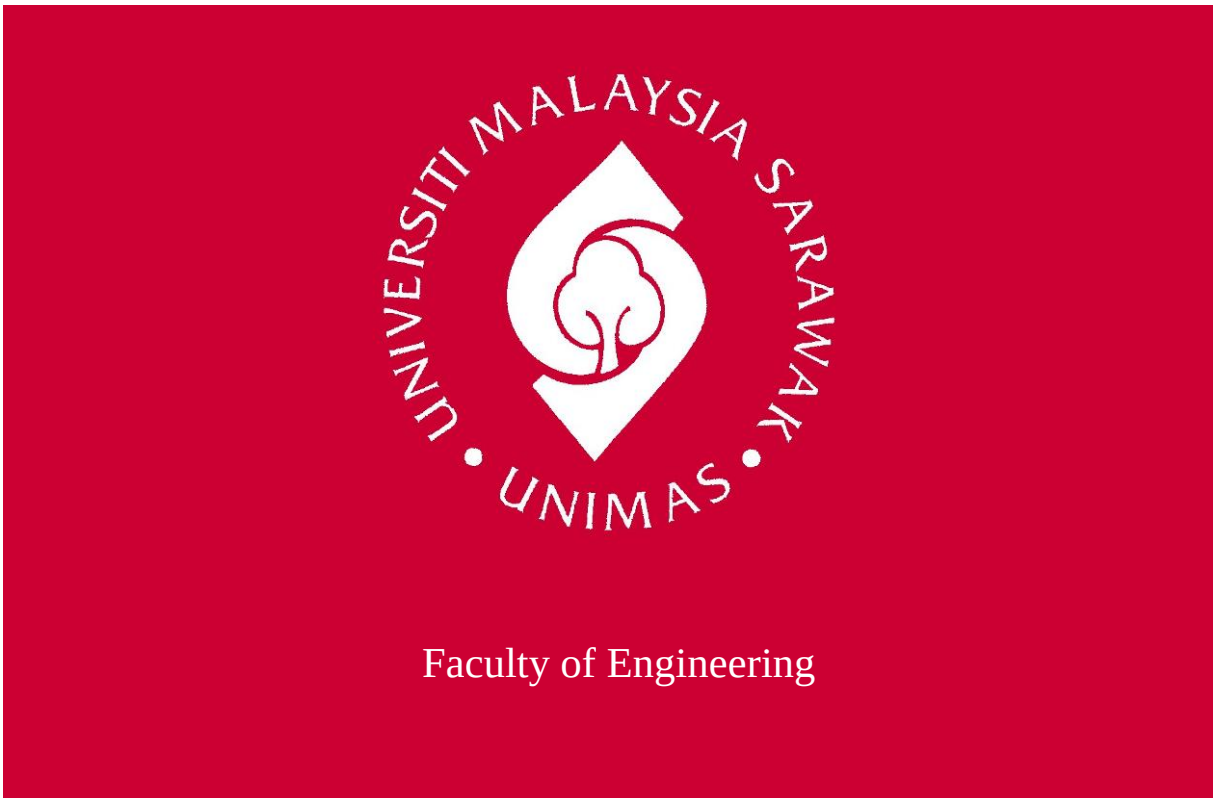


# REMOVAL OF AQUEOUS CONTAMINANTS USING BANANA PEEL WASTE

RUBAN A/L RAMACHANDRAN

Bachelor of Engineering with Honours

(Chemical Engineering)

2015

**UNIVERSITI MALAYSIA SARAWAK**

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This final year report which entitled **"REMOVAL OF AQUEOUS CONTAMINANTS USING BANANA PEEL WASTE"** was prepared by Ruban A/L Ramachandran (32729) as a partial KNC 4344 Final Year Project course fulfillment for the Degree of Bachelor of Chemical Engineering is hereby read and approved by:

_____ 31 JULY 2015

Dr.Lim Soh Fong Date
(Final Year Project Supervisor)

# REMOVAL OF AQUEOUS CONTAMINANTS USING BANANA PEEL WASTE

RUBAN A/L RAMACHANDRAN

A dissertation submitted in partial fulfillment
of the requirement for the degree of
Bachelor of Engineering with Honours
(Chemical Engineering)

Faculty of Engineering
Universiti Malaysia Sarawak

2015

Dedicated to my beloved parents, who always bestow me sustainable motivations and encouragements

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# ABSTRACT

Agricultural waste such as banana peels remains vastly unexploited. In this study, banana peels which were collected from local market are used to produce adsorbent for removing lead and copper ions from wastewater. The banana peels were washed, dried and grounded into powder. The effects of certain parameters such as contact time, agitation rate and initial metal concentration have been studied. It is found that both lead and copper metal ions depended on all these controlling parameter. The experimental kinetic data shows lead metal ion adsorption best fits into Elovich kinetic model whereas copper metal ion adsorption best fits into Pseudo-second order kinetic model. The isotherm study shows both lead and copper ions adsorption better described by Freundlich isotherm model. The results of this study indicated that banana peel based adsorbent has the potential to be a cheap and effective adsorbent to treat wastewater.

# ABSTRAK

Sisa pertanian seperti kulit buah pisang masih kurang pengeksploitasiannya . Dalam kajian ini, kulit pisang telah dikumpulkan dari gerai-gerai pasar bagi menghasilkan bahan penjerap untuk menyingkirkan ion plumbum dan kuprum dari sisa air. Kulit pisang tersebut telah dicuci, dikeringkan dan dikisar menjadi serbuk. Kesan daripada parameter tertentu seperti jangka masa persentuhan, kadar putaran dan konsentrasi logam awal telah dikaji. Analisis daripada penyelidikan ini mendapati bahawa kedua-dua plumbum dan kuprum ion logam bergantung kepada semua parameter yang dikaji. Data yang diperolehi menunjukkan model kinetik yang sesuai untuk penjerapan ion logam plumbum ialah kinetik model *Elovich* dan model kinetik untuk penjerapan ion logam kuprum ialah model kinetik *Pseudo-second order*. Kajian isotherm menunjukkan kedua-dua penjerapan ion logam plumbum dan kuprum digambarkan oleh model *Freundlich*. Keputusan kajian ini menunjukkan bahawa kulit pisang mempunyai potensi untuk menjadi penjerap  murah dan berkesan untuk merawat sisa air.

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# NOMENCLATURE

| | | |
|---|---|---|
| °C | - | degrees Celsius |
| $cm^2/g$ | - | centimeter square per gram |
| g | - | gram |
| K | - | kelvin |
| kg | - | kilogram |
| L | - | liter |
| mg | - | milligram |
| mg/g | - | milligram per gram |
| $mg\ L^{-1}$ , mg/L | - | milligram per litre |
| min | - | minute |
| ml | - | milliliter |
| Mt | - | million tonne |
| ppm | - | parts per million |
| rpm | - | rotations per minute |
| µm | - | micrometer |

# LIST OF SYMBOLS

| | | |
|---|---|---|
| B | - | heat of sorption |
| $b_t$ | - | Temkin isotherm constant |
| $C_e$ | - | final concentration |
| $C_o$ | - | initial concentration |
| $k_1$ | - | pseudo first-order rate constant |
| $k_2$ | - | pseudo second-order rate constant |
| $K_F$ | - | Freundlich constant |
| $k_{id}$ | - | intraparticle diffusion rate constant |
| $K_L$ | - | ratio of adsorption and desorption rates |
| n | - | intensity of adsorption constant |
| $q_e$ | - | adsorption capacity |
| $q_t$ | - | metal ions uptake at time *t* |
| R | - | universal gas constant |
| $R^2$ | - | correlation coefficient |
| $R_L$ | - | equilibrium parameter |
| t | - | time |
| T | - | temperature |
| V | - | volume of the solution |
| α | - | initial sorption rates |
| β | - | desorption constant |

# ABBREVIATIONS

| | | |
|---|---|---|
| AAS | - | Atomic absorption spectrometer |
| BOD | - | Biochemical oxygen demand |
| COD | - | Chemical oxygen demand |
| FTIR | - | Fourier Transform Infra – Red |
| MOH | - | Ministry of Health |
| IUPAC | - | International Union of Pure and Applied Chemistry |
| PSA | - | Particle – size analyzer |
| SEM | - | Scanning electron microscope |
| UNCTAD | - | United Nations Conference on Trade and Development |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Study

This research is mainly about the adsorption potential of banana peels. The chapter serves to introduce the research and the background of this study. The scope of this study is as defined later in this chapter.

### 1.1.1 Adsorption: An Overview

Adsorption is the most favored method to remove heavy metal ions in wastewater treatment process among other conventional process available in the industry. This is largely due to its high efficiency, low operating cost, the readiness of raw materials, and ease of handling (Philomina and Enoch, 2013). Adsorption technology also has the potential to recover the waste material which will reduce the operating cost (Phoon, 2013). Activated carbon remains as an expensive material despite the extensive use of it in wastewater management industries (Renge et al., 2012). Thus, the search for cheaper solution leads many researchers to utilize agricultural waste.

### 1.1.2 Banana Plants

Banana plant has been identified grown in at least 150 countries and it is the staple food for some 400 million people which makes it to become the fourth most vital food product within the least developed countries. India, China and Brazil are the world's largest banana fruit producers. India produces 18.5 million tones (Mt) of banana fruits meanwhile China and Brazil produces 7.4 Mt and 6.6 Mt respectively (UNCTAD, 2012).

Arunakumara *et al*. (2013) mentioned that the annual production of banana fruits around the globe exceeds 100 million tons. The banana peel is about 40% of the total production volume of the fresh fruit which is 40 million tons (Mt) remains massively unexploited. Thus, they believed that exploring banana peel to develop a sustainable green cleaning tool will not only address the heavy metal pollution problems but brings in additional value for banana industry worldwide.

## 1.2 Problem Statement

The discharge of industrial wastewater which leads to heavy metal contamination to the waters is in a great concern worldwide. Heavy metal pollutions mostly occurs in industries such as mining operations, metal plating facilities, battery manufacturing processes, production of paints, and ceramic industries (Abdul Salam *et al*., 2011). Since, heavy metal ions do not degrade into any harmless state like many organic pollutants which are susceptible to biological degradation, it poses a great danger to humans and environment (Khan *et al*., 2004). According to Barakat (2010), heavy metals can be easily absorbed by living organisms due to their high solubility in aquatic environment and it might be accumulated in human body if it enters the food chain. Johnson et al., (2008) asserted that 11 out of 20 classified metals are as toxic and pose risks if emitted to their environment in their study. The 11 metals are lead (Pb), chromium (Cr), mercury (Hg), uranium (U), selenium (Sc), zinc (Zn), arsenic (As), cadmium (Cd), cobalt (Co), copper (Cu) and nickel (Ni). The serious health effects that due to the accumulation of the heavy metals in the living tissues made the removal of heavy metal ions in the wastewater discharged into the natural water-body systems legally imposed (Chigondo *et al*., 2013).

## 1.3 Research Objectives

This study entitled Removal of Aqueous Contaminants using Banana Peel Waste has the main aim to investigate the potential of banana peel as adsorbent to remove heavy metal ions from aqueous condition. The specific objectives are as follows

i. To synthesize adsorbent from banana peel waste.

ii. To investigate the effect of the contact time, effect of the rate of agitation and the effect of initial metal concentration on the removal capacity of the heavy metal ions.

iii. To characterize the functional groups, surface morphology and particle size of the adsorbent prepared.

## 1.4 Scope of the study

The study focuses on the effectiveness of banana peel as adsorbent to adsorb two types heavy metal which are lead and copper ions. These two metal ions will be in the form of nitrate salts.

There are many factors of the surrounding solution that influences the efficiency of the banana peel as adsorbent. In this research only three variables that will be varied to investigate the most effective conditions for the banana peel to remove the heavy metal ions from the aqueous solution. The variables are the contact time (kinetic), initial metal concentration (equilibrium) and the agitation rate (physical).

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Malaysian water standards

According to Abbasi and Alikarami (2012), fresh water makes up 2.66% of the total global water resources. They also mentioned that only 0.6% from the fresh water available as drinking water. According to Azlan *et al*. (2011), the water supply governing in Malaysia is managed on a state-by-state basis and not centralized. Table 2.1 shows the Malaysian raw water quality standards and frequency of monitoring.

Table 2.1 Raw water quality standards and frequency of monitoring, (Engineering Services Division MOH, 2000)

| Parameters | Acceptable values (mg/L) | Monitoring Frequency |
|---|---|---|
| Mercury | 0.001 | Monitored once at least in every 3 months |
| Cadmium | 0.003 | |
| Selenium | 0.01 | |
| Arsenic | 0.01 | |
| Cyanide | 0.07 | |
| Lead | 0.05 | |
| Chromium | 0.05 | |
| Silver | 0.05 | |
| Copper | 1.0 | |
| Magnesium | 150 | |
| Sodium | 200 | |
| Zinc | 3 | |
| Sulphate | 250 | |
| Mineral Oil | 0.3 | |
| Phenol | 0.002 | |

There are few agencies that involved in water quality supervision in Malaysia (Azlan *et al*., 2011) such as Public Works Department (PWD), Department of Chemistry (DOC) and Department of Environment (DOE) (Engineering Services Division MOH, 2010). Azlan *et al.*

(2011) also reported that the Department of Environment (DOE) in Malaysia is the public agency that is responsible to monitor the river basins to determine the water quality if any major pollution occurs meanwhile the state water authorities will be responsible for the raw water intake quality at the treatment plant. Table 2.2 shows the drinking water quality standards and frequency of monitoring.

Table 2.2 Drinking water quality standards and frequency of monitoring, (Engineering Services Division MOH, 2000)

| **Parameters** | **Acceptable values (mg/L)** | **Monitoring Frequency** | | |
|---|---|---|---|---|
| | | **Water Treatment Plant Outlet** | **Service Reservoir Outlet** | **Distribution System** |
| Mercury | 0.001 | Monitored at least once every 3 months | Monitored at least once every 6 months | Monitored at least once every 12 months |
| Cadmium | 0.003 | | | |
| Arsenic | 0.01 | | | |
| Cyanide | 0.07 | | | |
| Lead | 0.01 | | | |
| Chromium | 0.05 | | | |
| Copper | 1.0 | | | |
| Zinc | 3.0 | | | |
| Sodium | 200 | | | |
| Sulphate | 250 | | | |

## 2.2 An Overview of Wastewater

Gray (2005) defined wastewater as a complex mixture which consists of natural organic and inorganic material together with man-made substance. Hornsfall *et al*. (2003) asserted that, contamination of the wastewater by heavy metals is a very severe environmental problem lately and the removal of the heavy metals is the primary importance in their research paper. According to Phaisanthia, *et al*. (2013), in a lot of developing countries the discharge of large amounts of water from the industrial sector is in a great concern due to the heavy metals pollution caused by it. These heavy metals that are discharged by industrial activities are non-biodegradable and can be accumulated in the body of the living organism (Phaisanthia *et al*. 2013). The presence of the heavy metals even in traces is toxic and detrimental for both human and environment (Das *et al*., 2008). Table 2.3 shows the Malaysian parameter limits for sewage and industrial effluents.

Table 2.3 Parameter's limits for sewage and industrial effluents, (Engineering Services Division MOH, 2000)

| Parameter | Unit | Standards | |
|---|---|---|---|
| | | A | B |
| Temperature | ˚C | 40 | 40 |
| pH | - | 6.0-9.0 | 5.5-9.0 |
| $BOD_5$ at 20˚C | mg/L | 20 | 50 |
| COD | mg/L | 50 | 100 |
| Suspended Solids | mg/L | 50 | 100 |
| Mercury | mg/L | 0.005 | 0.05 |
| Cadmium | mg/L | 0.01 | 0.02 |
| Chromium Hexavalent | mg/L | 0.05 | 0.05 |
| Arsenic | mg/L | 0.05 | 0.1 |
| Cyanide | mg/L | 0.05 | 0.1 |
| Lead | mg/L | 0.1 | 0.5 |
| Chromium, Trivalent | mg/L | 0.2 | 1 |
| Copper | mg/L | 0.2 | 1 |
| Manganese | mg/L | 0.2 | 1 |
| Nickel | mg/L | 0.2 | 1 |
| Tin | mg/L | 0.2 | 1 |
| Zinc | mg/L | 1 | 1 |
| Boron | mg/L | 1 | 4 |
| Iron | mg/L | 1 | 5 |

## 2.3 Significance of Heavy Metals Recovery

Heavy metals can be hazardous if it is not recovered from the aqueous system. The harmful effects of copper and lead metal ions which could occur if these ions penetrated human body are discussed below.

### 2.3.1 Copper

Wong *et al*. (2003) reported copper is also the most commonly found heavy metal ion in industrial wastewater and the eradication of copper is utmost importance. Copper is hazardous heavy metal that present as ions in aqueous system which can cause severe physiological or neurological damage to humans if absorbed into human body. (Wong *et al*. 2003). According Hossain *et al*. (2012), copper might generate reactive free oxygen species and harm the protein, lipids and DNA. Therefore, it is significant that copper is removed from wastewater.