include increased greenhouse gas (GHG) emissions, deforestation, and the loss of biodiversity (Datamonitor 2010, Bateman et al. 2010). The consequences of unsustainable practice in the palm oil production to the environment include high volume solid waste such as palm fronds, palm trunks, empty fruit bunches (EFB), mesocarp fibers and palm kernel shells, and palm oil mill effluent (POME) (Foo and Hameed 2010, Abdullah and Sulaiman 2013). Outside the solid waste and POME generation in 2011, over 487.1 metric tons of hazardous waste was generated through the use of fertilizer (DOEM 2015, Aja et al. 2016).

Various researchers have presented different approaches in sustainable management of the palm oil waste in Malaysia. The improvement and impacts of the various approaches developed by the different researchers have not been accessed to determine the status on sustainability. This work focuses on the status of sustainability in the palm oil industry considering the researches and development in the industry.

Malaysia Palm Oil Industry Development

Palm oil has been identified to originate from West Africa rain forest region (Corley and Tinker 2008). Palm oil was introduced to Indonesia by the Dutch in 1848 (Caroko et al. 2011) and later to Malaysia in 1911. The seeds introduced to Rantau Panjang Estate in Selangor Malaysia was expanded in 1917 to form the first commercial palm oil plantation situated at Tennamaram Estate, Malaysia (Teoh 2002, Tate 1996). The Malaysia palm oil industry stands as a role model to many other palm oil producing countries considering her growth and the development in oil world today (Okamoto 2001). Currently, Malaysia palm oil plantations cover about 5.74 million hectares (MPOB 2016b). Malaysia's palm oil export contributes about 37% of the world palm oil supply (MPOB 2016a).

Malaysia Palm Oil Solid Waste Generation

The palm oil solid waste generated in Malaysia has continued to grow with the increase in demand for the palm oil as awell as the increase in plantations developed for palm oil cultivation. McCarthy and Zen (2010) showed that palm oil processing mill for crude palm oil (CPO) production generated large amounts of solid waste and waste water which has high environmental impacts. In 2015, the solid waste generated was about 80 million tons (Loh 2017). The palm oil solid waste generation can be analysed from the plantation to the processing plant. In the analysis of the solid waste generation from palm oil industry considering the upstream and downstream sectors, Sundram and Basiron (2011) showed that about 77.8% of the solid waste comes from the upstream sector while 22.8% comes from the downstream as can be shown in Figure 1.

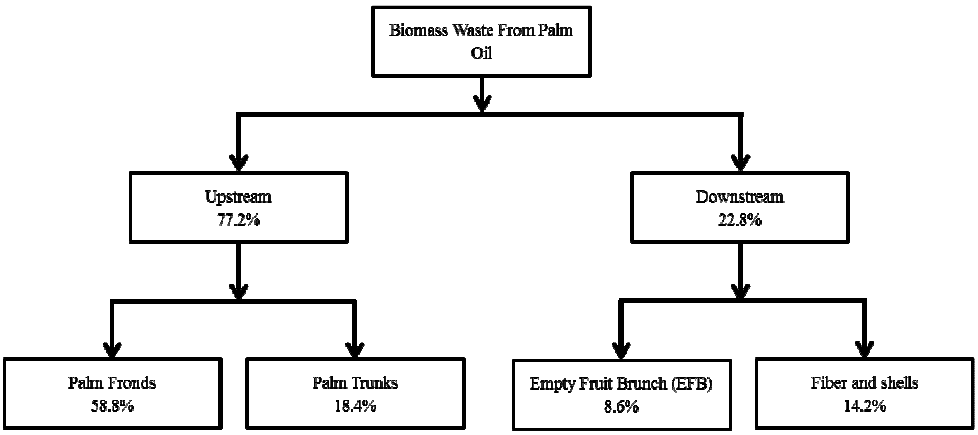

Figure 1: Solid waste generation from palm oil process
Extracted from Sundram and Basiron (2011)

At the downstream, the raw material that leads to the generation of the biomass waste is from the fresh fruit brunch (FFB) which was analysed as shown in Figure 2. Considering the different type of solid waste, their management procedures are described below.

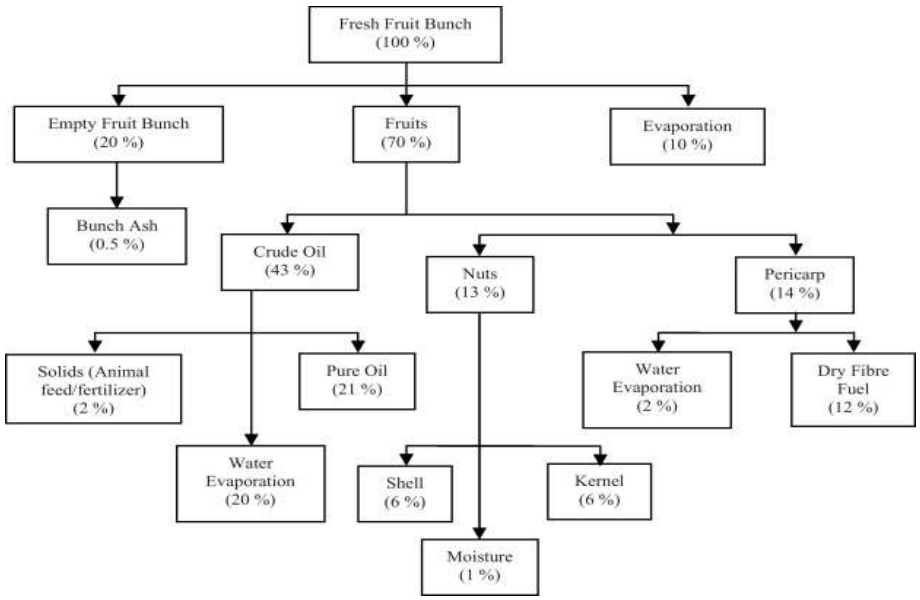

Figure 2: Palm oil mill process products from Fresh Fruit Brunch (Lorestani 2006)

Palm Trunks and Frond Waste Management

The palm fronds generated from pruning make up the highest percentage (58.8%) of solid waste generated in the palm oil industry. The industry has tried a sustainable method of placing the frond piles in the farm land to enrich the soil nutrients and mulching (MPOB 2014). The use of fronds was reported to return equivalent of 7.5 kg nitrogen to the soil while about 106 kg phosphorus, 9.81 kg potassium and 2.79 kg magnesium where also benefits enrichment of the soil by fronds piling in the plantation. It leads to cost saving in fertilizer and enhance environmental conservation by reduction on dependence on inorganic fertilizer (MPOB 2014). The palm fronds has also been employed in the production of pulp (Shuit et al. 2009, Wanrosli et al. 2007), as source of roughage feed for ruminants (Hassan et al. 1994), material for particleboard production (Hegazy and Aref 2010), and compost for agricultural activities (Mohammad et al. 2011, Siddiquee, Shafawati, and Naher 2017, Kala et al. 2009, Ahmad et al. 2011). Notwithstanding the research development in the management of palm fronds, Guangul, Sulaiman, and Ramli (2014) has reported that most of the fronds and trunks are abandoned at plantations without significant applications. Several researchers such as Atnaw, Sulaiman, and Yusup (2013), Guangul, Sulaiman, and Ramli (2014), Konda, Sulaiman, and Bambang (2012), Mom and Sulaiman (2013), Morris and Waldheim (1998), Nipattummakul et al. (2011), Nipattummakul et al. (2012) etc. have investigated the use of palm fronds and palm trunks for gasification. At present, the major application of the palm fronds and palm trunks is mainly soil enrichment via mulching. Composting has not been properly harnessed while gasification is still at the developmental stage. The industry has not provided statistical data on the excess palm fronds and trunks left in the plantation. This might be because the farmers do not report the excess to the authority as the waste can biodegrade with time.

Empty Fruit Brunch and Fibre & Shell Waste Management

The EFBs generated in the palm oil industry are incinerated, used for heat generation or applied to fields (Tabi et al. 2008, Nasution, Herawan, and Rivani 2014, Kramanandita et al. 2014). The combustion generates palm oil fuel ash (POFA) and boiler ash which are employed as fertilizer in the palm plantation (Zarina et al. 2013). POFA is a by-product of the combustion of palm oil shells and palm oil bunches to generate electricity while the boiler ash is the combustion of mesocarp fiber and shell in the boiler for steam generation. The combustion of the palm oil waste reduces the waste volume while providing energy for other activities in the industry. The combustion of palm oil waste has been identified to contribute to energy generation in Malaysia where about 300 MW are generated from palm oil solid waste combustion. Abdullah and Sulaiman (2013) highlighted that the use of EFB for mulching in palm oil plantation without recovering remnant oil in the EFB was detrimental to the environment as it contributes to oil spills while the use of inceration for the management of EFB solid waste is wasting energy which could be employed for other useful processed in the palm oil mill. The excess EFBs generated from the milling process which are returned to the plantations have no data from the Malaysia Palm Oil Board nor literature, this makes it difficult to ascertain the current status of the EFB management.

Palm Oil Mill Effluent (POME) Generation

As at May 2017, it was reported that Malaysia has 450 palm oil mills across the country with total production capacity of 111.49 million tons per year (MPOB 2017). The palm oil mills in Malaysia generated about 75 million tons of POME in 2016 (MPOB 2017). The POME generated in the palm oil mills is one of the major sources of methane gas emission and pollution to the environment (Khatun et al. 2017, Yacob et al. 2006). Methane gas has 21 times the potential effect of carbon dioxide. Out of the 450 palm oil mills in the country, 90 mills representing 20% have installed biogas capturing system. Out of the 92 mills with biogas capturing system, 52 mills representing 12% uses Digester Tank while 38 mills (8%) treat the POME in Covered Lagoon (Wan et al. 2016). Currently, 360 palm oil mills representing 80% of the total palm oil mills treat their generated POME in open ponding. The captured gas from the 90 mills with gas capturing system indicates that 52 mills flare the captured gas while 12 mills use the gas for Combined Heat & Power generation, 24 mills use the gas for electricity generation, while 2 mills use the gas for package boiler (Wan et al. 2016). Among the 24 mills that generates electricity; 19 are connected to the grid while the others generate electricity for their usage. POME has also been employed in composting of palm oil biomass. Wan et al. (2016) showed that only 76 palm oil mills have developed composting plants.

Conclusions

There is continuous improvement in the bid to grow the Malaysia palm oil industry sustainably. The government and the industry need to develop strategy to sustainably reduce the disposal to the plantation as the waste generation grows annually. Considering the efforts of different researchers, there is huge potential in utilizing palm oil solid waste in Malaysia. There should be proper integration of the research outputs into the industrial process for faster growth in sustainability in the industry. It was found that the major component of the waste management procedure that has been utilized effectively is mainly the areas that favour the industrial players economically such as the heat generation using the biomass waste. The development of biogas capturing system and the utilization of the gas generated from POME is still low considering the effect of the greenhouse gas generated from POME.

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