

BIODECOLOURISATION OF PALM OIL MILL EFFLUENT (POME) BY  
SELECTED EXOGENOUS BACTERIA

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A dissertation is submitted in partial fulfillment of the  
requirement for the award of the degree of  
Master of Science (Biotechnology)

Faculty of Biosciences and Medical Engineering  
Universiti Teknologi Malaysia

JANUARY 2013

*To my beloved parents and brother, whose enduring patience and loving support made this project enjoyable experience and inspired me along the way and to Assoc. Prof. Dr. Zaharah Ibrahim, thanks for all guidance and motivation given*

## ACKNOWLEDGEMENT

In the name of Allah, the Almighty and most Merciful, I am capable to complete this dissertation. With this opportunity, I would like to express my greatest gratitude and appreciation to my supervisor, Assoc. Prof. Dr. Zaharah Ibrahim who has given me a lot of suggestions, ideas, guidance, support and encouragement that enable me throughout my dissertation project.

Sincere appreciations are also extended to all my friends and my co-workers for helping and hearing my problems and also for creating conducive working environment throughout my entire hours in the laboratory. Special acknowledgement goes to laboratory staffs for their guidance during my presence which helped me a lot to finish up my project successfully.

Not to be forgotten, a wonderful regards toward my supportive parents, Mr. Mohd Nazir and Mrs. Nuraini, for their endless support, understanding and pray for my success in completing this project. My special thanks also dedicated to my brother, Mr. Khairul Anuar for all his encouragement and generosity.

Last but not least my obligations and an appreciation go to the Faculty of Biosciences and Medical Engineering and also Universiti Teknologi Malaysia (UTM) for allowing me to use their facilities throughout my research. I also would like to express my deepest gratitude to all individual who has directly or indirectly offered help, support and suggestion that contribute towards the successful completion of this project.

## ABSTRACT

Palm oil is now one of the top few edible oils in the world and will be leading player in the oil and fats market. However, palm oil mills generate large amount of by-product such as liquid effluent which requires effective management practices to minimize their negative impact on the environment. Palm Oil Mill Effluent (POME) is a highly polluted wastewater that pollutes the natural environment directly due to its high chemical oxygen demand (COD), biochemical oxygen demand (BOD), phenol and color concentration as well as unpleasant odors. This study was conducted to treat colour of final discharge POME using single bacterial culture. The processes being biological rely on suitable bacteria to break down the organic pollutants. The bacteria were originally isolated from palm oil mill sludge. The initial part of the research was selection of bacteria that can grow best in POME and screening the highest percentage of colour removal bacteria. Primary isolation is effected by streaking sample on the surface of agar containing nutrient broth and POME. The bacterium that showed the maximum reduction of colour was characterized from the genus *Bacillus* spp. via biochemical test. Parameters such as colour, COD, ammoniacal nitrogen, phenolic compound, lignin and pH were monitored. During the treatment, the maximum removal of colour was obtained up to 56% (2480 ADMI), COD removal of 26% (788 mg/L), ammoniacal nitrogen of 14% (42 mg/L), phenolic compound of 77% (56 mg/L) and lignin of 79% (25 mg/L) within 6 days. The pH of wastewater was in alkaline condition and increased from pH9.36 to pH9.59. In conclusion, biological treatment could potentially contribute in decolourisation of POME by using single bacteria itself.

## ABSTRAK

Minyak kelapa sawit kini merupakan salah satu di antara minyak makanan yang terlaris di dunia dan akan menjadi pembekal utama dalam pasaran minyak dan lemak. Walau bagaimanapun, kilang kelapa sawit menjana sejumlah besar bahan sisa buangan seperti cecair yang memerlukan amalan pengurusan yang berkesan untuk mengurangkan kesan negatif terhadap alam sekitar. Sisa bahan kelapa sawit adalah air sisa yang sangat tercemar yang boleh mencemarkan alam semulajadi secara langsung disebabkan oleh kandungan oksigen kimia yang tinggi (COD), kandungan oksigen biokimia (BOD), kepekatan fenol dan warna serta bau yang tidak menyenangkan. Kajian ini telah dijalankan untuk merawat warna sisa bahan kelapa sawit menggunakan kultur bakteria tunggal. Proses biologi bergantung pada bakteria yang sesuai untuk memecahkan bahan pencemar organik. Bakteria pada asalnya diesktrakkan daripada bahan sisa sawit. Bahagian awal kajian adalah pemilihan bakteria yang boleh membiak dengan baik dalam bahan sisa tersebut dan penyaringan peratusan tertinggi bakteria dalam penyingkiran warna dilakukan. Proses inokulasi dilaksanakan dengan sampel dicoretkan pada permukaan agar nutrien yang mengandungi sisa cecair kelapa sawit. Bakteria yang menunjukkan pengurangan maksimum warna dikenalpasti daripada genus *Bacillus* melalui ujian biokimia. Parameter seperti warna, COD, ammoniacal nitrogen, sebatian fenolik, lignin dan pH telah dipantau. Semasa rawatan, penyingkiran warna yang maksimum telah diperolehi sehingga 56% (2480 ADMI), penyingkiran COD sebanyak 26% (788 mg/L), ammoniacal nitrogen 14% (42 mg /L), sebatian fenolik 77% (56 mg /L) dan kepekatan lignin sebanyak 79% (25 mg /L) dalam tempoh 6 hari. Manakala pH sisa air adalah dalam keadaan beralkali dan meningkat dari pH 9.36 ke pH 9.59. Kesimpulannya, rawatan biologi berpotensi menyumbang dalam pengurangan warna sisa bahan kelapa sawit dengan menggunakan bakteria tunggal itu sendiri.

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**LIST OF ABBREVIATIONS**

ADMI	-	American Dye Manufacturing Institutes
AgSO <sub>4</sub>	-	Silver sulphate
BOD	-	Biochemical Oxygen Demand
CH <sub>3</sub> COOH	-	Acetic acid
COD	-	Chemical Oxygen Demand
CPO	-	Crude Palm Oil
et al.	-	and others
FFB	-	Fresh Fruit Bunch
g	-	gram
H <sup>+</sup>	-	Hydrogen ion
H <sub>2</sub> O	-	Water
H <sub>2</sub> O <sub>2</sub>	-	Hydrogen peroxide
H <sub>2</sub> SO <sub>4</sub>	-	Sulphuric acid
HgSO <sub>4</sub>	-	Mercury sulphate
K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	-	Potassium dichromate
L	-	Liter
mg/L	-	Miligram per liter
ml	-	milliliter
NaNO <sub>2</sub>	-	Sodium nitrite

NH <sub>4</sub> OH	-	Ammonium hydroxide
nm	-	nanometer
O <sub>2</sub>	-	Oxygen
OD	-	Optical density
O-F	-	Oxidation-Fermentation
OMW	-	Olive Mill Wastewater
pH	-	Hydrogen ion concentration
POME	-	Palm Oil Mill Effluent
POMS	-	Palm Oil Mill Sludge
psi	-	Per square inch
ppm	-	Part per million
rpm	-	Revolution per minutes
TSS	-	Total Suspended Solid
v/v	-	volume per volume
%	-	Percentage
°C	-	Degree Celsius
μl	-	microliter

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Research Background

The demand for palm oil has increased tremendously over the last few decades. Palm oil was commercially exploited as an oil crop thus becoming the preferred oil by more than 120 countries reflecting a very strong growth of the palm oil industry. As markets for palm oil vigorously expanded in Malaysia due to the fruit of oil palm (*Elaeis guineensis*) was cultivated on plantation scale starting in 1911 (Basiron and Weng, 2004). Thus, Malaysia became among the largest producers and suppliers of palm oil in the world. Malaysia produced 10.6 million tones of palm oil in 1999 and increased to 17.7 million tones of palm oil in 2008 (Kushairi and Parveez, 2009). However, the production of palm oil generates a large amount of wastes in the form of palm oil mill effluent (POME).

Specifically, Palm Oil Mill Effluent (POME) in general is referring to the effluent from the final stages of palm oil production in the mill. However, a continually increasing amount of Palm Oil Mill Effluent (POME) is produced every year due to the high global demand for palm oil so it is estimated that about 2.5 to 3.5 tonnes of POME is generated for every ton of crude palm oil produced (Ahmad *et al.*, 2005). POME in its untreated form is a very high strength waste containing various liquids, residual oil and suspended solids. The composition of POME includes high concentration of organic matter such as chemical oxygen demand (COD) from 40,000 to 50,000 mg/L (Zinatizadeh *et al.*, 2007), the biological oxygen demand (BOD) of these wastewater

ranges from 25000 to 35000 mg/L, oil and grease (6000 mg/L), total solids (40500 mg/L) and suspended solids (18000 mg/L). This palm oil sector however, contributes to a large amount of effluent that could pollute the environment if they are not properly treated. Discharging the effluents or by products on the lands may lead to pollution and might deteriorate the surrounding environment. There is a need for an efficient management system in the treatment of these by products in a way that will help to conserve the environment and check the deterioration of air and river water quality.

Therefore, the biological approaches received great deal of attention in the recent years for wastewater treatment system due to its environmental friendly. One of the common biological approaches to deal with the environmental contamination is conventional ponding system. Currently, most palm oil mill wastewater treatment methods are comprised of anaerobic pond/digester followed by either aerobic pond or aerobic and facultative pond.

## **1.2 Problem Statement**

Nowadays, environmental issues are becoming increasingly more important globally. Even though, the palm oil industry has significantly contributed towards Malaysia foreign exchange earnings and affected the increase rates in standard of living of its population (Yusoff and Hansen, 2007) due to high demand of oil palm, however the generated POME by the industry was considered being a major source of pollution in Malaysia. The effluent is known to be an environmental pollutant based on its high compositions of total solids, suspended organic solids, dissolved organic matter, chemical oxygen demand (COD), biochemical oxygen demand (BOD), phenol and colour concentration (Poh and Chong, 2009). The appeared colour in the effluent is derived from plant constituents such as lignin and phenolic compound as well as degraded products, tannin and humic acids from crushed palm nut and also lipids and fatty acids released during steam extraction process (Oswal *et al.*, 2002). Discharge of dark colored effluent to receiving water may reduced the penetration of light into the water reservoir and lead to the reduction of dissolved oxygen consequently hazardous to both micro and macro aquatic life by inhibit the growth of marine organisms. The



coloured compound may chelate with metal ions and thus become directly toxic to aquatic biota (Mohan and Karthikeyan, 1997). Therefore, it is necessary that the presence colour in POME is removed before discharge into water bodies and hence, this study was conducted to improve the current treatment system for colour removal of the wastewater by biological method for POME treatment.

### **1.3 Objectives**

There are three specific objectives in order to meet the goals:

- i. To isolate and screen the bacteria that able to remove colour which obtained from Palm Oil Mill Sludge (POMS).
- ii. To characterize selected bacteria capable of removing colour of Palm Oil Mill Effluent (POME).
- iii. To determine the colour removal performance in POME using selected bacteria.

### **1.4 Scope of Research**

In general, screening and characterization of bacterial culture was conducted in this research to obtain bacteria that able to decolorize palm oil mill effluent (POME). The research was focused on the color removal of high-strength industrial wastewater known as POME using selected bacteria isolate from palm oil mill sludge (POMS). The initial part of this research involved selection of bacteria that can grow in POME prior to use for treatment for colour removal. Parameters such as chemical oxygen demand (COD), pH, phenolic compound, lignin concentration and ammoniacal nitrogen were also determined.

## 1.5 Significance of Research

Palm oil mill effluent (POME) in Malaysia has been reported to produce high amount of organic compounds that contributes to the largest pollution load into the waterways. Although the coloured effluents are less toxic, the colour itself has always been regarded as a indicator of pollution affecting aesthetic values of water bodies. Hence, there is a great need to treat the POME to reduce the risk of the wastewater polluting water bodies into which the final effluent is being discharged such as rivers and their tributaries. The phenolic compounds are chemical substances that originated from plants that contribute to pollution in water and are usually treated using biological or chemical processes. Effluent containing lignin and its degraded compound are chemically stable, resistant to biological degradation and intractable to separation by conventional method (Mohan & Karthikeyan, 1997).

The biological treatment is most attractive because it can also reduce biological oxygen demand and low molecular weight chlorolignin instead of chemical oxygen demand. The organic substance of POME is generally biodegradable therefore treatment by biological method is most suitable. Biological treatment has considerable advantages over other processes such as less energy demand, minimum sludge formation, no unpleasant odor and production of methane gas as renewable energy.

Since, POME is treated without adding any chemicals or biological agents it is depend solely on the existence of indigenous microorganism. In this study, biological treatment was applied by obtaining new potential exogenous bacteria that effective to minimize pollutants in POME especially the colour of the wastewater. In subsequently, if not treat properly it will caused as high concentration of organic pollutant.

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