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

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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
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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 cecear 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 mencemari 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 diesktrak dari 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 dicorekan pada permukaan agar nutrien yang mengandungi sisa cecear 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.
TABLE OF CONTENTS

CHAPTER TITLE PAGE

TITLE i
DECLARATION ii
DEDICATION iii
ACKNOWLEDGEMENT iv
ABSTRACT v
ABSTRAK vi
TABLE OF CONTENTS vii
LIST OF TABLES xi
LIST OF FIGURES xii
LIST OF ABBREVIATIONS xiii
LIST OF APPENDICES xv

1 INTRODUCTION

1.1 Research Background 1
1.2 Problem Statement 2
1.3 Objectives 3
1.4 Scope of Research 3
1.5 Significance of Research 4
2 LITERATURE REVIEW

2.1 Palm Oil Mill Processing 5
2.2 Palm Oil Mill Effluent (POME) 7
2.3 Characteristic of POME 9
  2.3.1 Colour 9
  2.3.2 Lignin 9
  2.3.3 Phenolic Compound 10
  2.3.4 pH 11
  2.3.5 Chemical Oxygen Demand (COD) 12
  2.3.6 Biochemical Oxygen Demand (BOD) 12
  2.3.7 Ammoniacal Nitrogen 12
  2.3.8 Total Suspended Solid (TSS) 13
2.4 Palm Oil Mill Sludge (POMS) 13
2.5 Treatment System 13
2.6 The Role of Microorganism in the Treatment of Wastewater 15
2.7 The Impact of Wastewater Pollution to Environment 16

3 MATERIALS AND METHODS

3.1 Samples Collection and Preservation 17
3.2 Preparation of Culture Media and Reagents 17
  3.2.1 Preparation of Nutrient Broth 17
  3.2.2 Preparation of POME Agar Media 18
  3.2.3 Preparation of Glycerol Stock Cultures 18
  3.2.4 Preparation of COD Reagents 18
  3.2.5 Preparation of Sterilized POME 19
3.3 Isolation and Screening of Bacteria for Colour Removal 19
  3.3.1 Pure Culture 19
3.4 Characteristic of Bacteria 19
  3.4.1 Colony Morphology 19
  3.4.2 Microscopic Method 20
    3.4.2.1 Preparation of heat fixation bacterial smear 20
3.4.2.2 Gram Staining 20

3.4.3 Biochemical Test 21
  3.4.3.1 Catalase Test 21
  3.4.3.2 Oxidase Test 21
  3.4.3.3 MacConkey Agar Test 22
  3.4.3.4 Citrate Test 22
  3.4.3.5 Urease Test 22
  3.4.3.6 Motility Test 23
  3.4.3.7 Gelatin Liquefaction Test 23
  3.4.3.8 Methyl Red Test 23
  3.4.3.9 Oxidation-Fermentation 24
  3.4.3.10 Indole Test 24

3.5 Preparation of Inoculums 24

3.6 Treatment of Palm Oil Mill Effluent (POME) 25
  3.6.1 Determination of Growth Profile 25
  3.6.2 Determination of pH 25
  3.6.3 Determination of Colour Intensity 26
  3.6.4 Determination of Lignin 26
  3.6.5 Determination of Total Phenolic Compound 27
  3.6.6 Determination of Chemical Oxygen Demand (COD) 27
  3.6.7 Determination of Ammoniacal Nitrogen 27

4 RESULTS AND DISCUSSION

4.1 Sample Collection 29

4.2 Isolation and Screening of colour removal bacteria 30

4.3 Characterization of Bacteria 31
  4.3.1 Colony morphology 31
  4.3.2 Gram Staining 32

4.4 Biochemical Test 34
  4.4.1 Catalase Test 34
  4.4.2 Oxidase Test 34
4.4.3 MacConkey Agar Test 35
4.4.4 Citrate Utilization Test 35
4.4.5 Urease Test 36
4.4.6 Motility Test 36
4.4.7 Gelatin Liquefaction Test 36
4.4.8 Methyl Red Test 37
4.4.9 Oxidation-Fermentation Test 37
4.4.10 Indole Test 38

4.5 Treatment of POME 40
4.5.1 Growth Profile 43
4.5.2 pH Profile 43
4.5.3 Colour Profile 45
4.5.4 Lignin Profile 46
4.5.5 Phenolic Compounds Profile 47
4.5.6 Chemical Oxygen Demand (COD) Profile 49
4.5.7 Ammoniacal Nitrogen Profile 51

4.6 The analysis of POME Treatment 52

5 CONCLUSION AND FUTURE RESEARCH
5.1 Conclusion 54
5.2 Future research 55

REFERENCES 56

Appendices (A-B) 64-65
### LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE NO.</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Screening for potential colour removal bacteria</td>
<td>30</td>
</tr>
<tr>
<td>4.2</td>
<td>Physical observation of the colony morphology</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>on agar media</td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td>Morphological characteristic of BC bacteria under</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>light microscope</td>
<td></td>
</tr>
<tr>
<td>4.4</td>
<td>Biochemical test results</td>
<td>39</td>
</tr>
<tr>
<td>4.5</td>
<td>Summary analysis of POME treatment</td>
<td>53</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE NO.</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Simplified flow diagram of an oil palm mill process</td>
</tr>
<tr>
<td>2.2</td>
<td>Units of monolignols present in lignin</td>
</tr>
<tr>
<td>4.1</td>
<td>Palm Oil Mill Effluent Final Pond</td>
</tr>
<tr>
<td>4.2</td>
<td>Gram positive of BC bacteria under light microscope</td>
</tr>
<tr>
<td>4.3</td>
<td>Triplicates of bacterial cultures with control</td>
</tr>
<tr>
<td>4.4</td>
<td>Before the treatment of POME</td>
</tr>
<tr>
<td>4.5</td>
<td>After 6 days of treatment process</td>
</tr>
<tr>
<td>4.6</td>
<td>Control and treated POME</td>
</tr>
<tr>
<td>4.7</td>
<td>Growth Profile of BC during the treatment</td>
</tr>
<tr>
<td>4.8</td>
<td>Growth profile of bacterial and pH changes during treatment</td>
</tr>
<tr>
<td>4.9</td>
<td>Relationship between the bacterial growth and colour removal with time</td>
</tr>
<tr>
<td>4.10</td>
<td>Relationship between the bacterial growth and removal of lignin with time</td>
</tr>
<tr>
<td>4.11</td>
<td>Relationship between the bacterial growth and removal of phenolic compounds with time</td>
</tr>
<tr>
<td>4.12</td>
<td>Relationship between the bacterial growth and COD removal with time</td>
</tr>
<tr>
<td>4.13</td>
<td>Relationship between the bacterial growth and ammoniacal nitrogen removal with time</td>
</tr>
</tbody>
</table>

PAGE
---
7
10
29
33
40
41
41
42
43
44
46
47
49
50
52
# List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMI</td>
<td>American Dye Manufacturing Institutes</td>
</tr>
<tr>
<td>AgSO₄</td>
<td>Silver sulphate</td>
</tr>
<tr>
<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
</tr>
<tr>
<td>CH₃COOH</td>
<td>Acetic acid</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>CPO</td>
<td>Crude Palm Oil</td>
</tr>
<tr>
<td>et al.</td>
<td>and others</td>
</tr>
<tr>
<td>FFB</td>
<td>Fresh Fruit Bunch</td>
</tr>
<tr>
<td>g</td>
<td>gram</td>
</tr>
<tr>
<td>H+</td>
<td>Hydrogen ion</td>
</tr>
<tr>
<td>H₂O</td>
<td>Water</td>
</tr>
<tr>
<td>H₂O₂</td>
<td>Hydrogen peroxide</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>Sulphuric acid</td>
</tr>
<tr>
<td>HgSO₄</td>
<td>Mercury sulphate</td>
</tr>
<tr>
<td>K₂Cr₂O₇</td>
<td>Potassium dichromate</td>
</tr>
<tr>
<td>L</td>
<td>Liter</td>
</tr>
<tr>
<td>mg/L</td>
<td>Miligram per liter</td>
</tr>
<tr>
<td>ml</td>
<td>milliliter</td>
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<tr>
<td>NaNO₂</td>
<td>Sodium nitrite</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<td>--------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>NH$_4$OH</td>
<td>Ammonium hydroxide</td>
</tr>
<tr>
<td>nm</td>
<td>nanometer</td>
</tr>
<tr>
<td>O$_2$</td>
<td>Oxygen</td>
</tr>
<tr>
<td>OD</td>
<td>Optical density</td>
</tr>
<tr>
<td>O-F</td>
<td>Oxidation-Fermentation</td>
</tr>
<tr>
<td>OMW</td>
<td>Olive Mill Wastewater</td>
</tr>
<tr>
<td>pH</td>
<td>Hydrogen ion concentration</td>
</tr>
<tr>
<td>POME</td>
<td>Palm Oil Mill Effluent</td>
</tr>
<tr>
<td>POMS</td>
<td>Palm Oil Mill Sludge</td>
</tr>
<tr>
<td>psi</td>
<td>Per square inch</td>
</tr>
<tr>
<td>ppm</td>
<td>Part per million</td>
</tr>
<tr>
<td>rpm</td>
<td>Revolution per minutes</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solid</td>
</tr>
<tr>
<td>v/v</td>
<td>volume per volume</td>
</tr>
<tr>
<td>%</td>
<td>Percentage</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
</tr>
<tr>
<td>μl</td>
<td>microliter</td>
</tr>
</tbody>
</table>
# LIST OF APPENDICES

<table>
<thead>
<tr>
<th>APPENDIX NO.</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Lignin Standard Curve</td>
<td>64</td>
</tr>
<tr>
<td>B</td>
<td>Folin Ciocalteau Gallic Acid Standard Curve</td>
<td>65</td>
</tr>
</tbody>
</table>
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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