SUSTAINABLE MANAGEMENT OF PALM OIL MILLS WASTES IN MALAYSIA: A CASE STUDY OF SABAH AND SARAWAK

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(Environmental Management)
SUSTAINABLE MANAGEMENT OF PALM OIL MILLS WASTES IN MALAYSIA: A CASE STUDY OF SABAH AND SARAWAK

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Dedication

I dedicated this study to my family, for their patience, understanding, and encouragement, and for putting up with all of the time I spent outside Nigeria for this study.
Acknowledgement

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Abstract

Palm oil mills play an important role in the economic development of all countries involved in a large scale palm oil production. Despite obvious benefits of this industrial development, it is also one of the major sources of world environmental pollution and degradation. Many researches and developments have been carried out on zero-discharge technologies that will serve as an alternative for palm oil mills to achieve zero-discharge concepts to control environmental pollution. However, till to date most of the palm oil mills in Malaysia still discharged either partially treated or raw palm oil mill effluent (POME) into nearby rivers. Excessive quantities of either partially treated or untreated POME deplete a water body of its oxygen and suffocate aquatic life. In addition, vast amounts of biogas are generated during anaerobic digestion of POME. Biogas contains about 65% of methane (CH\textsubscript{4}), 35% of carbon dioxide (CO\textsubscript{2}) and trace amount of hydrogen sulphide (H\textsubscript{2}S). Biogas is corrosive to metal and possess bad odour while both CH\textsubscript{4} and CO\textsubscript{2} are greenhouse gases. On average around 58 million tons of POME is produce in Malaysia annually, and thus has been singled out as the chief contributor to Malaysia environmental pollution. This study examined and assessed wastes generated and method(s) of POME treatment used by palm oil mills. The study also attempts to develop a practical sustainable environmental management plan for palm oil mills that incorporate zero discharged technology to achieve zero discharge concepts. This was achieved by laboratory analysis of raw and treated POME samples, using a designed participant observation, field observation, and questionnaires survey to conduct evaluation of management of palm oil mills in Malaysia, all current available technologies use in treating the wastes, and reuse or recycle all treated by-products from palm oil mills. The study shows that palm oil mills generate both solid and liquid wastes like shells and nut fibres, empty fruit bunch (EFB), fibres, and decanter cake. This study discovered that POME has been singled
out by the operators as the most difficult and most expensive waste to manage. POME treatment method or technology found commonly among palm oil mills is open ponding consisting of both aerobic and anaerobic digestion. It is not possible for palm oil mills to achieve the current discharge limit of 20 mg L$^{-1}$ and zero discharge emission proposed by Department of Environment (DOE) using open ponding POME treatment as the results of BOD of the treated POME samples analysed and monitoring data of treated POME samples from DOE were higher than 20 mg L$^{-1}$ allowed by DOE. Based on the findings of this study, a Sustainable Environmental Management Plan (SEMP) consisting of four approaches or components, zero discharge concept implementation models and zero discharge concept operational system was developed. The four approaches or components in an interconnected and overlapping relationships to a central component (Waste to energy POME treatment technology) in a continual process contained in SEMP are; waste to energy POME treatment technology, integrated waste management (waste utilization and recycling), environmental management programs, and enabling environment (Policy, legislation, institutional framework, and incentives). Although each of the components can stand alone and function to produce results, but they must operate simultaneously to achieve zero discharge concepts in palm oil mills, since if any of the component is missing during implementation, a vacuum that will make the management plan incomplete. SEMP must be an integral part of the overall corporate management structure of palm oil mills, and not a stand-alone plan or system. However, there is need for further research on short and long term economic benefits of adopting these four components contain in SEMP to achieve zero discharge concepts in palm oil mills.
Abstrak

Kilang kelapa sawit memainkan peranan penting dalam kemajuan ekonomi semua negara yang mempunyai ladang sawit yang luas. Di samping banyak kebaikkan ekonomiknya, ia adalah juga salah satu punca utama kecemasan dan penyebab kemudaratan alam sekitar. Ramai kajian dan kemajuan telah dijalankan mengenai teknologi buangan sifar supaya kilang-kilang kelapa sawit mencapai konsep sisa sifar demi mencegah pencemaran alam sekitar. Bagaimanapun, hingga sekarang kebanyakan kilang kelapa sawit di Malaysia masih mengeluarkan sisa kelapa sawit (POME) separa olah atau tanpa diolah sama sekali. Buangan POME yang berlebihan mengurangkan kandungan oksigen dalam air dan memberi kesan buruk terhadap hidupan air. Gashayat (biogas) mengandungi lebih kurang 65% methan (CH₄), 35% karbon dioksida (CO₂) dan sedikit hidrogen sulfida (H₂S). Gas ini boleh mengaratkan logam dan mengeluarkan bau hangat sementara CH₄ dan CO₂ adalah salah satu gas rumah hijau. Maka perlepasan gas tersebut ke alam sekitar bukan sahaja merbahaya (racun) terhadap kesihatan manusia tetapi juga menyebab kepanasan iklim. Secara purata, Malaysia mengeluarkan lebih kurang 58 juta ton POME setahun, maka ia telah disenaraikan sebagai penyumbang utama terhadap pencemaran alam sekitar. Projek ini mengkaji dan menilaikan sisa buangan POME yang dikeluarkan daripada kilang kelapa sawit dan cara-cara yang digunakan oleh kilang-kilang untuk mengolahnya. Kajian ini juga menghasilkan sebatang pelan pengurusan mampu bagi sisa buangan kilang kelapa sawit yang lebih praktik dengan mengambilkira sisa buangan sifar. Ini dibuat dengan menganalisa sampel POME yang belum dirawat dan telah dirawat di makmal, memerhati sisa pembuangan, kaedah rawatan pembuangan dan teknologi kumbahan yang digunakan di kilang kelapa sawit serta menggunakan soalselidik yang hantar ke beberapa kilang kelapa sawit di Malaysia. Kajian ini mendapat kilang-kilang kelapa sawit di Malaysia mengeluarkan sisa buangan cair dan pepejal terdiri
daripada tempurung, sabut, dan tangkai buah (FFB), serabut, dan kek decanter. Kajian in juga mendapat bahawa POME telah dinyatakan oleh operator kilang sebagai buangan yang amat sukar dan mahal untuk dirawat. Cara rawatan atau teknologi untuk merawat POME yang biasa didapati adalah dengan kolam mendakan terbuka terdiri daripada penshadaman aerobik dan bukau aerobik. Hasil daripada kajian, kilang kilang ini boleh menghasil 20mg L\(^{-1}\) had buangan dan sisa buangan sifar yang disyorkan oleh Jabatan Alam Sekitar (JAS) dengan menggunakan kolam mendakan terbuka. Kajian ini juga telah mencadang Pelan Pengurusan Mampan bagi Alam Sekitar (SEMP) terdiri daripada empat model/konsep implementasi dan sisa buangan sifar. Ini terdiri daripada empat kaedah/komponen yang berkaitan dengan komponen utama (buangan kepada tenaga bahanapi yang dihasil rawatan POME) dalam process berterusan dalam SEMP - buangan POME kepada teknologi tenaga bahanapi, rawatan buangan bersepadu (kegunaan buangan dan kitaran), program pengurusan alam sekitar, dan keadaan/alat yang sempurna (polisi, undang-undang, dan insentif). Walaupun setiap komponen adalah berasingan dan bertindak secara bersendirian, untuk mencapai sisa buangan sifar di kilang kelapa sawit, mereka kenalah bertindak bersama secara menyelesaikan keseluruhan. Jikalau salah satu daripada komponen tidak diambilkira, ini akan menyebabkan ruang akan dalam pelan pengurusan dan tidak sempurna. SEMP seharusnya jadi inti struktur pengurusan keseluruhan bagi setiap korporat yang mengilang kelapa sawit dan bukan sebagai dokumen berasingan. Adalah disyorkan bahawa kajian selanjutnya mengenai faedah yang berjangka pendek dan panjang harus dijalankan sebelum be menggunakan empat komponen tersebut.
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<td>Anaerobic Baffled Reactor</td>
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<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
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<td>CDM</td>
<td>Clean Development Mechanisms</td>
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<tr>
<td>CERs</td>
<td>Certified Emissions Reductions</td>
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<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
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<td>CPO</td>
<td>Crude Palm Oil</td>
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<tr>
<td>DOE</td>
<td>Department of Environment</td>
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<td>EMAS</td>
<td>Eco-Management and Audit Scheme</td>
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<td>EFB</td>
<td>Empty Fruit Bunch</td>
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<td>EPPs</td>
<td>Entry Point Projects</td>
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<td>EQA</td>
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<td>Environmental Management System</td>
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<td>Environmental Protection Agency</td>
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<td>FMM</td>
<td>Federation of Malaysia Manufacturers</td>
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<td>Fresh Fruit Bunch</td>
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<td>FAO</td>
<td>Food and Agriculture Organisation</td>
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<td>GHG</td>
<td>Green House Gas</td>
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<td>Green Technology Financing</td>
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<td>GNI</td>
<td>Gross National Income</td>
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<td>HRT</td>
<td>Hydraulic Retention Time</td>
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<td>IWMS</td>
<td>Integrated Waste Management System</td>
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<td>ITA</td>
<td>Investment Tax Allowance</td>
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<td>NKEA</td>
<td>National Key Economic Areas</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>NACRA</td>
<td>National Annual Corporate Report Award</td>
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<tr>
<td>OPT</td>
<td>Oil Palm Trunk</td>
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<td>OPF</td>
<td>Oil Palm Frond</td>
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<td>OPP</td>
<td>Oil Palm Phenolic</td>
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<td>PPF</td>
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<td>Mg L$^{-1}$</td>
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<td>PHA</td>
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<td>PTT</td>
<td>POME Treatment Technology</td>
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<td>SEPA</td>
<td>Sabah Environment Protection Association</td>
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<td>SEMP</td>
<td>Sustainable Environmental Management plan</td>
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<td>UN</td>
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<td>NCED</td>
<td>United Nations Conference on Environment and Development</td>
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<td>UNFCC</td>
<td>United Nations Framework Convention on Climate Change</td>
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CHAPTER ONE

1.0 Introduction

1.1 Background Information

Palm oil industry plays an important role in the economic development of many countries of the world, and in enhancing the economic welfare of the population especially in Thailand, Indonesia, and Malaysia. Malaysia’s palm oil industry is one of the important industries of the nation and it is the fourth largest contributor to the national economy. It currently accounts for RM 53 billion (US$ 15.14 billion) in Gross National Income (GNI). The Palm Oil National Key Economic Areas (NKEA) is targeted to increase by RM 125 billion (US$ 35.71 billion) to reach RM 178 billion (US$ 50.86 billion) by 2020. Despite obvious benefits of this industrial development, it also significantly contributes to environmental degradation and pollution, both at the input and output sides of its activities.

It has been reported that in 2005, there was a total of 425 palm oil mills in Malaysia having production capacity of approximately 89 million tonnes of fresh fruit bunch (FFB) per year. According to 2012 statistics and data from Malaysia Palm Oil Board (MPOB), Malaysia has at least 5 million hectares of oil palm plantations, 430 mills, 46 crushers, 55 refineries, 17 oleo chemical and biodiesel plants (The Borneo post Newspaper, 23th Nov., 2012).

Waste from the oil palm mill process include palm oil effluent (POME) generated mainly from oil extraction, washing and cleaning up processes. Large quantities of water are used during the extraction of crude palm oil from the FFB and about 50% of the water results in palm oil mill effluent (Poku, 2002). It is estimated that about 5-7.5 metric tonnes of water is required to produced 1 metric tonne of crude palm oil (Ahmed et al., 2003). The raw or partially treated POME has an organic matter, which is due in part to the presence of unrecovered palm oil (Ahmed et al., 2003).
The major parameter that indicate the level of organic pollutant of POME is Biochemical Oxygen Demand (BOD). BOD is the amount of oxygen required by microorganism to completely decompose organic pollutants in POME. Raw or untreated POME have been reported to contain between 25,000 to 40,000 mg L$^{-1}$ of BOD. This highly polluting wastewater can cause pollution of waterways due to oxygen depletion and other related effects as reported by Ahmed et al. (2003). The depletion of the oxygen level in rivers leads to anaerobic conditions and the release of noxious gases, particularly hydrogen sulphide destroying the natural ecology of the affected rivers. (Khalid & Mustafa, 1992).

Palm oil industry in Malaysia is one of the potential candidates for the Clean Development Mechanisms (CDM) project because large amount of methane which contributes to global warming is emitted from lagoons and open digesting tank of the wastewater treatment system. In a research to investigate the actual greenhouse gases emission from lagoons and open digesting tanks in palm oil mills, the result indicated that methane contribution to biogas released from the open digesting tank and lagoon systems were 35% and 45% respectively. Also in a study to quantify the actual CH$_4$ emission from the open digesting tanks in Felda Serting Hilir palm oil mill Malaysia, CH$_4$ emission pattern recorded for 52 weeks from 3600 metric tonnes was between 13.5 % while 49.0 % total CH$_4$ emission per open digesting tank was 518.9kg per day (Yacob et al., 2003). In Malaysia, POME produces 25 million metric tonnes per year of chemical oxygen demand (COD), (Ma et al., 2001). POME contains cellulosic material, fat, oil and grease. While the solid wastes generated from palm oil mills (POMs) are mainly decanter cake, empty fruit bunches, seed shells and fibre from the mesocarp.

Modern processing of FFB into edible oil is practiced using various methods, which may be grouped into four categories according to their throughput and degree of complexity.