PEAT SOIL AS NATURAL ADSORBENT TO REDUCE AMMONIUM IN PALM OIL MILL EFFLUENT (POME)

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ABSTRAK

Kehadiran ammonia (NH_3) yang dihasilkan daripada efluen kilang kelapa sawit (POME) telah menyebabkan bau yang sangat tidak menyenangkan kepada kawasan sekitar. NH_3 yang dihasilkan oleh bakteria anaerobik dipancarkan apabila POME dirawat melalui pencernaan anaerobik. Oleh itu, kepekatan NH_3 perlu dikurangkan untuk mengurangkan bau dan kawalan kesihatan. Penyiasatan menggunakan tanah gambut yang diubah suai sebagai penjerap semula jadi secara pengaktifan kimia menggunakan natrium hidroksida, (NaOH) telah dijalankan untuk mengkaji ciri-ciri dan menentukan kesesuaiannya sebagai penjerap baharu dengan kesannya terhadap kecekapan penyingkiran ammonium yang dihasilkan oleh POME. Terdapat banyak kajian yang telah membuktikan bahawa tanah gambut berpotensi dan berguna sebagai penjerap dalam keadaan aerobik kerana mengandungi kandungan karbon dan liang yang tinggi. Keputusan menunjukkan NaOH diperolehi daripada ujian ammonia dengan 30 minit masa sentuhan, 100 rpm kelajuan pengadukan dan 9 g penjerap dos dengan nilai 85%. Manakala bagi nisbah 1:3 pengaktifan NaOH, keputusan diperolehi sebanyak 90 min masa sentuhan, 50 rpm kelajuan pengadukan dan 9 g dos penjerap dengan nilai 79%. Imej Mikroskop Elektron Pengimbasan (SEM) bagi tanah gambut yang diubah suai yang pengaktifan oleh NaOH menunjukkan struktur ruang yang lebih berliang dan mencipta lompang yang lebih besar. Manakala, Fourier-transform Infrared (FTIR) menunjukkan fungsi berbeza bagi tanah gambut mentah dan tanah gambut diubah suai. Dalam hal ini, tanah gambut yang diubah suai oleh pengaktifan NaOH boleh mewujudkan industri baru untuk aplikasi dalam NH_3 dan penyingkiran bau, sekali gus dapat melindungi alam sekitar daripada pencemaran bau.

ABSTRACT

The presence of ammonia (NH_3) which are emitted from palm oil mill effluent (POME) cause a highly unpleasant odour to the surrounding areas. NH_3 produced by anaerobic bacteria are emitted when POME is treated via anaerobic digestion. Therefore, concentrations of NH_3 need to be reduced for abatement of odour and health control. An investigation using modified peat soil as natural adsorbent by chemical activation using sodium hydroxide (NaOH) was carried out to study the characteristics and determine its suitability as a new adsorbent with its effect on the removal efficiency of ammonium produced by POME. Numerous studies have proved that peat soil potentially be useful as adsorbent in an aerobic condition due to contain high carbon content and pores. Result shows of NaOH were obtained from the ammonia test by 30 min of contact time, 100 rpm of agitation speed and 9 g of dosage adsorbent with value of 85%. Meanwhile for ratio 1:3 of NaOH activation, the result obtained by 90 min of contact time, 50 rpm of agitation speed and 9 g of dosage of adsorbent with value of 79%. The Scanning Electron Microscope (SEM) images of modified peat soil that activation by NaOH showed more porous space structure and create larger voids. While, the Fourier-transform Infrared (FTIR) demonstrated the different functional of the raw peat soil and modified peat soil. In this regard, the modified peat soil by NaOH activation can create a new industry for application in NH_3 and odour removal, thus can protect the environment from odour pollution.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Cd	Cadmium Hydrogen
H_2S	Sulphide
NH_3	Ammonia
N	Nitrogen
NH_3-N	Ammoniacal Nitrogen
Pb	Lead

LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DOE	Department of Environment
EPA	Environmental Protection Agency
POME	Palm Oil Mill Effluent
RPM	Revolutions Per Minute
SEM	Scanning Electron Microscope
SOC	Soil Organic Carbon
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
WT	Weight

CHAPTER 1

INTRODUCTION

1.1 Background

Palm Oil Mill Effluent (POME) treatment has always been a topic of research in Malaysia (Guest, 2022). POME is one of the major wastewaters produced in Malaysia which can damage the environment if not treated properly (Muhamad et al., 2022). This effluent that is extremely rich in organic content needs to be properly treated to minimize the environmental hazards before it is released into watercourses (Guest, 2022).

Based on previous researches study by (All Answers Ltd, 2021), it is proven that the effluent produced during palm oil production emits a highly unpleasant odour which will cause discomfort to the neighboring areas especially housing and commercial area. Odorous gases such as ammonia, NH_3 produced by anaerobic bacteria are emitted when palm oil mill effluent is treated via anaerobic digestion. NH_3 gas is an irritating gas with a pungent and suffocating odour (Yap et al., 2021). As to the effect of NH_3, due to high exposure concentration in air can cause immediate burning of the eyes, nose, throat and respiratory tract that can result in blindness and lung damage (Loh et al., 2019). Therefore, concentrations of NH_3 need to be reduced for abatement of odour and health control.

The main aim of this study is to evaluate the potential of applying peat soil as a natural adsorbent by using chemical activation process produce by POME. Therefore, the use of peat soils as an absorbent is one a strategy that can partially solve the problem of malodour. Peat soils are also known as organic soils. Peat soil have the ability to remove odour in an aerobic condition. It is because, according to (Budihardjo et al., 2021), peat soil contains high carbon content and pores which can potentially be useful in an adsorbent and it is widely available in Malaysia. The potential of peat soil as natural adsorbent to treat malodour has yet to be investigated.

Every treatment has its own advantages and disadvantages. The most efficient and commonly used adsorbent is commercially available activated carbon which is expensive and has regeneration problems. Recent investigations focused on effectiveness of low-cost adsorbents like pearl millet husk, coconut husk, wheat straw, wood, peat, banana pith, and agricultural waste in the removal of dyes from wastewater effluent (Guest, 2022). However, there is still scarcity of information in the literature on the use of low-cost adsorbents of POME.

Thus, this study was conducted with the purpose of determining the characteristics of peat soil and determining its sustainability as a medium for the treatment of malodour. Hence, the objective of this study to determine the characteristics of peat soil as adsorbent for treatment of malodour by using chemical activation process and determine the removal efficiency of ammonium in POME by using modified peat soil as adsorbent.

1.2 Problem Statement

Palm oil mill effluent (POME) has become a serious problem for the oil palm industries because of it is high organic contents and produces contaminant waste along with it that results in dark colour, slurry and unpleasant odour (Lau et al., 2021). According to (Yaacof et al., 2017), POME smell is so strong that the odour can be detected up to 1.5 km away from the mill, even reaching to about 5 km at times. The palm oil mill industry has always been linked to the environment issues. For instance, the establishment of the mill is believed to lead to issues of biodiversity loss, deforestation, land degradation, contributes to global warming and also environmental pollution such as water and air from the process's effluent and chemical reaction release (Yaacof et al., 2017). As the industry continues to grow, these issues may only intensify.

Effluent pond is the major source of odours. It is assumed that the odour emission from ponds is mainly driven by pond loading rate. This undesirable odour will not only affect the air quality concern but also the surrounding residential and institutional area. As shown by anaerobic digestion of landfill industries, odour is likely to be cause anaerobic process because of the anaerobic process emits ammonia, thus the anaerobic process for POME is likely generated from the anaerobic digestion process (Yaacof et al., 2017). Anaerobic digestion occurs when organic material is broken down by bacteria in the absence of oxygen into methane and carbon dioxide in four stages which are hydrolysis, acidogenesis, acetogenesis and methanogenesis (MDPI, 2018).

The anaerobic digestion system is being chosen because of several reasons, mainly because it requires low energy as it does not have aeration process (Eiman Hakim et., al 2018). It known as a particular kind of air pollutants which have become serious environmental concern for many years. As the population is increasing together with the urbanization in the nearby area around the plant palm oil mill, odour problem should be controlled to provide cleaner and fresh environment (All Answers Ltd, 2021).

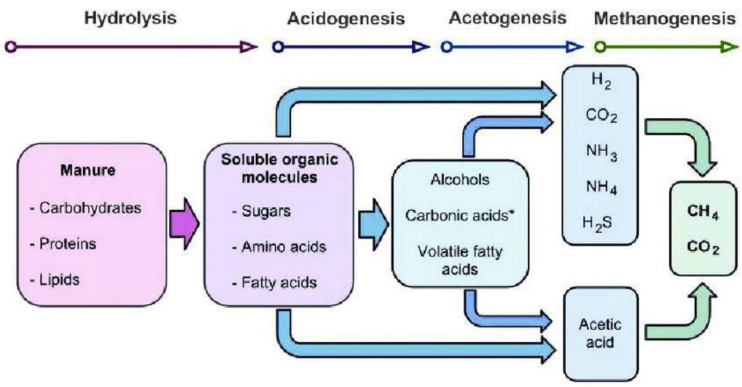


Figure 1.1 *Anaerobic Digestion Stages*
Source: Azhari (2017)

There have been numerous cases of odour pollution reported in Malaysia including the closure of wastewater treatment plant at Langat and Cheras (Malay Mail Online, 2016). Additionally, residents of the Kampung Titi Hitam have complained about a palm oil mill at Jawi that emits a strong unpleasant odour that depresses them and makes them feel ashamed around their family and friends (Shah, 2017). Besides that, the Semenyih water treatment plant was closed fourtimes following contamination in Sungai Semenyih which resulted in water disruption in several areas such as Hulu Langat, Kuala Langat, Sepang and Petaling due to odour pollution suspected to be from Semantan River in Pahang. (Bernama, 2016). From the reports, those complaints were submitted years ago but nothing was done because Malaysia lacked on odour legislation, a proper way for conducting odour assessments and a strategy to reduce the odour emissions (Yaacof et al., 2017).

There are a lot of odour control technologies can be applied but those technologies are expensive and high maintenance. Therefore, this research was made to fill the gap in finding the right method in reducing the problem of odour in Malaysia. In improving this problem, there is a method that is more efficient and low cost which is peat soil as a natural adsorbent by using chemical activation process.

1.3 Objective

The objectives of the study are:

1. To create natural adsorbent from peat soil by using chemical activation process.
2. To determine the characteristics of peat soil as adsorbent for treatment of malodour.
3. To determine the removal efficiency of ammonium in POME by using modified peat soil as adsorbent.

1.4 Scope of Work

This study generally focused on the ability of peat soil as a natural adsorbent by using chemical activation process to reduce the effluent of odour from palm oil factories. The POME was collected from Palm Oil Mill Sdn Bhd, Felda Lepar Hilir 3, Gambang, Pahang. The sample was obtained from anaerobic pond and the effluent was collected in plastic containers from the pond 1 effluent. The containers were properly washed and rinsed with the effluent before collection to avoid contamination and dilution.

POME sample taken was stored in the chiller at 6°C and stored in a 6L tank to prevent the changes on its characteristics. The sample was kept not more than two weeks to avoid excessive deterioration and then should be discarded (Efluen et al., 2017). It will be kept in an anaerobic condition for 36 to 48 hours to obtain the sufficient amount of the target which are NH_3. The date and time were recorded together with all the relevant details of location and sampling conditions on the label. Analysis of various parameters were carried out within 24 hours after the sample collection. Furthermore, the total duration of this study is 30 days and palm oil mill effluent (POME) sample was collected two times per month. The sample was taken from the fourth pond which is the anaerobic pond 2 at the palm oil processing factory.

The peat soil was obtained at Jalan Gambang, Pahang and then dried at 110°C (ATM, 2019) in oven for 24 hours to remove all pore water from the soil. After drying, peat soil was sieved by the sieve of 1 mm mesh size. Then, the sample of adsorbents were examined by a Scanning Electron Microscope (SEM) and Fourier-transform Infrared (FTIR) for surface morphology and chemical compositions. The sample by using chemical activation process with peat soil will be discussed more in Chapter 3.

The treatability studies were done on Environmental Laboratory of Civil Engineering Technology, Universiti Malaysia Pahang by finding optimum parameter such as contact time, dosage and agitation speed with the differentiation ratio of peat soil and the solution of NaOH. Lastly, the removal efficiency of ammonium in POME with modified peat soil as adsorbent were determined by using spectrophotometer.

1.5 Importance of Study

This research focuses on evaluating the effective of using natural adsorbent which is peat soil will act as an odour control in reducing the odour produced by Palm Oil Mill Effluent (POME). Besides, this study also to determine the characteristics of using peat soil by using chemical activation process as an adsorbent media for treatment of malodour and at the same time it will helping the Department of Environment (DOE) recognizing odour control technique for odorous area (All answers Ltd, 2021). It is very important to tackle odour pollution resulting from palm oil mill which almost caused a less comfortable in all areas.

Therefore, this study aimed to help to reduce the odour resulting from waste treatment ponds of palm oil. With the establishment of this odour barrier the problem of odour resulting from the treatment pond plants can be controlled from spreading and almost caused severe odour problems to the neighboring area including villages, residential areas and institutions. In addition, from this research also could help oil palm industry in forming a way to curb the problem of smell that produce from palm oil mill.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explains about the palm oil mill since it is the potential source of odour problem in the study area. The information about the odour definition and the odour treatment used are discussed in this chapter. Next, the details about the Palm Oil Mill Effluent (POME) and the environmental problem involved in this treatment. One of the highlighted in this chapter is POME odour problem where it reviews the compounds in POME malodour emission and the natural adsorbent that have been implemented to reduce malodour produced by POME.

2.2 Palm Oil Industries in Malaysia

The Malaysian palm oil industry has grown significantly in recent years to become one of the largest oil exporters and producers in the world (Tan & Lim, 2019). Table 2.2 is the distribution list of the palm oil mill industry in Malaysia.

Table 2.1 Lists of Palm Oil Mill around state in Malaysia

States in Malaysia	Number of Palm Oil Mill
Sabah	124
Pahang	71
Johor	65
Sarawak	62
Perak	46
Selangor	20
Negeri Sembilan	15
Terengganu	13
Kelantan	11
Kedah	6
Melaka	3
Pulau Pinang	2

Malaysia is the second leading producer of palm oil worldwide, supplying around a third of the world's palm oil after Indonesia (R. Hirschmann, 2022). The palm oil factories in Malaysia and palm oil suppliers in Malaysia produce around 16.5 million tons of palm oil annually and almost 2 million tons palm kernel oil every year (BizVibe, 2018).

2.3 Palm Oil Mill Effluent (POME)

Palm oil processing is a multi-stage operation that produces a large amount of effluent known as palm oil mill effluent (POME) (Mohammed et al.,2017). POME has become a serious problem for the oil palm industries because of its high organic contents and other contaminant formation that results in dark colour, turbid and unpleasant odour (Lau et al., 2021). A study by Krishnan et al. (2017), agro-wastewater like POME can be considered as one of the critical environmental problems in Malaysia due to the enormousness of hazards, voluminous, abundance and disposal issues ((Mohammad et al., 2021) released to the environment.

According to (Hesam Kamyab et al., 2018), although it is a non-harmful waste, POME has an extremely unpleasant odour that will cause discomfort in the surrounding areas especially residential and commercial areas. The unpleasant smell from those facilities may lead to worker various kinds of disease such as nausea and headache. Its characteristic palm oil mill effluent smell is so strong that the odour can be detected up to 1.5 km away from the mill, even reaching to about 5 km at times (Yaacof et al., 2017). Odour commonly exist as a form of gas such as ammonia, (NH_3) and hydrogen sulphide, (H_2S). Therefore, concentrations of H_2S and NH_3 need to be reduced for abatement of odour and health control.

Next, POME is 100 times more polluted than the municipal sewage which has a high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) (Hesam Kamyab et al., 2018). POME is an oily wastewater and form of thick brownish colour liquid waste and slurry. Therefore, the odour problem should be controlled to provide cleaner and fresh environment is increasing together with the urbanization in the nearby area around the plant palm oil mill. Furthermore, it is necessary to properly address the POME treatment so as not to contribute to human health hazards and environmental pollution.

2.4 Palm Oil Mill Treatment Process

Different techniques were used in Malaysia for the treatment of POME for biological control which are consists of anaerobic, facultative and aerobic pond systems over the past 20 years. POME is one of the major wastewaters produced in Malaysia which can damage the environment if not treated properly (Muhamad et al., 2022). Ponding system or land application is the most widely used at the majority of palm oil mills (85%) for effluent treatment, due to cost-effectiveness, low maintenance costs, energy efficiency, system reliability, and simple design (Mohammad et al., 2021). Figure 2.4 shows the standard process flow of the POME treatment ponds that are usually being used in the mill.

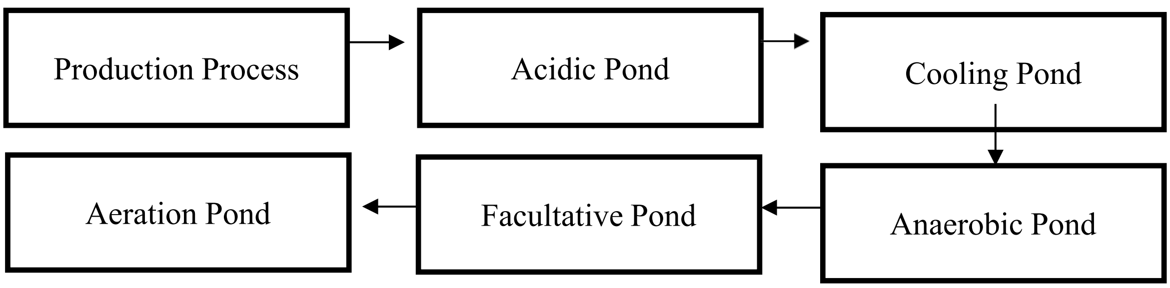


Figure 2.1 *Process flow for palm oil mill effluent (POME) treatment pond*

POME treatment ponds are different from ordinary wastewater treatment ponds because each step has its own function and purpose depends on the amount of the wastewater. In this mill, the treatment system using for effluent is ponding system. It consists of production pond, acidic pond, cooling pond, anaerobic pond, facultative pond and aeration pond. In the acidic pond, the content is thick and a layer of solid is covering the top. This part has the strongest sourly smell.

The process started with acid pond where the acidification phase covers the acid forming anaerobic bacteria into free fatty acids. After that, the content from acidic pond will goes through cooling pond for further treatment. In cooling pond, this pond will be cool down the temperature of the wastewater for the bacterial treatment. The content of cooling pond still looked much like the acidic pond. While cooling, high initial temperature of POME promotes thermal and anaerobic digestion, mainly via hydrolysis and acidogenesis. (Mohammad et al., 2021).

Then, it will flow into the anaerobic ponds usually by gravity. Anaerobic bacteria in anaerobic pond decompose organic matter to methane and other gases such as hydrogen sulphide which is known as one of the odorous gases. There is lack of research in studying the amount of the odorous gaseous that emit during the POME wastewater treatment process which is the formation and chemical reaction mostly happen in the anaerobic digestion.

Next process will be aeration pond where greater amount of dissolved oxygen is supplied by using an aerator. Through aeration, the aerobic microorganism in the pond will decompose most of the soluble organic matter. Finally, the wastewater will flow to the facultative pond. This pond is to make sure that the surface area of the lagoon should be large enough to provide atmospheric oxygen to prevent aerobic condition. Among all of the treatment ponds, the anaerobic pond releases the highest amount of biogas compared to other ponds (Alawa et al., 2022). For the ponding system, the long retention time of 20 days are needed before the biogas will be released to the atmosphere. Therefore, the untreated wastewater from the palm oil industry can bring adverse environmental effects and should not be neglected.

2.4.1 Anaerobic Digestion Process

Anaerobic digestion occurs when organic material is broken down by bacteria in the absence of oxygen into methane and carbon dioxide in four stages which are hydrolysis, acidogenesis, acetogenesis and methanogenesis (MDPI, 2018). According to (Yap et al., 2021), ammonia and hydrogen sulphide as odorous gases produced by anaerobic bacteria are emitted when palm oil mill effluent (POME) is treated by anaerobic digestion. The anaerobic digestion system is being chosen because of several reasons, mainly because it requires low energy as it does not have aeration process (Eiman Hakim et., al 2018).

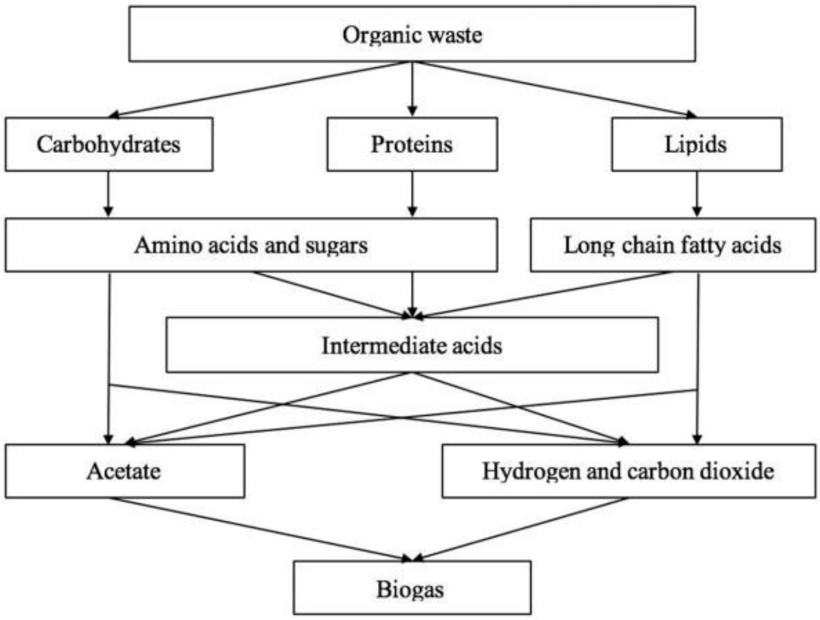


Figure 2.2 *Anaerobic Digestion Processes*
Source: MDPI (2018)

Hydrolysis is the process in which carbohydrate, proteins, fats are converted to sugars, fatty acid and amino acids. Acidogenesis is the process in which the sugars, fatty acids, and amino acids are converted to carbon dioxide, ammonia, and acids, Acetogenesis is the process which creates acetic acid and carbon dioxide. The final process, methanogenesis is when biogas is formed. Biogas contains a mixture methane and carbon dioxide gases.

2.5 Odour

Odour pollution is one of the particular kinds that ever existed as environmental pollution in Malaysia especially in air pollution (Nasir Nayan et al., 2020). People may react to odour in different ways. An odour can be pleasant or unpleasant depending on how everyone evaluates it. For example, people who would walk into a bakery would enjoy the smell of fresh baked breads compared to people who living near the bakery might not enjoy those strong smells every day (Odors & Health, 2019).

The unpleasant smell has usually been called offensive odour and something smell that everyone wants to avoid. There are various offensive odour sources in the industries such as farms, livestock operations, palm oil mill, sewage treatment, wastewater treatment plant, industrial factories and rubber factory. The impact of offensive odour not only created inconveniences but also exposed the surrounding population to mild discomfort to more serious problems such as may get headaches, eye irritation, feel dizzy or nauseous and breathing problems. In reality, most of the large-scale operations such as animal farming activities are do not really have significant odour control strategies in place, thus it would contribute to the rise in complaints in Malaysia (Jabatan Alam Sekitar, 2019).

If an odour keeps occurring, it also could affect mood, anxiety and stress level. In general, odour pollution usually contributes to the deterioration of air quality and affect the human lifestyle as it can be spread widely into the environment. Repeated exposure to odour can lead to a high level of annoyance and the receiver may become particularly sensitive to the odour (Jabatan Alam Sekitar, 2019). Everyone have the right to live in a clean and odour-free environment, thus an odour threat should not be taken lightly as it is capable of violating daily activities of the local population.

2.6 Odour Substances

The substance that produces an odour is called an odorant (Alberta,2017). Some odours can be health hazards and some are not. There are a variety of chemical contaminants found in a variety of sources. For example, volatile organic compounds (VOCs) are common chemical contaminants found in environments and are a source of odour that can easily evaporate into the air (NIOSH, 2022). Many industries processes including livestock and palm oil mill production emit hazardous gases such as hydrogen sulphide (H_2S) and ammonia (NH_3). The presence of both gases are the most problematic contaminants causing odour nuisance to the surrounding community (F. Farhana et al., 2020). H_2S and NH_3 are highly toxic gases which could potentially be fatal to human and animals at certain concentration levels (Suraj Kumar, 2018). Ammonia emissions impact human and ecosystem health while hydrogen sulphide is primarily a human health concern. Thus, emissions of hazardous gases from industry poses a risk to workers, animals and environment (Suraj Kumar, 2018).

2.6.1 Ammonia (NH_3)

Similarly, NH_3 gas is also very toxic to human, animals and environment which is both naturally occurring and manufactured. NH_3 is a colourless gas, lighter than air, highly water-soluble and has a sharp and pungent odour (Ammonia, 2022). Its pungent character makes it easy to identify among other gases. Due to the low evaporation temperature, NH_3 can easily evaporate and release odours in the atmosphere (Senatore et al., 2021). NH_3 can be produced from both anaerobic and aerobic processes. NH_3 is a pollutant which can have significant effects on both human health and the natural environment. According to (Guthrie et al., 2018), the main source of NH_3 pollution is agriculture, where it is released from manure and slurry. NH_3 is also emitted in smaller quantities from the other sources, including landfill sites, sewage works, car emissions and industry (Guthrie et al., 2018).

2.7 Odour Treatment

Odour treatment system is a system created to help control and reduce the odour pollutant in the environment. In this chapter, the system discussed was focused more towards NH_3 treatment. Various processes involving physical, chemical and biological with each with its own benefits such as adsorbents usage, biofilter, bio trickling filter, activated sludge, wet-scrubbers and ultra-violet. These methods were commonly used to remove the odour by POME. Odour treatment system is a promising alternative because it is energy saving, environmentally sustainable and low cost of service. There are many types of adsorbents such as natural adsorbent, activated carbon, activated alumina and polymeric adsorbents. For this research, adsorbent was chosen as a method to remove odour malodour produce by POME because it suits everyone budget. Therefore, adsorbent method as a another alternative due to energy saving, environmentally sustainable, low cost of service and more efficient in order to remove odour and gas.

2.7.1 Biofiltration

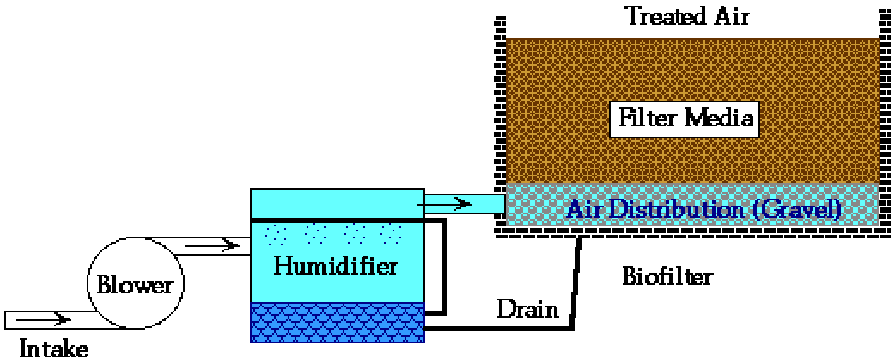


Figure 2.3 *Biofiltration*
Source: Odor Treatment – Biofiltration - Cornell University (2021)

Biofiltration is one of the odour treatments that is widely used globally. A biofilter adsorbs and then biologically degrades odorous chemicals using moist organic materials. Cooled and humidified compost process air is typically injected into a bed of filtration media through a grid of perforated pipes. Compost, soil, peat, chipped brush, and bark have all been used in the creation of biofilters, which are sometimes combined with a biologically inert material like gravel to ensure proper porosity. Biofilter beds typically range in depth from 1 to 1.5 metres, with shallower beds being more susceptible to gas flow short-circuiting and deeper beds being more difficult to keep evenly moist. Biofilters have been proven to be effective at treating odours associated with composting, including ammonia and a wide spectrum of volatile organic chemicals (Biofiltration - Cornell University, 2022).

2.7.2 Wet Scrubbers

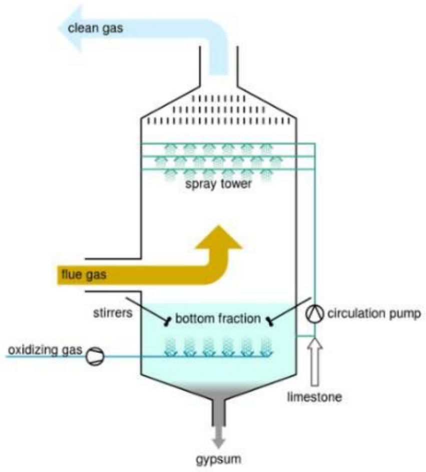


Figure 2.4 *Wet scrubber*

Source: Wet Scrubber - Energy Education (2018)

Wet scrubber is a device that remove pollutants from a furnace flue gas or from other gas streams. In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid, by spraying it with the liquid, by forcing it through a pool of liquid, or by some other contact method, so as to remove the pollutants. Scrubbers can be designed to collect particulate matter and/or gaseous pollutants depends on the industrial process conditions and nature of the air pollutants involved. Besides, Wet scrubbers remove dust particles by capturing them in liquid droplets. The droplets are then collected, the liquid dissolving or absorbing the pollutant gases. Moreover, Wet scrubbers that remove gaseous pollutants are referred to as absorbers. Good gas-to-liquid contact is essential to obtain high removal efficiencies in absorbers.

2.7.3 Ultra-Violet

Figure 2.5 *Ultra-Violet*

Source: Hydroxyls for Odour Control with Waste Water (2015)

Ultra-violet (UV) is nowadays most advanced and environmentally friendly solution to odour problem. It effectively eliminates odours from kitchen emissions by utilizing the natural cleansing characteristics of UV light and ozone. This device has been professionally developed to assure efficiency, from the modules unique, self-cleaning, and reflecting inner surfaces to the ozone control mechanism that adjusts ozone production in line with cooking activities. Basically, UV light gets rid of odour because of oxygen in the ambient air is converted into ozone, this highly unstable compound is a natural air cleanser and will oxidize contaminants and allergens on contact.

2.7.4 Adsorption

One of the most common physicochemical processes for removing pollutants from water and wastewater is adsorption. It has a known for being one of the most effective environmental control techniques (Baccar et al. 2017). The adsorption method is frequently used to remove several types of contaminants from water, including dyes and heavy metals (Burakov et al. 2018; Gisi et al. 2016). For instance, Hameed et al. (2007) reported that Methylene Blue, a common pollutant present in textile, plastic, and dye industrial effluents, may be efficiently removed from water by using an adsorbent. Its widespread appeal in the water and wastewater treatment industry may be attributed to its simplicity, efficiency, and ease of use (Bhatnagar et al. 2015).

Adsorption is a process, in which malodorous substances will be retained on the surface of the sorbent or a solid (Wysocka et al., 2019). Adsorption is also considered as a green technology because of the potential of recyclability of the adsorbents and the production of quality-treated effluent suitable for discharge (Oyekanmi et al., 2019). For this research adsorbent is used as a method to remove odour released by the POME. Adsorbent process is found to be the most suitable technique to remove pollutants from wastewater. Apart of removing many types of pollutants, it also has wide application in water pollution control.

In the palm oil industry, the most conventional treatment method is biological process of effluent management towards safe discharge such as the use of anaerobic digestion, aerobic treatment system such as advanced oxidation including photocatalysis and Fenton oxidation, membrane separation and solvent extraction. However, the conventional approach especially the application of biological treatment system is very expensive and in most of the cases, they are not effective for the treatment of organic pollutants of high strength wastewater at low concentration.

In general, an adsorbent can be considered as low cost if it does not require complicated processing for production and it can be easily obtained or abundantly available in nature (Hong Tan et al., 2018). Other than that, adsorption is more applicable because of its high potential to treat pollutants at low concentration which is considered as the major limitation of existing conventional treatment methods among the wastewater treatment methods. Table 2.2 shows types as adsorbent to remove substances.

Table 2.2 Example of Adsorbents

Types	Removal substances	% Removal of substances	Optimal condition	References
Recycled Paper Mill Sludge with Sulphur Oxidizing	H_2S, NH_3	60.45% for retention time, 69.55% of agitation speed	30 min contact time, 55 rpm of agitation speed and 8% of PVA concentration	(F. Farhana et al., 2020)
Oil Palm Trunk Derived Activated Carbon	Colour and COD	99% in removal COD, colour	dosage of 15 % w v^{-1} in 48 hours	(Lau et al., 2021)
Activated Coconut Shells Carbon	COD and NH_3-N	45.2% reduction of COD and 65.4% removal of NH_3-N	35cm^3	(Oyekanmi et al., 2019)
Peat	Nickel and Lead (ii) ions from aqueous solution	100%	3 min 15 and 30mg/L,	(Bartczak et al., 2018)
Banana Peel	Colour, TSS COD, tannin and lignin and BOD	95.96%, 100%, 97.41% and 76.74%	pH of 2, contact time of 30h and adsorbent dosage of 30 g/100ml	(Mohammed & Chong, 2014)

2.8 Peat Soil as adsorbent

A Malaysia study by (Rosli et al. (2017) suggests that adsorbents derived from peat can be used to successfully remove colour and Fe in landfill liners. A lab- based study using activated carbon from peat soil has successfully reduced Pb and Cd concentrations in artificial solution (Marques et al., 2020). Besides, removal of nickel (II) and lead (II) ions from aqueous solution using peat as a low-cost adsorbent (Bartczak et al., 2018).

Several studies have reported on the adsorbent properties of physically and chemically activated peat soil and coal. According to Rosli et al. (2017) suggests that adsorbents derived from peat can be used to successfully remove color and Fe in landfill liners. The combination of activated carbon and peat successfully reduced 75% of color at a ratio of 2:2, and the most effective combination for Fe removal was found to be activated carbon and peat at a ratio of 5:3. A lab-based study using activated carbon from peat soil has successfully reduced Pb and Cd concentrations in artificial solution (Marques et al., 2020).

Peat also has high water absorption properties. Dry mineral soils can hold water 1/5 - 1/2 of its weight while peat soil can hold 2–4 times its dry weight (Dedik B, 2018). Peat soil are low-cost adsorbents, and more readily available in remote areas than other adsorbent materials such as zeolite, bentonite, and coconut shells (Fazal et al., 2021 Therefore, peat soil have the ability to remove odour in an aerobic condition due to contain high carbon content and pores which can potentially be useful in an adsorbent and it is widely available in Malaysia (Budihardjo et al., 2021).

Peat soil is also one of the carbon rich materials. Peat soil has a low mineral concentration but is rich in celluloses, hemicelluloses, and lignin. It is made up of partially decomposed leaves, branches, twigs, and tree trunks. Peat soil is unsuitable for the agriculture business due to its high acidity and low amounts of accessible nutrients, which has unfortunately led to its reputation as a troublesome soil (Wong 1991; Cheong and Ng 1977). Peat soil also has a very low carrying capacity and shear strength, making it unsuitable for the construction of bridges, roads, or any other load-bearing engineering structures (Islam and Hashim 2010).

2.9 Chemical Activation

Chemical activation refers to a single step process in which the carbonization and activation process occurs simultaneously. The most common chemical agents used are $ZnCl_2$, H_3PO_4, KOH and NaOH (Hong Tan et al., 2018). Alkali hydroxydes such as NaOH and KOH are usually used as agent for the activating of AC because of the good development of porosity produced by them (Foo & Hameed et al.,2017). It also known as multi-million-ton per annum commodities and strong chemical bases that have large scale applications.

Some of them are related with their consequent ability to degrade most materials, depending on the temperature used. As an example, these chemicals are involved in the manufacture of pulp and paper, textiles, biodiesels, soaps and detergents, acid gases removal (e.g., SO2) and others, as well as in many organic synthesis processes (Linares-Solano et al., 2017). Although these two hydroxides are strong and corrosive bases, NaOH and KOH are interestingly stable chemicals that melt without decomposition at 318ºC and at 360ºC, respectively (Linares-Solano et al., 2017).

Although KOH and NaOH can be used interchangeably in a large number of applications, NaOH is preferred by the industry because of its lower cost. Hence the worldwide production of NaOH is about one hundred times higher than for KOH, the production of NaOH was 70 million tonnes, whereas it was approximately 700,000 tonnes for KOH. NaOH activation in comparison with KOH activation has advantages such as lower dosage, cheaper, more environmentally friendly and less corrosive (Cazetta et al., 2017).

2.10 Summary

The odour emission from the palm oil has been recognized as nuisance to the surrounding areas especially to the surrounding community. According to the previous researches, ammonia NH_3 is one of the odorous compounds contributing to the strong offensive smell of generated from the anaerobic treatment of effluent. Thus, it is important to work on the efforts in reducing this malodour. A study is required to address this knowledge especially in the management of odour from palm oil mills.

The literature review suggest that peat soil is one of the potential successful methods as adsorbent. Based on its characteristics, peat soil contains high carbon content and pores which can potentially be useful in an adsorbent in an aerobic condition. Adsorbent is proven as a method to remove odour malodour produce by POME because it suits everyone budget. These would help because adsorbent method as a another alternative due to energy saving, environmentally sustainable, low cost of service and more efficient in order to remove odour and gas. However, the effectiveness of peat soil as adsorbent to reduce ammonium in palm oil mill effluent by using NaOH activation has yet to be proven and thus research needs to be conducted to prove it.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This study is to use peat soil as a natural adsorbent for treatment of malodour. This study evaluates the characteristics of peat soil and defines its suitability as a new adsorbent for treatment in terms of elimination of NH_3. The test characteristics included Scanning Electron Microscopy (SEM) and Fourier-transform Infrared (FTIR). The modification of peat soil using chemical activation as new adsorbent are introduced. Besides that, to determine the removal efficiency of ammonium in Palm Oil Mill Effluent (POME), the operating optimal parameters will conduct include agitation rate, contact of time and dosage of adsorbent. This chapter will explain further the materials and methods used in the experimental work to reduce odour in the wastewater. Figure 3.1 shows the chart of the research flow of this study.

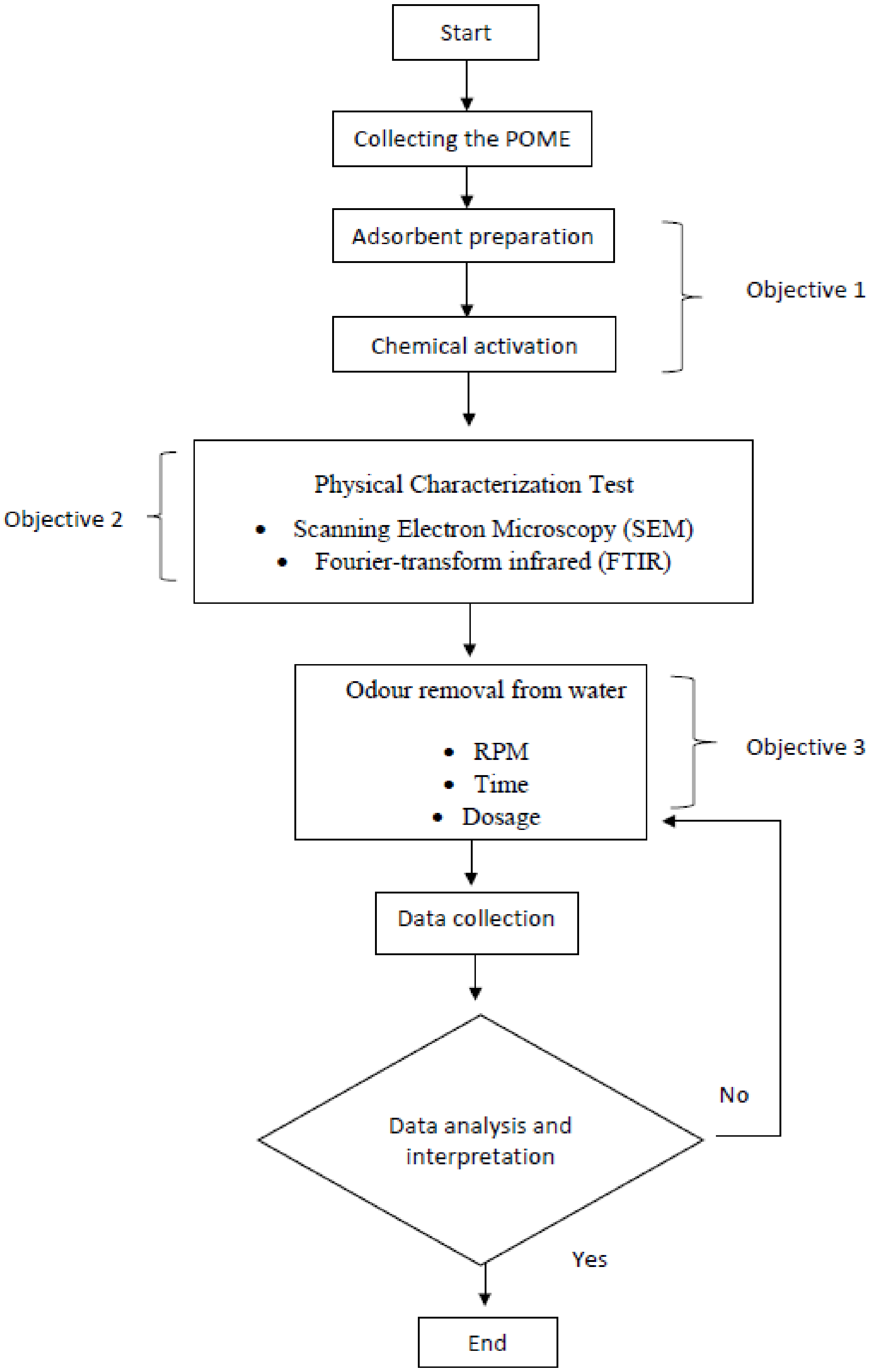


Figure 3.1 *Research Flow Chart*

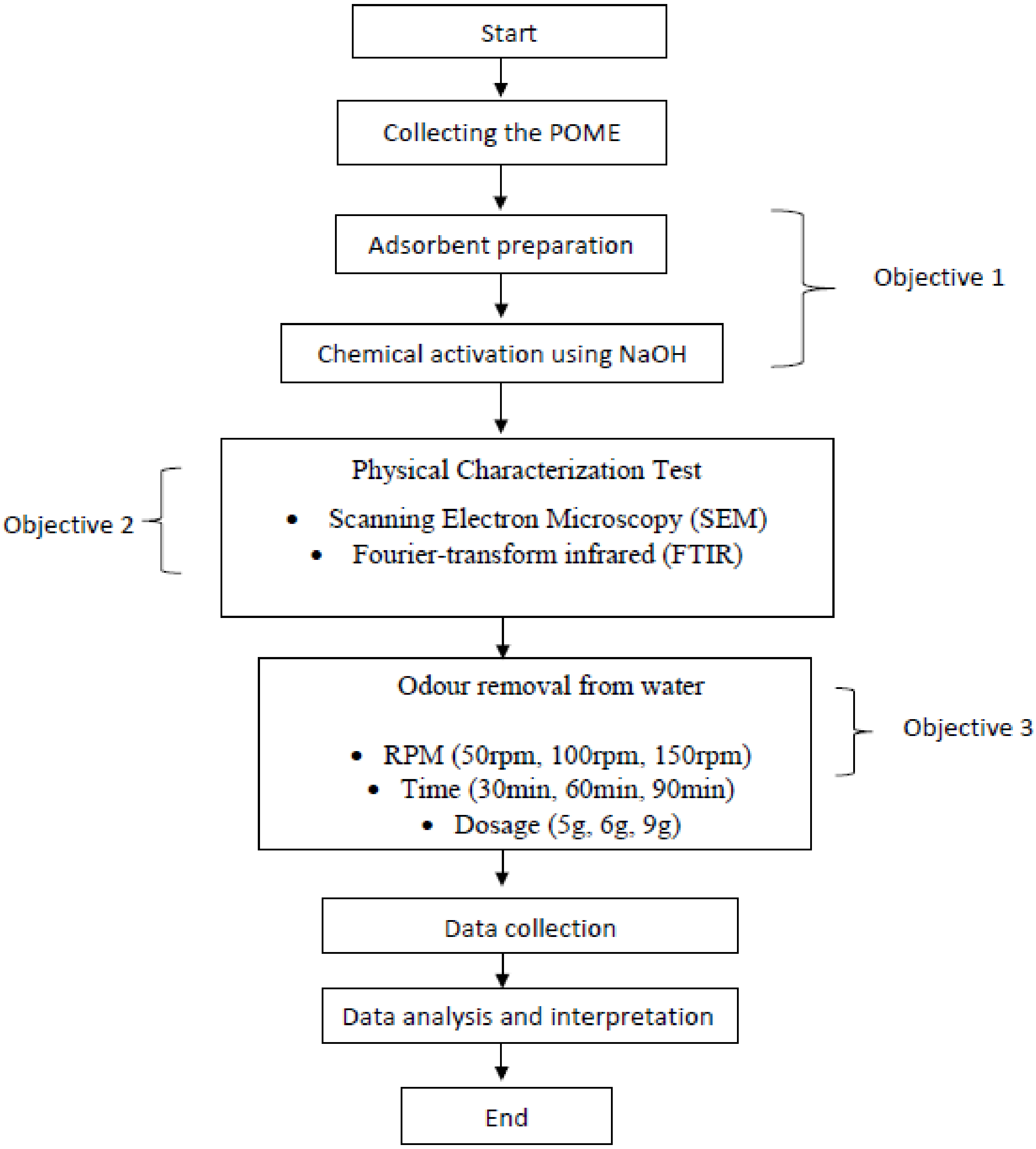


Figure 3.2 *Flow Chart for Odour Removal from Water*

3.2 Sample of Palm Oil Mill Effluents

This study was conducted to investigate odour disturbance produce by palm oil mill at Felda Palm Industries Sdn Bhd, Felda Lepar Hilir 3, Gambang, Malaysia. The total duration of this study is 30 days and Palm Oil Mill Effluent (POME) sample was collected two times per month.

After that, the effluent was collected in plastic containers from the 1st pond effluent. The containers were properly washed and rinsed with the effluent before collection to avoid contamination and dilution.

Then, the containers were brought back to laboratory and store in chiller at temperature of 6°C to maintain in its original condition for tests and analysis (F. Farhana et al., 2020). The date and time were recorded together with all the relevant details of location and sampling conditions on the label. Analysis of various parameters are carried out within 24 hours after the sample collection. The specific location of POME sample collection is show in Figure 3.3 which is located at coordinate 102°59’15” E, 3°39’37” N.

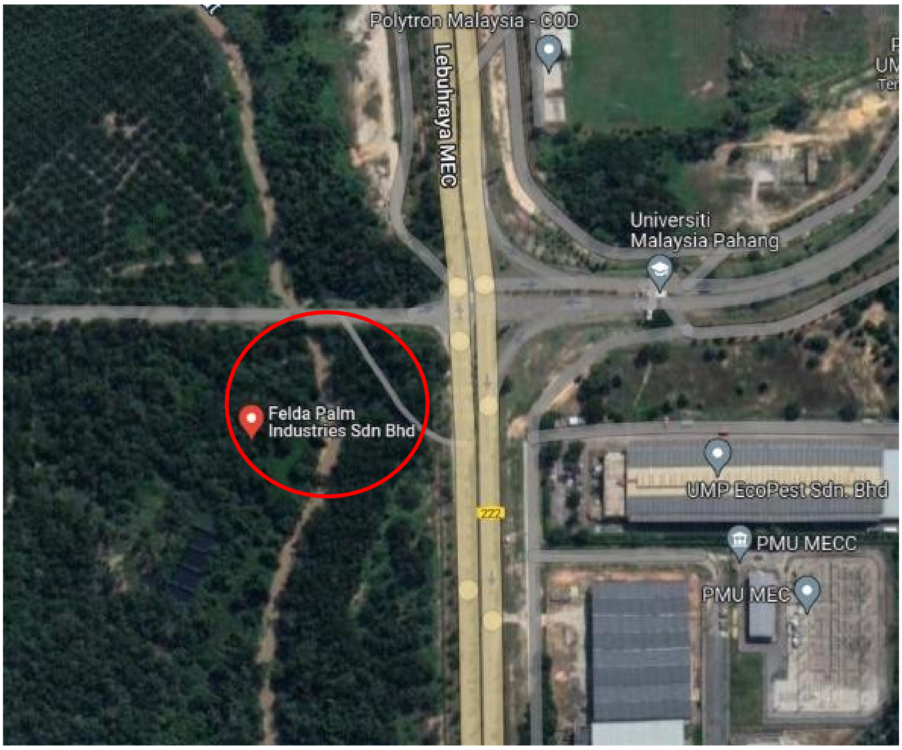


Figure 3.3 *Location Map of Felda Lepar Hilir 3 Palm Oil Mill Sdn Bhd*
Source: Google Maps (2022)

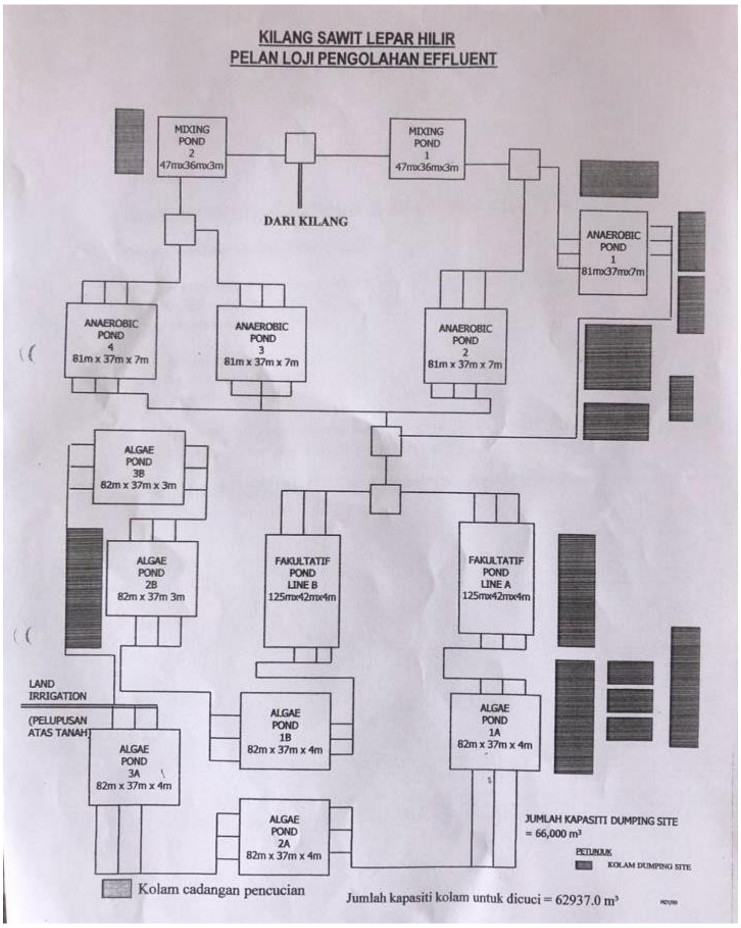


Figure 3.4 *Plant Layout of Felda Lepar Hilir 3 Palm Oil Mill Sdn Bhd*

Source: Felda Palm Oil Lepar Hilir 3 (2022)

Figure 3.5 *Collection of POME Sample in Anaerobic Pond*

Source: Felda Palm Oil Lepar Hilir 3 (2022)

3.3 Collection and Preparation of Adsorbents

The samples were prepared by chemical activation with Sodium Hydroxide, NaOH solution as activating agent. Initially, peat soil was obtained at Jalan Gambang, Pahang. The peat soil was taken from a depth of 5 until 20 cm.

Figure 3.6 *The Sample of Peat Soil*

Peat soils were dried at 110°C (ATM, 2019) in oven for 24 hours to remove all pore water from the soil. After drying, peat soil was sieved by the sieve of 1 mm mesh size. The particle size is obtained by using standard mesh sieves (standard sieve AS 200) to obtain particles of sizes up to 0.375 and 1.0 mm (ATM, 2019).

Figure 3.7 *Condition of Peat soils after in oven*

3.4 NaOH Activation

In this study, we used sodium hydroxide (NaOH) as an activating agent instead of KOH. The ratio between raw peat soil (g) and NaOH solutions (mL) were 1:2 and 1:3. 10ml of 2 mol/L NaOH solution and 990 ml of purified water were added in a beaker. Then, 10g of peat soils were impregnated with 200ml of dilute NaOH solution for NaOH activation 1:2. The test solutions were stirred with magnetic stir on a hot plate at 85°C for 8 hours.

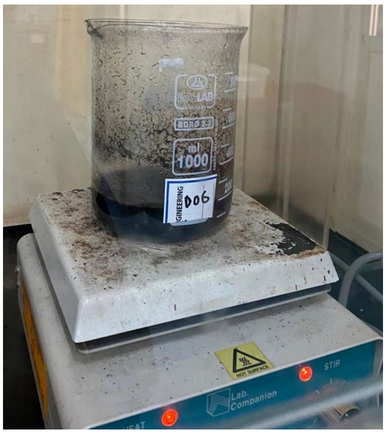


Figure 3.8 *The sample were stirred on a hot plate*

After cooling, the sample was subjected to thorough washing with distilled water until the samples obtained by filtration showed neutral pH which was 6.5-7.5 value by pH meter to ensure total remove of acid. Then, the samples were dried in oven at 120°C for 5 hours before the experiment. The step was repeated for ratio 1:3 NaOH activation.

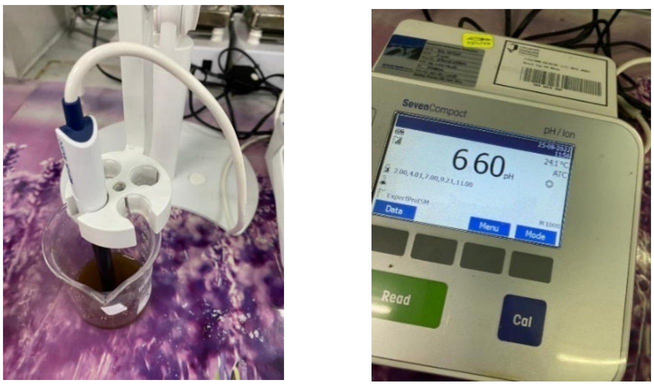


Figure 3.9 *The adsorbent was checked with pH meter.*

Figure 3.10 *The adsorbent After Dried*

3.5 Physical Characterization Test

The sample of adsorbents were examined by a Scanning Electron Microscope (SEM) and Fourier-Transform Infrared (FTIR) for surface morphology and chemical composition. Both samples were submitted to Central Lab, Universiti Malaysia Pahang and the samples must be dried in advance. This is because higher temperature of temperature of 105ºC will destroy the fiber. The SEM test was conducted by using JEOL SEM instruments. The oven dried peat samples used in this test were coated with gold before taking SEM images. The micrographs were taken at a magnification of 20µm for both samples.

Meanwhile, FTIR was used to identify its surface functional groups. The chemical characterization of the functional groups of peat soil was analyzed by a Thermo Fisher Scientific Nicolet iS50 FTIR. The analysis was carried out at room temperature by using Potassium Bromide (KBr) pellet technique where the absorbance spectrums were recorded in the range 440-3900 cm^{-1} with a resolution of factor 4 cm^{-1} (Rosi et al., 2022).

3.6 Adsorption Experiment

In each adsorption experiment, 100 ml of POME was added to different amounts of adsorbent (5 g, 6 g, 9 g) respectively in conical flask with covering by aluminum foil as a lid to prevent contamination of microorganism from surrounding air. After that, determined the optimum parameters such as contact of time, agitation of speed and differentiation adsorbent of dose using orbital shaker (New Brunswick Scientific Excella E1 Platform Shaker) as shown in figure 3.10. After obtained their optimum, the adsorbent tested with ammonia test by using the spectrophotometer.

Figure 3.11 *The samples of adsorbent to determine optimum parameter*

3.6.1 Effect of Contact Time

The effect of time on the chemical activation process between modified peat soil and raw peat soil was determined by incubating the solution at 30 min, 60 min and 90 min. Result shows the effect of agitation time on 1:2 and 1:3 NaOH activation by modified peat soil at different dosage. This study confirms that agitation time effects the rate of adsorption of ammonium reduction. The longer the agitation time, the more NaOH will be adsorbed into the adsorbent. The results indicate that the optimum adsorption capacity of modified peat soil is 85% on 100 rpm with 9 g of adsorbent, after an agitation process lasting for 30 min. An increase in removal percentage was seen with increased contact time.

3.6.2 Effect of Agitation

The effect of agitation rate on the NaOH activation of adsorbent at various speeds of 50, 100 and 150 rpm. Maximum adsorption capacity was reached when the adsorbent and NaOH were agitated for 90 minutes at a speed of 100 rpm. The agitation process was carried out to accelerate the collision rate between the adsorbent and NaOH. The faster the collision rate, the faster the rate at which the adsorption process occurs (Budihardjo et al., 2021).

3.6.3 Effect of Adsorbent Dose

The peat dose is a very important parameter for the quantity removal of ammonium in POME. In this research, the process was carried out for different masses of sorbent were 5g, 6g, and 9g to investigate the suitability of chemical activation on the adsorbent media. The highest value obtained was 85% when 9 g of peat was used.

3.7 Wastewater Quality Test

Nitrogen ammonia was the parameter in wastewater quality to test in this study. That parameter was chosen because of the possibility in contributing the odour problem in the POME. It was analyses using DR5000 and the procedure follows a standard method accepted by USEPA. A spectrophotometer, HACH DR5000 was used to measure the POME wastewater analysis. DR5000 capable to store more than 240 analytical methods and those methods are complied with EPA. It uses 190-1100 nm of the wavelength to detect the chosen component.

3.7.2 Nitrogen Ammonia Test

First, start program 385 Nitrogen Ammonia by using Salicylate Method. Then, prepare the sample cell with 10ml of sample. Next step is to prepare the blank sample. Fill with 10ml with deionized water. Then, add the content of one Ammonia Salicylate Powder Pillow to each cell. Stopper and shake to dissolve. Start the instrument timer and wait for 3 minutes reaction time starts. When the timer expires, add the contents of one Ammonia Cyanurate Reagent Powder Pillow to each cell. After that, start the instrument timer and wait for 15 minutes reaction time starts. A green colour will develop if ammonia-nitrogen is present. When the timer expires, insert the blank into the cell holder for zeroing. The display shows 0mg/L. Clean the prepare sample and insert the prepare sample into the cell holder and the concentration can be obtain immediately.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter presents the result of the experimental work to address the objective of the present study. The results were discussed in terms of removal efficiency for ammonia (NH_3) in palm oil mill effluent. In this study, the results obtained were discussed based on the activation of peat soil was carried out using the chemical activation method. NaOH was used as the activating agents at two different impregnation ratio; 1:2 and 1:3 respectively to neutral them to non-odorous

4.2 Experimental Data for Finding Optimum Parameters

4.2.1 1.2 Activation Ratio for NaOH

Manipulated Variable: 1. Retention Time (min)

2. Dosage (g)

Responding Variable: Adsorption Rate (%)

Constant Variable: Agitation Speed (50 rpm)

Table 4.1 Ammonia Test Data for 50rpm

Time	30 min		60 min		90 min	
Dosage	5g		5g		5g	
	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)
	8.1	4.5	8.1	3.8	8.1	3.7
	8.3	5.5	8.3	3.8	8.3	3.7
	8.7	5.5	8.7	3.7	8.7	3.6
Adsorption Rate	38%		55%		56%	
Dosage	6g		6g		6g	
	8.1	3.7	8.1	3.7	8.1	3.7
	8.3	3.5	8.3	3.7	8.3	3.7
	8.7	3.5	8.7	3.6	8.7	3.6
Adsorption Rate	57%		56%		56%	
Dosage	9g		9g		9g	
	8.1	3.7	8.1	3.8	8.1	4.1
	8.3	3.5	8.3	3.8	8.3	4.0
	8.7	3.5	8.7	3.7	8.7	4.0
Adsorption Rate	57%		55%		52%	

Manipulated Variable: 1. Retention Time (min)

2. Dosage (g)

Responding Variable: Adsorption Rate (%)

Constant Variable: Agitation Speed (100 rpm)

Table 4.2 Ammonia Test Data for 100rpm

Time	30 min		60 min		90 min	
Dosage	5g		5g		5g	
	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)
	9.0	4.5	9.0	3.0	9.0	3.0
	10.0	5.0	10.0	3.0	10.0	3.0
	10.0	4.5	10.0	3.0	10.0	3.0
Adsorption Rate	52%		69%		69%	
Dosage	6g		6g		6g	
	9.0	2.5	9.0	2.0	9.0	1.5
	10.0	2.0	10.0	2.0	10.0	1.5
	10.0	2.5	10.0	2.0	10.0	1.5
Adsorption Rate	76%		79%		85%	
Dosage	9g		9g		9g	
	9.0	1.5	9.0	2.0	9.0	2.0
	10.0	1.5	10.0	2.0	10.0	2.0
	10.0	1.5	10.0	2.0	10.0	2.0
Adsorption Rate	85%		79%		79%	

Manipulated Variable: 1. Retention Time (min)

2. Dosage (g)

Responding Variable: Adsorption Rate (%)

Constant Variable: Agitation Speed (150 rpm)

Table 4.3 Ammonia Test Data for 150rpm

Time	30 min		60 min		90 min	
Dosage	5g		5g		5g	
	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)
	8.7	4.5	8.7	3.9	8.7	3.7
	8.2	4.9	8.2	3.8	8.2	3.5
	8.2	5.5	8.2	3.8	8.2	3.5
Adsorption Rate	40%		54%		57%	
Dosage	6g		6g		6g	
	8.7	4.3	8.7	3.8	8.7	5.6
	8.2	5.2	8.2	3.8	8.2	5.7
	8.2	4.7	8.2	3.7	8.2	5.7
Adsorption Rate	44%		55%		32%	
Dosage	9g		9g		9g	
	8.7	4.1	8.7	3.7	8.7	5.6
	8.2	4.0	8.2	3.7	8.2	5.7
	8.2	4.0	8.2	3.6	8.2	5.7
Adsorption Rate	52%		56%		32%	

4.2.2 1:3 Activation Ratio for NaOH

Manipulated Variable: 1. Retention Time (min)

2. Dosage (g)

Responding Variable: Adsorption Rate (%)

Constant Variable: Agitation Speed (50 rpm)

Table 4.4 Ammonia Test Data for 50rpm

Time	30 min		60 min		90 min	
Dosage	5g		5g		5g	
	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)
	8.7	4.0	8.3	3.7	8.7	3.8
	8.3	4.1	8.7	3.8	8.1	3.8
	8.1	4.1	8.1	3.8	8.3	3.7
Adsorption Rate	52%		55%		55%	
Dosage	6g		6g		6g	
	8.7	3.7	9.0	3.0	9.0	2.5
	8.3	3.7	10.0	3.0	10.0	2.5
	8.1	3.6	10.0	3.0	10.0	2.0
Adsorption Rate	56%		69%		76%	
Dosage	9g		9g		9g	
	9.0	2.0	9.0	2.0	9.0	2.0
	10.0	2.5	10.0	2.0	10.0	2.0
	10.0	2.5	10.0	2.0	10.0	2.0
Adsorption Rate	76%		79%		79%	

Manipulated Variable: 1. Retention Time (min)

2. Dosage (g)

Responding Variable: Adsorption Rate (%)

Constant Variable: Agitation Speed (100 rpm)

Table 4.5 Ammonia Test Data for 100rpm

Time	30 min		60 min		90 min	
Dosage	5g		5g		5g	
	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)
	9.0	2.0	9.0	3.0	9.0	3.0
	10.0	2.5	10.0	3.0	10.0	3.0
	10.0	2.5	10.0	3.0	10.0	3.0
Adsorption Rate	76%		69%		69%	
Dosage	6g		6g		6g	
	8.3	3.5	8.3	3.5	8.1	3.7
	8.7	3.5	8.7	3.5	8.3	3.8
	8.1	3.7	8.1	3.7	8.7	3.8
Adsorption Rate	57%		57%		55%	
Dosage	9g		9g		9g	
	8.3	3.5	8.7	4.0	8.7	4.0
	8.7	3.5	8.3	4.1	8.3	4.1
	8.1	3.7	8.1	4.1	8.1	4.1
Adsorption Rate	57%		52%		52%	

Manipulated Variable: 1. Retention Time (min)

2. Dosage (g)

Responding Variable: Adsorption Rate (%)

Constant Variable: Agitation Speed (150 rpm)

Table 4.6 Ammonia Test for 150rpm

Time	30 min		60 min		90 min	
Dosage	5g		5g		5g	
	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)	Initial (mg/L)	Final (mg/L)
	8.1	3.7	8.2	3.8	8.2	4.7
	8.3	3.8	8.2	3.9	8.2	4.2
	8.7	3.8	8.7	3.8	8.7	4.3
Adsorption Rate	55%		54%		44%	
Dosage	6g		6g		6g	
	8.2	4.7	8.2	4.7	8.2	4.9
	8.2	4.2	8.2	4.2	8.7	4.5
	8.7	4.3	8.7	4.3	8.7	5.5
Adsorption Rate	44%		44%		40%	
Dosage	9g		9g		9g	
	8.2	4.9	8.2	4.9	8.2	4.9
	8.7	4.5	8.7	4.5	8.7	4.5
	8.7	5.5	8.7	5.5	8.7	5.5
Adsorption Rate	40%		40%		40%	

4.3 NaOH Activation at Ratio 1:2

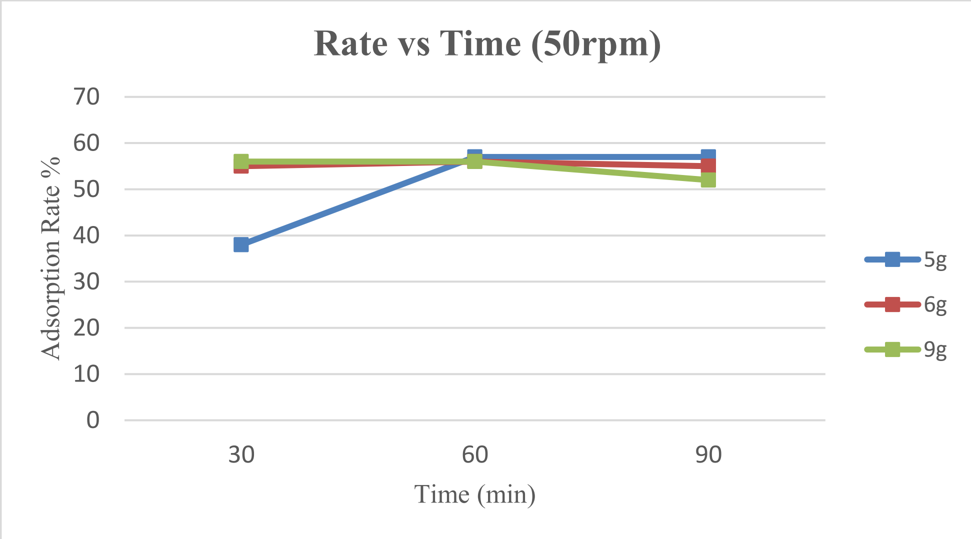


Figure 4.1 *Rate vs Time at 50rpm*

Based on Figure 4.1, the adsorption rate at 30 min was increased from 38% (5g of dosage), 55% (6g of dosage) and 56% (9g of dosage) at 50 rpm. This shows that there is an effect of the removal efficiency of ammonium in POME. Then, the adsorption rate at 60 min was 57% (5g of dosage) and then at 6g and 9g of dosage was static which was 56% which is higher than 50 rpm. This is maybe due to the huge difference in adsorbent. At the same time, followed by 90 min, there were only 56% (5g of dosage), 55% (6g of dosage) and 52% (9g of dosage).

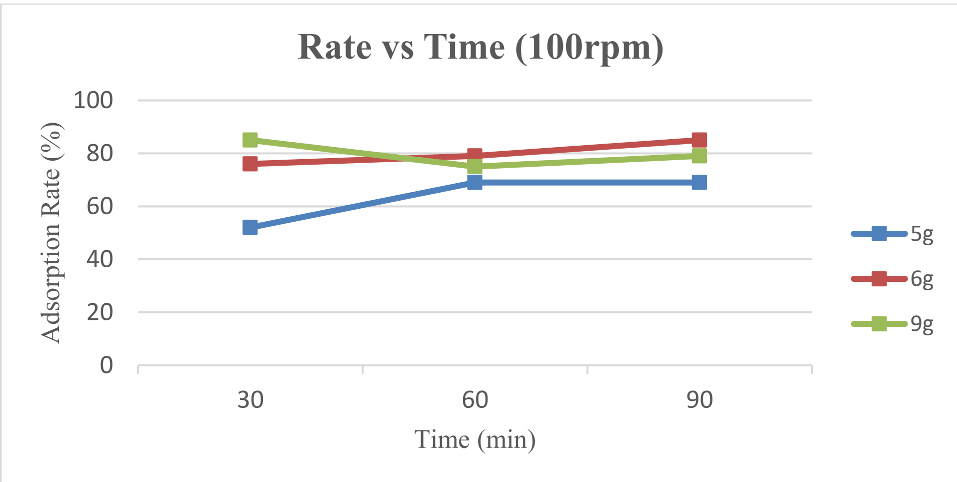


Figure 4.2 *Rate vs Time (100rpm)*

Interestingly, the adsorption rate was significantly increased to value of 85% (6 g of adsorbent) when the time reached 90 min of contact time at 100rpm as shown in Figure 4.2. The adsorbents' ability to adsorb the NaOH seems to continue to increase from 30 min to 90 min. This significant increase occurs because the adsorbents pores can still be filled with NaOH until the 90 minutes. But then, at 30 min with 9 g of adsorbent, it appears that the adsorbents' ability to adsorb NaOH remains constant with value of 85%. Based on this result, the highest adsorption rate occurred at 30 min of contact time which can achieve an optimal parameter.

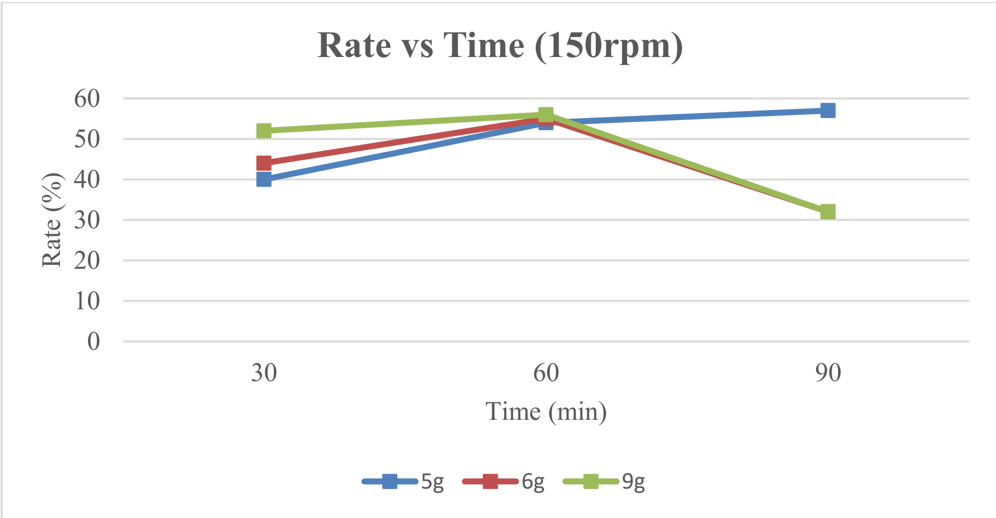


Figure 4.3 *Rate vs Time (150rpm)*

From the results, about 40% to 57% of adsorption rate were increased at 30 min to 90 min contact time with 5g of dosage, respectively. At the same time, followed by 6g of dosage, the adsorption rate was decreased from 44% (30 min) then 55% (60 min) to 32%. (90 min). Lastly, by 9g of dosage, the adsorption rate was decreased from 52% (30 min) to 32% (90 min). To explain, NH_3 removal capacity decreased over time. This phenomenon is occurring due to the effectiveness of ammonia getting less time by time. These factors also affect the performance of removal ammonium due to the temperature surrounding, moisture content (Farhana et al.,2020).

4.4 NaOH Activation at Ratio 1:3

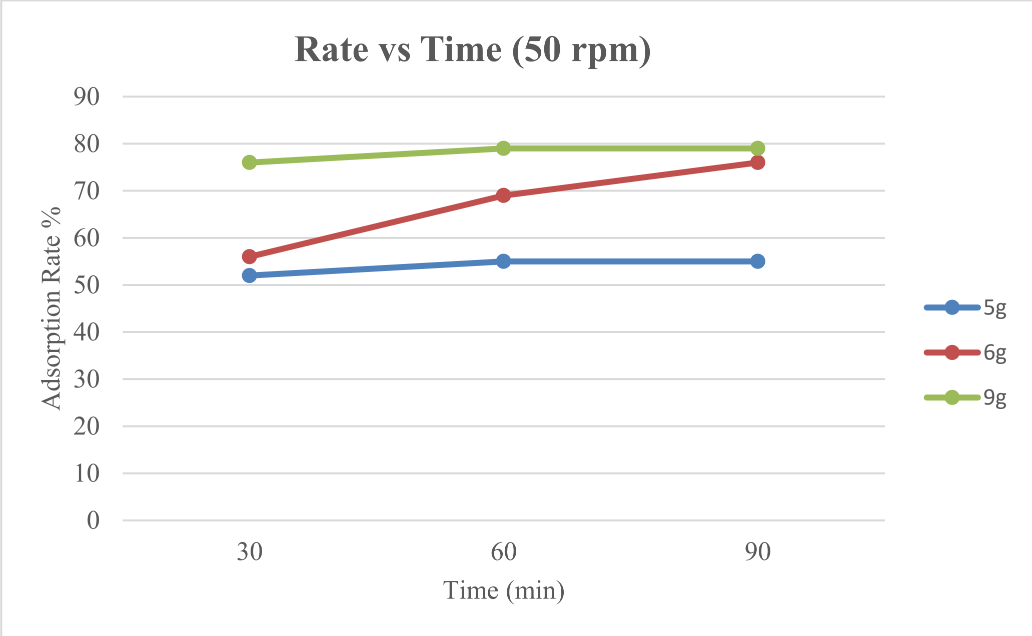


Figure 4.4 *Rate vs Time (50rpm)*

Based on the graph, the reading of adsorption rate from 5g to 6g of dosage increased from 52% to 56% (30 min), 55% to 69% (60 min) and 55% to 76% (90 min). Then followed up by 9g of dosage, the adsorption rate was significantly increased from 79% when the time reached 60 min and 90 min of contact time. To explain this phase, modified peat soil has an ability to reduce the concentration of NH_3 by adsorbing NaOH that is contained in NH_3 gas. It was proven by Mudliar et al, (2017) state that as the odorous and contaminated air passes through the media, the contaminants of the air stream are absorbed. Hence, this is a basic removal mechanism that is called the absorption-adsorption process (Farhana et.,al 2020). Based on the result, the highest adsorption rate by using chemical activation for 1:3 at 90 min of contact time with 9g of dosage, which can achieve an optimal parameter.

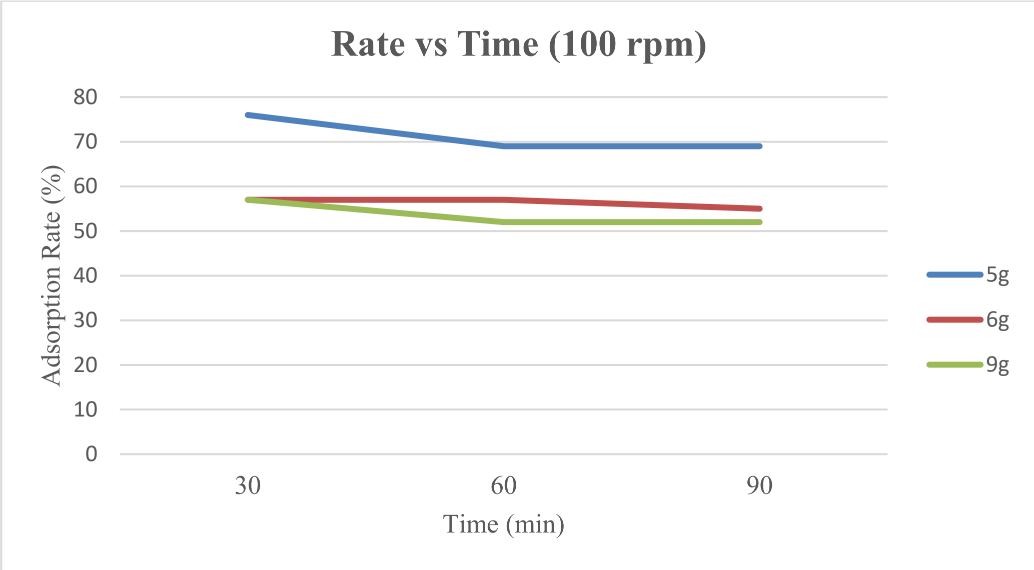


Figure 4.5 *Rate vs Time (100rpm)*

Based on Figure 4.5, the adsorption rate at 30 min was significantly decreased from 76% (5g of dosage), 57% for both 6g of dosage and 9g of dosage at 50 rpm. Then, the adsorption rate at 60 min was 69% (5g of dosage) to 57% (6g of dosage) and then at 9g of dosage was decreased to 52%. The same goes for removal efficiency of NH3, followed by 90 min, there were only 69% (5g of dosage), 55% (6g of dosage) and 52% (9g of dosage). Thus, this result may be affected due to lack of ability for modified peat soil to absorb NaOH. However, it can be concluded that the removal of NH_3 was determined by the process of adsorption-adsorption of modified peat soil which can be a new potential medium for the chemical activation process.

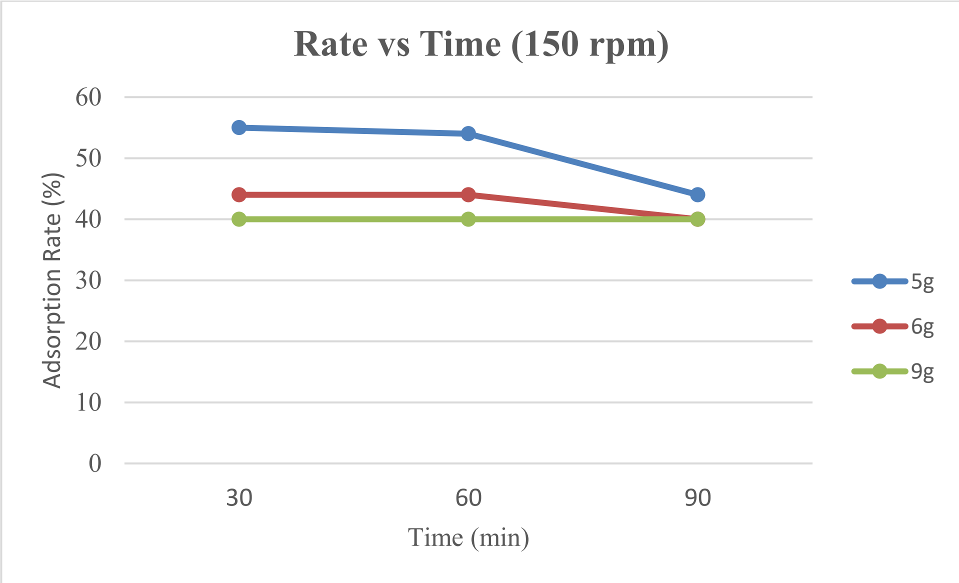
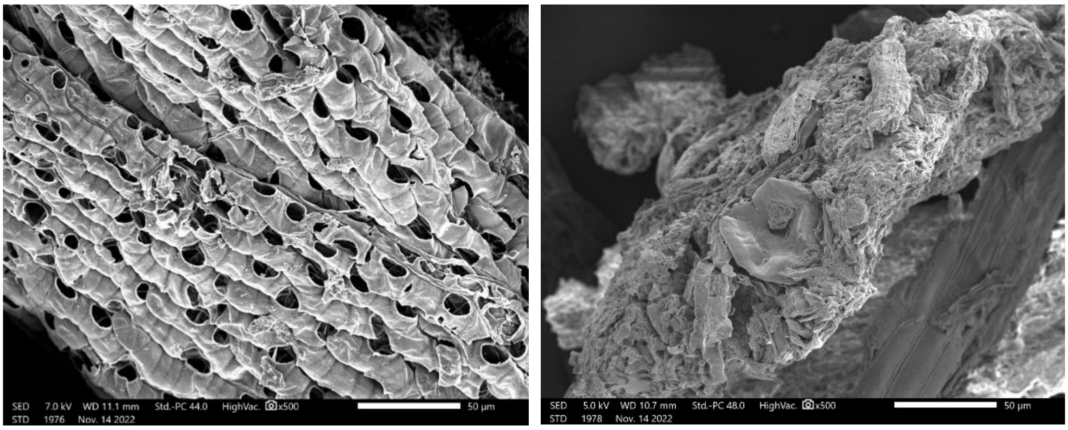


Figure 4.6 *Rate vs Time (150rpm)*

From the results, about 55% to 44% of adsorption rate were decreased at 30 min to 90 min contact time with 5g of dosage, respectively. At the same time, followed by 6g of dosage, the adsorption rate was decreased from 44% (30 min) then maintained 44% (60 min) to 40%. (90 min). Lastly, by 9g of dosage, the adsorption rate was 40% for 30 min, 60 min and 90 min. To explain this phase, NH_3 removal capacity decreased over time. Thus, this result may be affected due to lack of ability for modified peat soil to absorb NaOH.

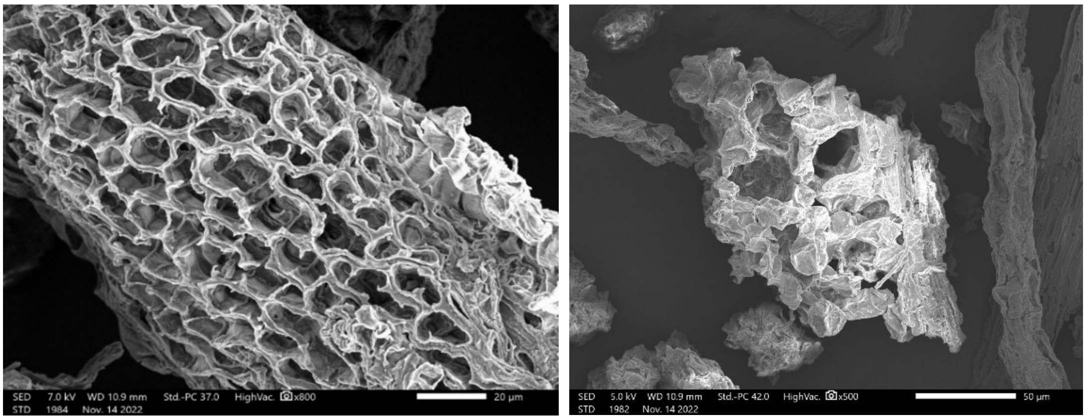
4.5 SEM Result

The surface morphology for peat soil before and after chemical activation process also observed through the Fourier-(FTIR) and Scanning Electron Microscope (SEM) to determine its constituents, size and phase of its compound. Result of SEM test for peat soil are shown in Figure 4.7a and figure 4.7b respectively.



a) Sample 1 b) Sample 2

Figure 4.7: *Scanning Electron Microscope for Peat Soil before Chemical Activation Process*



a) Sample 1 b) Sample 2

Figure 4.8: *Scanning Electron Microscope for Peat Soil After Chemical Activation Process*

Scanning Electron Micrographs (SEM) for peat samples were performed to study the pore size and morphology of the surface area. The SEM test was conducted by using JEOL SEM. The oven dried peat samples used in this test were coated with gold before taking SEM images. The micrographs were taken at a magnification of 20μm for both samples. Based on SEM results, it can be identified the different initial and final conditions for both media. Figure 4.7 shows raw peat soil meanwhile Figure 4.8 shows SEM images of modified peat soil by using chemical activation process.

Figure 4.7a and 4.7b clearly show that raw peat soil contains less organic matter and fiber in it as well as flaky granular nature and less voids pores than the modified sample. The occurrence of flaky structures in the SEM image is responsible for the peat to show low shear strength and high compressibility.

In contrast, Figure 4.8a and 4.8b shows modified peat soil samples are composed of fibers, woody and more defined pore structure can be seen via scanning electron microscopy (SEM). Modified sample shows slightly loose fibric arrangements which create larger voids that appear in the form of dark spaces as shown in Figure 4.8b. In other words, the modified sample which contains more fibrous and organic content in its soil shows more porous space structure. The presence of high perforated particles in peat makes it more compressible and permeable in nature. SEM micrographs of the chemical activation in comparison with the raw one is shown as in Figure 4.7. It is obvious that activation is accompanied by significant changes in the size and number of pores.

4.6 FTIR Result

FTIR is one of the methods that are used to characterize modification products and to identify compounds, detect functional group and analyse the synthesized material. The blue line shows the results of modified peat soil and the red lines shows the result for raw peat soil. Major changes of modified peat and raw peat FTIR could be observed at wavenumber from 400-1900 cm^{-1}. As it can be seen in Figure 4.9 the intensity of several functional group signal varies after the formation of NaOH complexes, thus indicating that structural changes have occurred in the molecule due to interaction with the NaOH. The two main peaks could be observed at wavenumber from 3900-1600 cm-1. The first peak is due to the OH (hydroxyl) bond. The OH bonds shows that the sample has water inside it. Water molecules contain hydroxyl group. And then after treatment method the OH bond is disappeared since the modified peat soil has been dried and treated. As for C-C (alkane) bond, we can see here the peak is shifted right this is because an infrared light causes stretching vibrations, so bond dipoles will change.

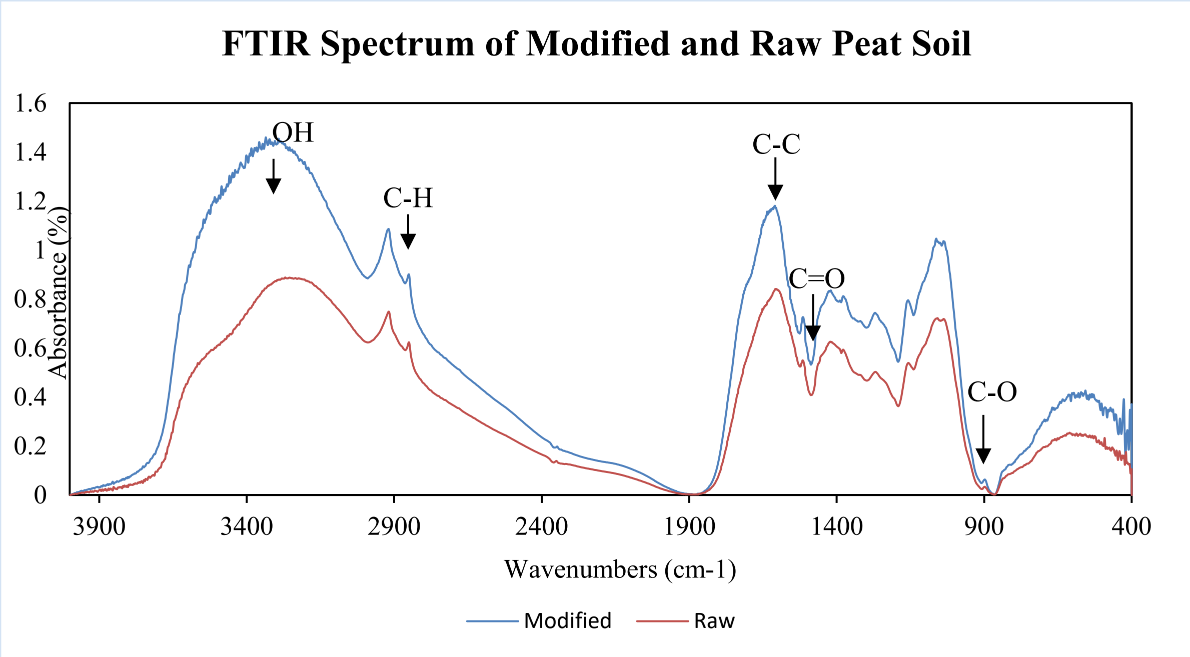


Figure 4.9 *FTIR Spectrum of Modified and Raw Peat Soil*

Figure 4.9 shows the FTIR spectra of the modified and raw peat soil. Both spectra showed similar peaks in the range of 2400 – 3900 cm^{-1}. Analysis of the FTIR spectrum of raw and modified of peat soil confirmed the presence of functional group characteristic of peat. Hydroxyl groups were identified by the broad band attributed to stretching vibrations of O—H vibrations of the water molecules adsorbing on the surface in the range 3654- 2980 cm^{-1}, while additionally ether groups were manifested by the band attributed to stretching vibrations of C—O bonds at 900 cm^{-1}. Based on this result, the modified showed a greater peak than the raw peat. Carbonyl groups by the band attributed to stretching vibrations of C=O bonds at 1464 cm^{-1} and signal at 1550 cm^{-1} is associated with the stretching vibrations of C—OH groups in the structure of peat.

C-H stretching bonds lead to vibrations around 400-500 cm^{-1} and 1300-1600 cm^{-1}. The amount of this group decreased after the activation belonging to O-H vibrations sharpened. Sharpening was also observed in bands at 1550-1600 cm^{-1} belonging to C-O and C=O groups (Şencan & Kılıç, 2017). The presence of a developed aliphatic structure is confirmed by the absorption band attributed to the stretching vibrations of C—H bonds in the range 2844-2900 cm^{-1}. The bands originating from the bonds of the aromatic structure may overlap with those attributed to the bonds of other groups. This shows that new carboxyl groups were formed by oxidation during treatment with NaOH. FTIR shows that the absorbance of the bands observed at 1100-1200 cm^{-1} and 2900-3000 cm^{-1} decreased after adsorption. This decrease can be explained by the fact that weak and broken bands such as O—H and C—O which resulted from NaOH bonding with carbonyl groups, could not be observed in the spectrum. Therefore, it was thought that NaOH may be chemically adsorbed on the surface through the chemical activation process. In general, the FTIR spectrum confirms the diversity of the peat's structural composition. The presence of such a variety of functional groups on the peat surface makes it an attractive adsorbing material.

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CHAPTER 5

CONCLUSION

5.1 Conclusion

This chapter summarizes the results of this research that was conducted in order to reduce pollutants of NH_3 from Palm Oil Mill Effluent (POME) through chemical activation process by using peat soil as a new potential media as natural adsorbent. However, this research is not only concerned with the removal of odours and gas emissions, but also with the selection of the best and newer better adsorbent. In addition, there are also some suggestions for improving the effectiveness of research for future consideration. Generally, from this study, it can be observed that the objective of this research was successfully achieved.

The research was started to create natural adsorbent from peat soil by using chemical activation and also to determine the characteristics of peat soil as an adsorbent for treatment of malodour produced by Palm Oil Mill Effluent (POME). As result of the characteristics were analysed using a Scanning Electron Microscope (SEM) and Fourier Transform Infrared (FTIR) to determine the surface morphology of the media. The results of SEM characterization, the modified peat soil that activation using NaOH had a surface structure with more open pores and more waves. While, the FTIR characterisation shows the diversity of the peat's structural composition. The presence of such a variety of functional groups on the peat surface makes it an attractive adsorbing material. This confirms that peat soil is potentially a more useful adsorbent material for treatment of malodour. With this, the first and second objective of the research was fulfilled.

The objective to determine the removal efficiency of ammonium in POME by using modified peat soil as adsorbent was tested by finding the optimum parameters such as agitation speed, contact time, differentiation of dosage adsorbent with ratio 1:2 and 1:3 of NaOH. The optimum parameters for adsorption rate with ratio 1:2 of NaOH were obtained from the ammonia test by 30 min of contact time, 100 rpm of agitation speed and 9g of dosage adsorbent with value of 85%. While for ratio 1:3 of NaOH, the result obtained by 90 min of contact time, 50 rpm of agitation speed and 9g of dosage of adsorbent with value of 79%. Thus, the goal of determining the removal efficiency of ammonium in POME was achieved. Although, removal of NH_3 was determined by the process of chemical activation, it can act as a new adsorbent and potential in reduce malodour produce by POME.

This research proved that modified peat soil by using chemical activation were successfully decreasing malodour from POME by more than 80%. This research also proved that peat can create as adsorbent. The findings from this research would be benefit the researchers, engineers and also the publics as it opens a new door towards the use of modified peat soil and also help reducing the emission of nuisance odour from palm oil factories.

5.2 Recommendation for Future Work

This research was part of the effort on better understanding for discover modified peat soil and new adsorbent from palm oil mill effluent for odour reduction with fundamental knowledge using chemical activation process. Hence, there are more works to be explored and several concerns have been identified. Consequently, several recommendations for future work put forward:

1. Prolong the duration for each batch up to 24 hours to further study the impact of adsorption rate to the modified peat soil by using chemical activation. In this research, the duration for each ratio of NaOH is 90 min which might not be enough for the chemical activation to reduce the ammonia in POME.
2. Future research on the study of other characterisation test such as Brunauer-Emmett-Teller (BET) analysis instead of FTIR analysis. This is because, with BET we would know the surface area, the total pore volume and their average pore width of the materials.
3. Future work should mainly focus on various factors that influenced to the offensive odour such as hydrogen sulphide which also contribute to the odour that came from the POME treatment ponds.
4. Future research should make raw peat soil as an adsorbent in comparison with modified peat soil to find out which one results better for reducing ammonium in POME.

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