
# ADSORPTION PERFORMANCE OF METHYLENE BLUE AND LISSAMINE GREEN B. DYES BY ARECA CATECHU NUTS (*BUAH PINANG*) HUSK

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Bachelor of Engineering with Honours

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The final year project report, which entitled **ADSORPTION PERFORMANCE OF METHYLENE BLUE AND LISSAMINE GREEN B. DYES BY ARECA CATECHU NUTS (*BUAH PINANG*) HUSK** was prepared by Aina Sabrina Binti Sait (65342) as a partial fulfilment for the Degree of Bachelor of Chemical Engineering is hereby read and approved by:

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(Supervisor)

# ADSORPTION PERFORMANCE OF METHYLENE BLUE AND LISSAMINE GREEN B. DYES BY ARECA CATECHU NUTS (*BUAH PINANG*) HUSK

AINA SABRINA BINTI SAIT

A dissertation submitted in partial fulfilment
of the requirement for the degree of
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Faculty of Engineering
Universiti Malaysia Sarawak

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Dedicated to my beloved parents and supervisor, who never cease to motivate and support me.

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# ABSTRACT

*Areca Catechu L.*, often known as betel nut, was applied as an alkali-treated adsorbent to reduce the adsorption of methylene blue (MB) and Lissamine green b. (LGB) dyes in aqueous solution. Moreover, using the final concentration data obtained from Ultraviolet-Visible (UV-Vis) spectrophotometer, the dye removal percentage of all parameters, including adsorbent dosage, initial dye concentration and temperature, was calculated. For MB dye, the optimal parameters were 1.0 g, 5 mg/L and 50 °C for adsorbent dosage, initial MB concentration and temperature, respectively. Whereas, for LGB dye, the optimal parameters were 1.0 g, 25 mg/L and 40 °C for adsorbent dosage, initial LGB concentration and temperature, respectively. The surface structure of the areca nut husk adsorbents was examined using a Scanning Electron Microscope with Energy Dispersive X-Ray (SEM-EDX). It was discovered that the areca nut husk surface before treated with NaOH was rough and uneven in terms of pores dimension, as opposed to the post treated surface. The presence of functional groups such as -C=O, -O-H, -C-O and -C-H were determined using Fourier Transform Infrared (FTIR) and KBr disc. Last but not least, isothermal studies on the adsorption performance of MB and LGB dyes by areca nut husk adsorbent, incorporating Langmuir and Freundlich models. The Freundlich model was found to suit the MB and LGB dye adsorption reactions with regression coefficients ($R^2$) of 0.946 and 0.945, respectively. Therefore, the study revealed the NaOH-treated areca nut husk adsorbent can be used as a long-term adsorbent for the removal of MB and LGB dyes from contaminated wastewater.



Keywords: *Areca Catechu L.*, adsorption, isothermal, Langmuir, Freundlich

# *ABSTRAK*

*Areca Catechu L., sering dikenali sebagai pinang, digunakan sebagai penjerap yang dirawat alkali untuk mengurangkan penjerapan metilena biru (MB) dan Lissamine hijau b. (LGB) pewarna dalam larutan akueus. Selain itu, menggunakan data kepekatan akhir yang diperoleh daripada spektrofotometer Ultraviolet-Visible (UV-Vis), peratusan penyingkiran pewarna semua parameter, termasuk dos penjerap, kepekatan pewarna awal dan suhu, telah dikira. Bagi pewarna MB, parameter optimum ialah 1.0 g, 5 mg/L dan 50 °C untuk dos penjerap, kepekatan MB awal dan suhu, masing-masing. Manakala, untuk pewarna LGB, parameter optimum ialah 1.0 g, 25 mg/L dan 40 °C untuk dos penjerap, kepekatan LGB awal dan suhu, masing-masing. Struktur permukaan bahan penjerap sekam pinang telah diperiksa menggunakan Mikroskop Elektron Pengimbasan dengan X-Ray Penyebaran Tenaga (SEM-EDX). Telah didapati bahawa permukaan sekam pinang sebelum dirawat dengan NaOH adalah kasar dan tidak sekata dari segi dimensi liang, berbanding permukaan pasca dirawat. Kehadiran kumpulan berfungsi seperti -C=O, -O-H, -C-O dan -C-H ditentukan menggunakan Fourier Transform Infrared (FTIR) dan cakera KBr. Akhir sekali, kajian isoterma tentang prestasi penjerapan pewarna MB dan LGB oleh penjerap sekam pinang, menggabungkan model Langmuir dan Freundlich. Model Freundlich didapati sesuai dengan tindak balas penjerapan pewarna MB dan LGB dengan pekali regresi ($R^2$) masing-masing* 0.946 dan 0.945. *Oleh itu, kajian mendedahkan penjerap sekam pinang yang dirawat dengan NaOH boleh digunakan sebagai penjerap jangka panjang untuk penyingkiran pewarna MB dan LGB daripada air sisa tercemar.*



*Kata kunci: Areca Catechu L., penjerapan, isoterma, Langmuir, Freundlich*

# TABLE OF CONTENTS

# LIST OF TABLES

**Table** **Page**

# LIST OF FIGURES

**Figure** **Page**

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| FTIR | - | Fourier Transform Infrared Spectroscopy |
| UV-Vis | - | Ultraviolet Visible Spectroscopy |
| SEM-EDX | - | Scanning Electron Microscope with Energy Dispersive X-Ray |
| MB | - | Methylene Blue |
| LGB | - | Lissamine Green B. |
| AC | - | Activated Carbon |
| BG | - | Brilliant Green |
| BA | - | Bisphenol A |
| MG | - | Malachite Green |
| CR | - | Congo Red |
| CV | - | Crystal Violet |
| AO74 | - | Acid Orange 74 |
| RB19 | - | Reactive Blue 19 |
| RR218 | - | Reactive Red 218 |

# LIST OF NOMENCLATURES

| | | |
|---|---|---|
| g/L | - | gram per litre |
| mL/min | - | millilitre per minute |
| nm | - | nanometre |
| mg/g | - | milligram per gram |
| L/mg | - | Litre per milligram |
| μm | - | micrometre |
| min | - | minute |
| g | - | gram |
| mL | - | millilitre |
| °C | - | degree Celsius |
| amu | - | atomic mass unit |
| % | - | percent |
| KBr | - | Potassium Bromide |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Primarily, areca nut (*Areca Catechu L.*) or betel nut is originated from Arecaceae palm family. Areca nut trees are tall, single-trunked trees with a conspicuous crown shaft that can reach to 30 metres in height as shown in **Figure 1.1** (Xiao et al., 2019). It is extensively consumed as a masticatory product by people from all over the world, including India, Southeast Asia and South China (Xiao et al., 2019). Gupta et al. (2019) described that the red areca seed is more desired for chewing and has a higher market rate, whereas white areca seed is even less alluring.

**Figure 1.1:** Areca catechu L. fruit (*Buah pinang*)

Volgin et al. (2019), Gupta et al. (2019) and Aurora, and Squier (2019) reported that over 600 million people consumed areca nut across the world. This is because areca nut can be classified as the most often used addictive stimulant after nicotine, alcohol and caffeine. Moreover, the areca nut, often known as betel nut, can be combined with *Piper Betel* leaf and slaked lime with or without tobacco to form betel quid (Arora & Squier, 2019). Volgin et al. (2019) described that the betel quid can be denoted as a mixture of areca nut and piper betel leaf that is vigorously chewed in the mouth and thus produce a friction with the mucosa. Areca nut can be easily found at India, as it is the world's largest

producer and consumer of areca nut (Tridge, 2019). The production of areca nut per year is around 50% of the world market (Tridge, 2019).

Furthermore, 222 hectares of land in Malaysia generates approximately 368 tonnes of areca nut as described by Arora and Squier (2019). Malaysia is currently the world's top 10 areca nut producer which accounts for relatively 206 metric tonnes of areca nut produced. Consequently, according to Tridge (2019), Malaysia accounted 0.01% of global areca nut production share in 2019. In accordance to that, the areca nut husks also increase comparatively. Based on the study by Lalhmunsiama et al. (2017), the areca nut husk is a lignocellulose substance that is widely accessible in plethora of countries, albeit no mention of its possible utilization for practical reasons has been made. Due to the inapplicability of areca nut husk in other businesses, most researchers have attempted to incorporate areca nut husk in their adsorption study, as well as minimize the amount of agricultural wastes on the land. In consideration of the foregoing statements, the detailed explanations of adsorption performance on MB and LGB dyes using areca nut husk adsorbent will be discussed further in the next chapter. On top of that, the characterization of the results and isothermal studies will be further addressed.

## 1.2 Problem Statement

Nowadays, the demand for textiles, pharmaceuticals, manufacturing, cosmetics and other industries has exacerbated wastewater contamination (Lalhmunsiama et al., 2017; Ismail et al., 2020; Tabassum et al., 2020). Theses industries' wastewater effluents such as dyes have resulted in severe water contamination, which can distract human and animal ecosystems (Akter et al. 2021; Kuang et al., 2020; Kumar et al., 2018; Kulkarni et al., 2017). The dyes produced contain colouring, which has a significant influence on municipal impression of water quality (Gadekar, & Ahammed, 2019). Nonetheless, the dyes' hues can devastate the ecology by preventing sunlight from penetrating into the water (Kulkarni et al., 2017; Kuang et al., 2020; Gadekar, & Ahammed, 2019). This is because the dyes have high toxicity, organic matter content, non-biodegradability in nature (Kuang et al., 2017), as well as their tolerance to degrading chemicals, making it difficult to determine an effective approach for their removal (Gadekar, & Ahammed, 2019).

According to Akter et al. (2021), Gadekar and Ahammed (2019) and Oyekanmi et al. (2019), there are numerous techniques for treating wastewater, whether biological, chemical or physicochemical, such as filter membrane, flocculation, separation, adsorption and so on. However, based on the findings by Kulkarni et al. (2017); Mouni et al. (2018); Lu et al. (2018) and Pathania et al. (2017), they concluded that adsorption is the most feasible separation method for treating wastewater by removing dyes. Therefore, the adsorption approach is essential to eliminate the dyes from wastewater before releasing it into waterways (Lalhmunsiama et al., 2017).

Based on the previous findings, only a few researchers have explored the adsorption of areca nut husk adsorbent using MB and LGB dyes as the adsorbate. It is necessary to study and research numerous literatures in order to attain the best outcomes. Therefore, this research aims to discover the adsorption performance using areca nut husk as an agricultural waste adsorbent.

## 1.3 Research Questions

This project will explore the adsorption performance of MB and LGB dyes using sodium hydroxide (NaOH) treated-areca nut husk adsorbent, with the following research questions:

i. What are the key factors affecting the adsorption of MB and LGB dyes using the alkali-treated areca nut husk adsorbent?
ii. How can the presence of the chemical compounds in the alkali-treated areca nut husk adsorbent be determined, as well as the significance of the adsorption?
iii. How can the results of analytical methods be utilized to predict the adsorption performance of MB and LGB dyes on alkali-treated areca nut husk adsorbent?

## 1.4 Objectives of Study

According to the problem statement, the overall aim of this research project is to study the adsorption performance of MB and LGB dyes on the NaOH treated areca nut husk adsorbent. Therefore, this will be achieved by successfully completing the following objectives:

i. To study the effects of dye adsorption performance on adsorbent dosage, initial dye concentration and temperature.
ii. To characterize the adsorbent using three different analytical equipment, including Ultraviolet-Visible (UV-Vis) Spectrophotometer, Fourier Transform Infrared (FTIR) and Scanning Electron Microscopy (SEM) with Energy Dispersive X-Ray (EDX) Spectroscopy.
iii. To conduct isothermal studies of adsorption performances such as Langmuir and Freundlich isotherm models.

## 1.5 Scope of Study

The focus of this research is on the study of adsorption of MB and LGB dyes by the areca nut husk adsorbent. The findings of this project will be used to determine the optimal parameters for achieving the best adsorption performance by taking three key factors into account, including adsorbent dosage, initial dye concentration and temperature, as well as characterization using Ultraviolet-Visible (UV-Vis) Spectroscopy, Fourier Transform Infrared (FTIR) and Scanning Electron Microscopy with Energy Dispersive X-Ray (SEM-EDX) and isothermal studies, including Langmuir and Freundlich models. The significance of this study is to use an adsorbent to remove the dye as an adsorbate in an aqueous solution. In this study, the adsorbate is the dyes used which are Methylene Blue (MB) and Lissamine Green B. (LGB), whereas the adsorbent is alkali-treated areca nut husk. In reality, adsorption in wastewater treatment is frequently performed by employing activated carbon, which is exceptionally porous and has a greater adsorption capacity. This is because activated carbon adsorption is substantially more complex to create than modified areca nut husk adsorption. In addition, the areca nut husk is a low-cost agricultural waste that can be applied as an alternative

adsorbent to activated carbon, which is one of the most elementary ways to cut the adsorption material cost.

## 1.6 Significance of Study

There are several significances based on the findings resulted from this project which are stated as follows:

i. A thorough study of the adsorption of MB and LGB dyes on the areca nut husk adsorbent in order to enhance the performance.
ii. The results of the analytical methods and isothermal studies provide significant information for further research into the adsorption performance of MB and LGB dyes on the areca nut husk adsorbent.
iii. The experimental findings give valid parameters for optimization, such as adsorbent dosage, initial dye concentration and temperature.

## 1.7 Summary

This chapter presents an overview of the project, which intends to introduce adsorption process in the removal of dye from aqueous solution. *Areca Catechu L.* husk is abundant as agricultural waste since it is typically of little value to the community. To overcome this issue, the researcher will study on the adsorption of Methylene Blue (MB) and Lissamine Green B. (LGB) dyes on areca nut husk adsorbent. In this project, the agricultural waste is used to produce an alkali-treated areca nut husk adsorbent that may be used instead of activated carbon. As a result, wastewater pollution can be mitigated, and the ecosystem can be protected. Furthermore, three objectives are developed to support in accomplishing the aim of studying the adsorption performance of the MB and LGB dye on the areca nut husk adsorbent, three different types of analytical methods and isothermal studies. Correspondingly, the results of this research will be used to identify the best parameters and isotherm model for optimizing the adsorption performance.