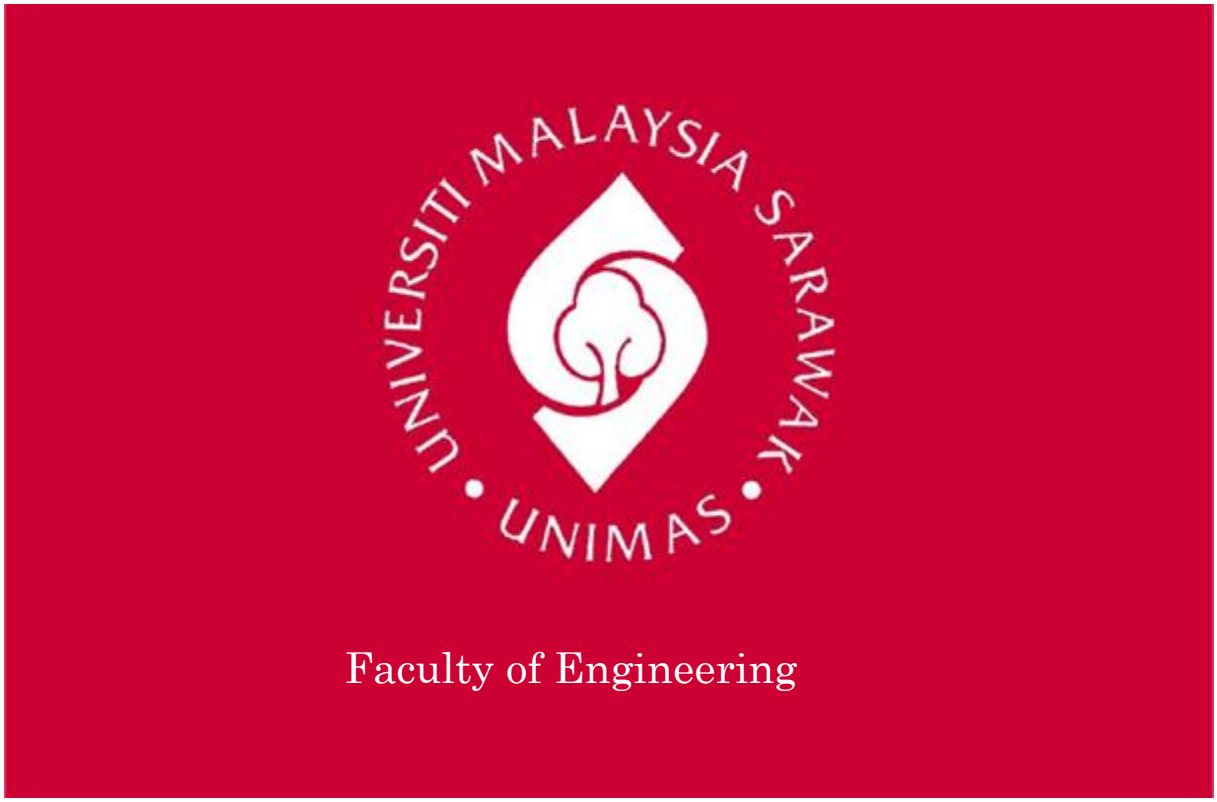

ANALYSIS OF BATCH ELECTROCOAGULATION OF NATIONAL PARK AND PALM OIL PLANTATION PEAT WATER IN SOUTHERN SARAWAK

NOORANISHA BINTI BAHARUDIN

Bachelor of Chemical Engineering with Honours

2022

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DR. NAZERI ABDUL RAHMAN

(FINAL YEAR PROJECT SUPERVISOR)

Date

ANALYSIS OF BATCH ELECTROCOAGULATION OF NATIONAL PARK AND PALM OIL PLANTATION PEAT WATER IN SOUTHERN SARAWAK

Analysis Of Batch Electrocoagulation Of National Park And Palm Oil Plantation Peat Water In Southern Sarawak

NOORANISHA BINTI BAHARUDIN

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

Faculty of Engineering
Universiti Malaysia Sarawak
2021

Bismillahirrahmanirrahim

Dedicated to my beloved Mama and Ayah,

For all their endless love, prayers, and limitless sacrifices to make me a better person.

Not forgetting, Fakeh for your efforts and hard work.

'kencana itu tidak hilang nilainya meski pudar kilaunya'

'Ya Allah, there is no ease except in that which You have made easy, and You make the difficulty, if You wish, easy'

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ABSTRACT

Domestic water is the most fundamental necessity required for living. However, not all people are privileged to have access to clean water every day especially those who live in rural areas or estates and plantation areas. In the plantation area of rural Sarawak, the local community in the area relies on water from various sources for their daily usage such as rainwater, peat water, and river water. However, water obtained from these sources has questionable qualities especially nearby the palm oil plantation areas. The water might be contaminated with pesticides or the heavy metals that are present in the pesticides used in the plantation. Therefore, the innovation of this electrocoagulation treatment system is needed to be implemented especially in the rural plantation areas of Sarawak. The electrocoagulation treatment system is used to treat the peat water so that it can be consumed by the locals as their domestic water for daily life consumption. Several parameters are studied in this research including turbidity, colour, pH, total suspended solids (TSS), and total dissolved solids (TDS). Other than that, the flocs composition analysis, and heavy metal removal efficiency were also studied in this research. Kinetic and statistical models are developed for the electrocoagulation treatment system. Lastly, an economic analysis is performed to evaluate the cost of the electrocoagulation treatment system to ensure it is affordable and low-cost to be implemented in the rural plantation area.

Keyword: peat water, electrocoagulation, kinetic modeling, response surface methodology, ANOVA

ABSTRAK

Air domestik adalah keperluan paling asas yang diperlukan untuk hidup. Namun, tidak semua rakyat mendapat keistimewaan untuk mendapat bekalan air bersih setiap hari terutamanya mereka yang tinggal di kawasan luar bandar atau estet dan kawasan ladang. Di kawasan ladang luar bandar Sarawak, masyarakat setempat di kawasan itu bergantung kepada air daripada pelbagai sumber untuk kegunaan harian mereka seperti air hujan, air paya, dan air sungai. Walau bagaimanapun, air yang diperoleh daripada sumber ini mempunyai kualiti yang boleh dipersoalkan terutamanya berhampiran kawasan ladang kelapa sawit. Air mungkin tercemar dengan racun perosak atau logam berat yang terdapat dalam racun perosak yang digunakan di ladang. Oleh itu, inovasi sistem rawatan elektrokoagulasi ini amat diperlukan untuk dilaksanakan khususnya di kawasan ladang luar bandar Sarawak. Sistem rawatan elektrokoagulasi digunakan untuk mengolah air paya supaya dapat digunakan oleh penduduk tempatan sebagai air domestik untuk kegunaan harian. Beberapa parameter yang dikaji dalam penyelidikan ini termasuklah kekeruhan, warna, pH, jumlah pepejal terampai (TSS), dan jumlah pepejal terlarut (TDS). Selain itu, analisis komposisi flok, dan kecekapan penyingkiran logam berat turut dikaji dalam penyelidikan ini. Model kinetik dan statistik dibangunkan untuk sistem rawatan elektrokoagulasi. Akhir sekali, analisis ekonomi dilakukan untuk menilai kos sistem rawatan elektrokoagulasi bagi memastikan ia berpatutan dan kos rendah untuk dilaksanakan di kawasan ladang luar bandar.

Kata kunci: air paya, elektrokoagulasi, pemodelan kinetik, metodologi permukaan tindak balas, ANOVA

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LIST OF ABBREVIATIONS

ANOVA	-	Analysis of Variance
BOD	-	Biochemical Oxygen Demand
CCD	-	Central Composite Design
COD	-	Chemical Oxygen Demand
DC	-	Direct Current
EC	-	Electrocoagulation
NWQS	-	National Water Quality Standard
RSM	-	Response Surface Methodology
SS	-	Suspended Solids
TDS	-	Total Dissolved Solids
TSS	-	Total Suspended Solids
WHO	-	World Health Organization
WQI	-	Water Quality Index

LIST OF NOMENCLATURE

°C	-	Degree Celcius
%	-	Percentage
µs/cm	-	microSiemens per centimeter
A	-	Ampere
A/m^2	-	Ampere per square meter
cm	-	Centimeter
g/mol	-	Gram per mol
H_2O	-	Water
min	-	Minutes
NTU	-	Nephelometric Turbidity Unit
pH	-	Potential of Hydrogen
ppm	-	Part per million
RM	-	Ringgit Malaysia
TCU	-	True Color Units
V	-	Voltage
W	-	Watt

Chapter 1

INTRODUCTION

1.1 Domestic Water

Domestic water is the water consumed by consumer in daily life for drinking, cooking, bathing, and other household chores. It is one of the most basic necessities required for human being to keep living. However, due to increasing human population, daily domestic water consumption is also increasing. Hence, having access to clean water supply is almost a privilege nowadays. According to Boretti and Rosa (2019), global water demand has rapidly increase by 600% corresponding to 1.8% of increment rate annually. Lau (2017) stated that in 2017, the reported average amount of water consumed daily in Malaysia is 210 liters per capita. The recommended amount of daily water consumption per capita by World Health Organization was only at 165 liters per capita daily, therefore, the amount consumed by Malaysians were 27% higher than the recommended amount. **Figure 1.1** below shows the increasing trend of domestic water consumption in Malaysia from 2012 to 2019 in billions per day. In 2019, approximately 6.83 billion of water consumed by Malaysian on a daily basis.

In Sarawak specifically, the main sources of raw water for daily domestic consumption comes from the surface water and groundwater. Some parts of Sarawak would also opt for rainwater and desalinated water as their source of raw water supply (Mahyan & Selaman, 2016). Although the water supply is provided across the state by the Sarawak Water Supply Authority, there are some rural areas does not fully receive the water supply provided. Therefore, people in those rural area will opt to utilize the rainwater collection, mechanical pump, or ramp pump to supply water to their home for domestic use (Ng et al., 2004). Other than that, some rural area would also utilize peat water that is available as their raw water sources.

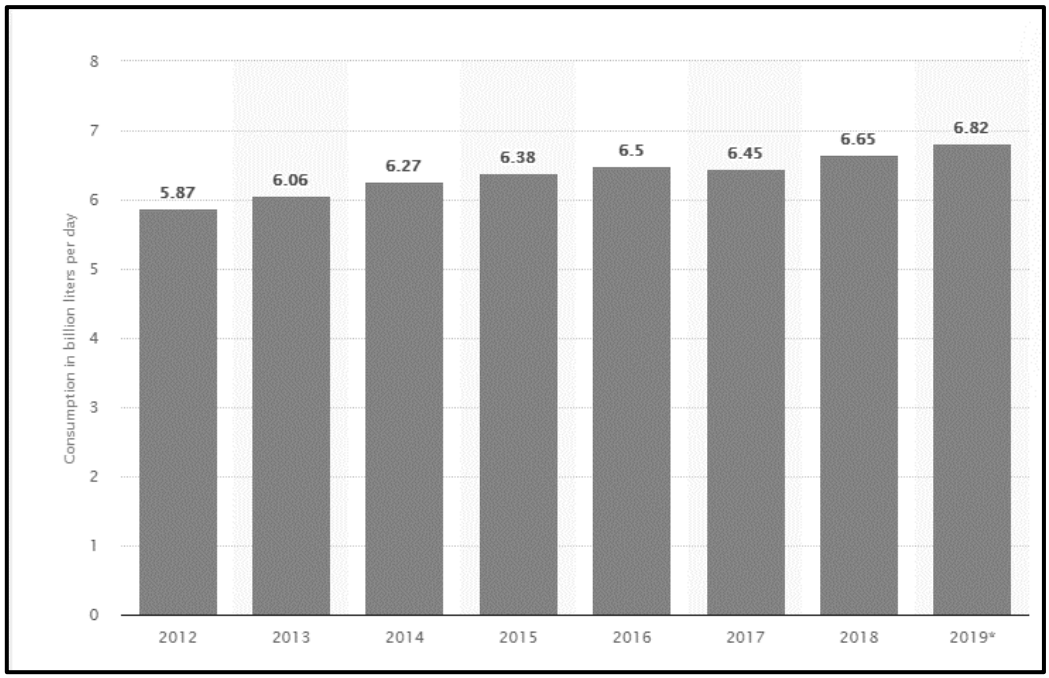

Figure 1.1: Domestic water consumption in Malaysia from 2012 to 2019 (Müller-Dum et al., 2019)

1.2 Peat Water

Water that are derived from peatlands can be classified as peat water. Based on the data obtained from Department of Irrigation and Drainage (2018), the peatland is mostly covered by peat swamp forest, with a coverage of 19% of the state land area. Hence, Sarawak has approximately 1.7 million hectares of freshwater peat that is commonly located in the coastal area of Southern and Central Sarawak. Due to lack of clean water supply in rural area of Sarawak, locals in the area are forced to use peat water as their main source of daily domestic consumption. However, the problems arise with the consumption of peat water is that it might contains organic matters with unpleasant smell and colour. The colour of peat water is dark brown-orange due to the high dissolved organic carbon content (Labadz et al., 2010). Sakarinen (2016) also stated that the consumption of untreated peat water may cause harm to human health due to the content of peat water such as humic substances. Other than that, the peat water has an acidic characteristics which is cause by the plant residues or animal decay (Rahman et al., 2020).

Therefore, continuous consumption of peat water that is treated improperly might results in serious health problems such as diarrhoea and other waterborne disease as well as serious illnesses such as typhoid or poisoning. Hence, the abundance of peat water

supply in Sarawak allows it to be explored and treated as an alternative treatment method and let the community in rural Sarawak to have access to clean water supply. **Figure 1.2** shows the map distribution of peat area in Sarawak where the dark shaded region represents the peat soil. It can be observed that Sibu area has the largest area covered by peat soil followed by Sri Aman and Miri division. **Table 1.1** below shows the distribution of peat soil area in Sarawak.

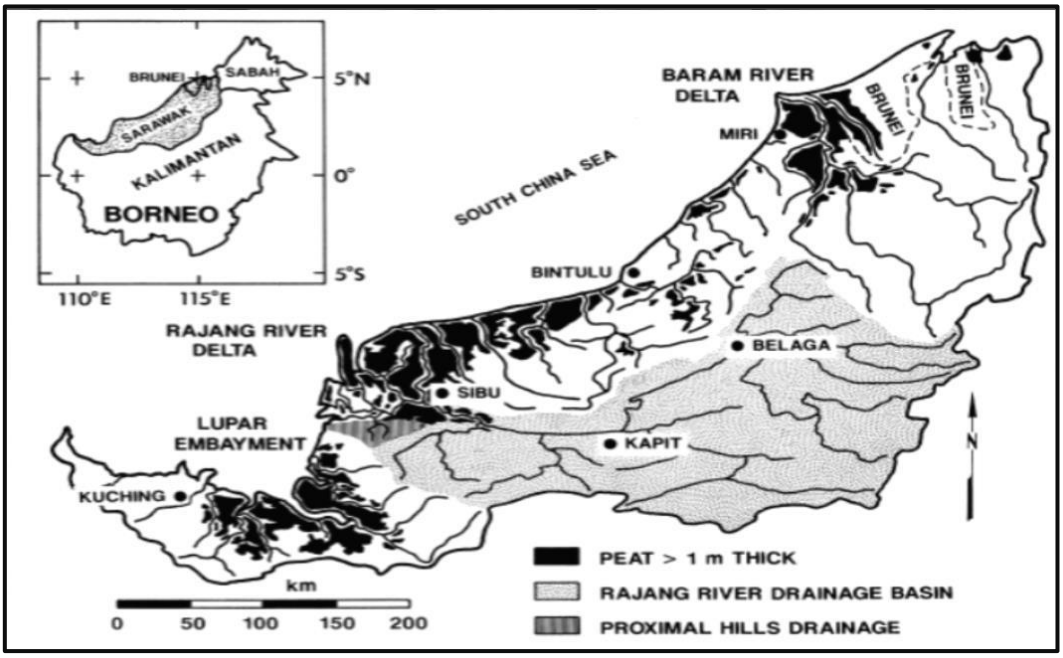

Figure 1.2: Peat Area in Sarawak (Sa don et al., 2014).

Table 1.1: Peat Soil Distribution Area (Sa don et al., 2014)

Division	**Area (ha.)**
Kuching	23,059
Kota Samarahan	192,775
Sri Aman	283,076
Sibu	540,800
Sarikei	169,900
Bintulu	146,121
Miri	276,579
Limbang	25,300

From **Table 1.1**, the largest coverage of peat soil area is in Sibu Division with the coverage of approximately 540,800 ha. from total peat soil coverage which are 1,657,000 ha. Followed by Sri Aman and Miri where the peat soil area cover approximately 283,076 and 276,579 respectively in both divisions. Based on the selected division in **Table 1.1,** Kuching division are known to have the least coverage of peat soil among the selected division.

1.3 Electrocoagulation

In Malaysia, the raw water obtained will be treated in a conventional water treatment plant before it is distributed to the consumers for domestic use and other consumption. Typically, a conventional water treatment plant combines physical, chemical, and biological processes to treat the raw water and remove the pollutants (Moussa et al., 2017). Despite the conventional treatment system is feasible method that was used since a long time, it also consumes a large amount of energy. Therefore, non-conventional method such as electrocoagulation are studied and implemented to be fully utilized in water treatment as it is environmentally friendly with low cost and low maintenance.

Electrocoagulation occurs when there is electrical current pass through an untreated water, and the ability was proven as there are high efficiency of pollutants removal from the untreated water. According to Lu et al. (2016), electrocoagulation is also able to treat wastewater with heavy metals ion and toxic organic in an environmentally friendly process. By implementing the basic principle of electrochemistry, the cathode will be losing electrons meanwhile the water will be gaining electron as the contaminated water will be treated. Electrocoagulation process involves metal cations dissolutions at the anode electrode while the hydrogen gas and hydroxyl ions being formed at the cathode. According to Akanksha et al. (2014), iron and aluminium electrodes are the most commonly used metals as it is locally available, non-toxic characteristics, and it is proven to be reliable compared to other metals.

The most fundamental electrocoagulation system can be developed with a pair of electrodes that consist of anode and cathode which will be connected to a power supply. As the power supply is turned on, the current will pass through the metal electrode, and oxidation will occur where water component is reduced to hydrogen gas and hydroxyl ion

simultaneously. Metal cation that is used in this electrocoagulation process will provide a neutral charge that will destabilize colloidal particles meanwhile the electrocoagulation process will also produce chemicals that acts as a coagulant to help in the process (Charisiadis, 2017).

There are a few advantages of implementing the electrocoagulation treatment system which are requiring simple equipment which leads to the ease of operation of water treatment, less treatment time, little to no use of chemicals for treatment, and lesser amount of sludge (Charisiadis, 2017). To add more, according to Tezcan Un et al. (2009), the electrocoagulation process provides rapid sedimentation of the electro-generated flocs with less sludge production. Despite the positive result obtained from the electrocoagulation treatment system, the water treated should be adhere to the National Water Quality Standard (NWQS) as imposed by Ministry of Health Malaysia (MOH).

1.4 Research Problem

Sarawak with 22% of the nation's palm oil plantation area is the second largest palm oil contributor in Malaysia (Aghamohammadi et al., 2016). Fertilizers, pesticides, and rodenticides are some of the agrochemical pollutants that are commonly used by planters in palm oil plantation (Sulaiman et al., 2019). Lack of the fertilizing regulations has cause adverse effects towards the water quality in the palm oil plantation area. Hence, the clean water supply to the community in the will also be affected.

Furthermore, the demand for clean water supply is also increasing due to the rapid growth of population in Sarawak (Mahyan & Selaman, 2016). As reported in Bernama (2018), source of raw water to supply clean water in rural area of Sarawak is in severe level. It is estimated that 97% of Malaysian are able to receive clean water supply except for the 3% of the population that live in rural areas.

Therefore, in some palm oil plantation area in Lundu and Sematan, Sarawak, the locals had to rely to the water supply from untreated sources such as river water, rainwater, and peat water. As peat water is easily available in Sarawak due to the nature of the peat swamp forest, the chances of getting peat water as raw water supply are possible. However, water obtained from these sources have questionable qualities especially nearby the palm oil plantation areas. Water consumed by the locals might be contaminated with the pesticides or the heavy metals that present in the pesticides used

in the plantation. Hence, the problem that might be faced is treating the peat water with conventional treatment method. Implementing the conventional treatment method to treat peat water might rise problems due to the properties of the peat water specifically the dissolved organic carbons as well as the presence of heavy metals in the peat water. Thus, the innovation of this electrocoagulation treatment system is needed to be implemented and utilized especially in the rural plantation areas of Sarawak.

1.5 Scopes of Study

This study focuses on the treatment of peat water in the palm oil plantation and the peat water from the natural source by using the batch electrocoagulation treatment system. The kinetic and statistical modelling for the performance of the treatment system is also developed. Other than that, the economic analysis is also conducted to ensure that the treatment system is affordable to be implemented in the palm oil plantation area in Sarawak.

1.6 Aim and Objectives

The aim of this study is to compare the treated water of the peat water from palm oil plantations and natural peat water from the national park in southern Sarawak. Several objectives are devised to achieve the aim of this study which are as follows:

i) **To conduct an experimental study for peat water from both sources**
   The factors affecting the performance of the batch electrocoagulation treatment system such as turbidity, colour, and pH level are studied to obtain the best operating condition.

ii) **To analyze the treated water and compare to the standard**
   The untreated and treated peat water quality will be examined and compared according to the National Water Quality Standard (NWQS) and the flocs produced in the batch electrocoagulation process are also studied in detail.

iii) **To develop kinetic and statistical models for optimization**
   Kinetic model is conducted by investigating the parameters that is involved in the chemical reaction kinetic such as the amount of the metal dissolved and the reaction rates. Then, the statistical model is developed by using Response