TREATMENT OF STABILISED LANDFILL LEACHATE USING BIO-COAGULANT *AZADIRACHTA INDICA*

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CERTIFICATION

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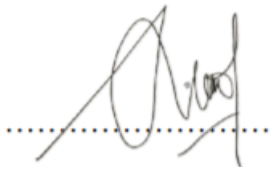

DECLARATION

I certify that this thesis, submitted to University Malaysia Sabah as a partial fulfilment of the prerequisites for the degree of Bachelor of Civil Engineering. There has been no submission of this thesis to any other university for any degree. I also certify that the work described below is all mine, except for quotations and summaries, which have been properly credited.

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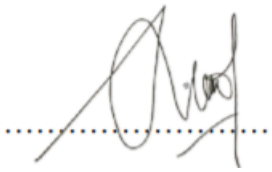

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ABSTRAK

Pengeluaran sisa pepejal perbandaran meningkat setiap hari. Selain itu, pencemaran air larut resapan kepada air bawah tanah dan sungai tidak dapat dikawal, disebabkan pengurusan tapak pelupusan sisa pepejal perbandaran (MSW) yang lemah. Air larut resapan mempunyai kuantiti COD, pH, nitrogen ammonia, kekeruhan dan logam berat yang tinggi, serta warna yang kuat dan bau busuk, membuangnya terus ke dalam badan air atau alam sekitar membahayakan ekologi dan kesihatan manusia. Oleh itu, perhatian serius untuk mengenal pasti dan menyediakan rawatan larut resapan yang berkesan sememangnya diperlukan. Matlamat penyelidikan ini adalah untuk menilai sejauh mana prestasi bio-koagulan Azadirachta Indica (b-Ai) sebagai koagulan dalam proses koagulasi-flokulasi untuk rawatan sisa larut resapan pada keadaan eksperimen yang berbeza. Selain itu, prestasi koagulan konvensional yang merupakan tawas dan zeolit asli juga akan diuji dan dibandingkan dengan penyingkiran b-Ai. Parameter penyingkiran kekeruhan akan digunakan sebagai penunjuk untuk menilai prestasi koagulan. Data eksperimen menunjukkan bahawa, penyingkiran kekeruhan optimum menggunakan b-Ai dicapai sehingga 26% pada keadaan eksperimen dos b-Ai 0.1 g, pH 8 dan masa tindak balas 5 min, 15 min dan 30 min untuk cepat, perlahan dan penyelesaian, masing-masing. Selain itu, prestasi koagulan konvensional yang merupakan tawas, dan satu lagi koagulan semula jadi bernama zeolit asli juga telah diuji dan dibandingkan dengan prestasi b-Ai. Mengikut data yang diperoleh, tawas mencatatkan penyingkiran kekeruhan tertinggi iaitu 96% berbanding zeolit asli, 52% dan b-Ai pada keadaan optimum, masing-masing. Walau bagaimanapun, penggunaan tawas sahaja telah menghasilkan bahan pencemar sekunder, yang memudaratkan alam sekitar dan kesihatan manusia, justeru, kajian menggunakan koagulan atau flokulan semulajadi untuk mengurangkan jumlah penggunaan koagulan kimia (alum) dalam rawatan larut larut lesap diperlukan. Berdasarkan dapatan yang diperolehi dalam kajian ini, b-Ai berpotensi untuk membekukan bahan pencemar, tetapi ia kurang berkesan untuk berfungsi sebagai satu-satunya koagulan terutamanya dalam kekuatan pencemar yang tinggi bagi sampel seperti larut lesap. Oleh itu, kajian lanjut tentang potensi b-Ai sebagai bantuan koagulan atau flokulan adalah dicadangkan.

ABSTRACT

Municipal solid waste production increases every day. On top of that, leachate contamination to the groundwater and river is uncontrollable, due to poor municipal solid waste (MSW) landfill management. Landfill leachate has high quantities of COD, pH, ammonia nitrogen, turbidity, and heavy metals, as well as a strong colour and foul odour, dumping it directly into a body of water or the environment endangers the ecology and human health. Therefore, serious attention on identifying and providing an effective landfill leachate treatment is certainly needed. The goal of this research is to assess how well perform of bio-coagulant *Azadirachta Indica* (b-Ai) as coagulant in coagulation-flocculation process for landfill leachate treatment at different experimental conditions. Additionally, the performance of conventional coagulant which are alum and natural zeolite will also be experimented and compared with b-Ai removal. Parameter of turbidity removal will be used as indicator to evaluate the performance of the coagulants. The experimental data showed that, the optimum removal of turbidity using b-Ai was achieved up to 26% at experiment condition of b-Ai dosage 0.1 g, pH 8 and reaction time 5 min, 15 min and 30 min for rapid, slow and settlement, respectively. Additionally, the performance of conventional coagulant which are alum, and another natural coagulant name natural zeolite was also experimented and compared with b-Ai performance. According to the data obtained, alum recorded the highest removal of turbidity which is 96% compared to natural zeolite, 52% and b-Ai at optimum condition, respectively. However, the usage of alum alone has created secondary pollutant, which is harmful toward the environment and human health, therefore, the study on using natural coagulant or flocculant to reduce the amount of chemical coagulant (alum) consume in leachate treatment is needed. Based on the finding obtained in this study, b-Ai has potential to coagulate the pollutant, but it is less effective to work as a sole coagulant especially in high pollutant strength of sample like leachate. Therefore, further study on the potential of b-Ai as coagulant aid or flocculant is proposed.

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CHAPTER 1: INTRODUCTION

1.0 Background of study

In Malaysia, a sanitary landfill is considered as a practical method to dispose municipal solid wastes and apply widely in each state due to its economic advantages. Municipal solid waste (MSW) consists of a mixture of household waste and commercial waste which is consisting of organic waste, plastic, glass, tin packaging, and wood. Although this method is economical and easy to handle, the mixture and compression of various types of MSW initiate the generation of by-products, leachate is a relatively complex and difficult to remediate substance.

Generally, landfill leachate comprises of various natural and inorganic compound that can be either dissolved or suspended in wastewater. Landfill leachate results from the processes of infiltration of liquid from rainwater or solid waste through the product of compaction, and the degradation of solid waste. Furthermore, landfill leachate is characterised by high COD, pH, ammonia nitrogen, and heavy metals levels, as well as a distinct colour and odour (Raghab et al., 2013). Before dumping leachates into natural waters, the removal of organic material based on COD, biological oxygen demand (BOD), and ammonium is usually required (Kettunen et al., 2009). At the same time, the content and volume of the leachate, as well as the amount of biodegradable stuff contained in the leachate, change with time (Raghab et al., 2013).

Leachate treatment must be done to avoid pollution of the environment and its negative impact towards environment and human health. The quantity and quality of leachate produce is depending on type of waste and its volume. Usually, the increment of population or economic growth contribute to the increment of the quantity of solid waste as well as leachate production. Landfill leachate can be treated in a variety of ways, including conventional and advanced such as leachate transfer, leachate recycling, biological treatment (aerobic or aerobic), and physical-chemical treatment, such as the coagulation-flocculation process, are all examples of traditional treatment (Chelliapan, 2020).

Coagulation flocculation is one of the proven methods in wastewater treatment and commonly used in leachate treatment. However, several issues have restricted this method to be applied widely on site such as chemical coagulant used in conventional coagulation-flocculation potentially produce secondary by-product which gives harmful effect toward environment especially soil and waterways. Therefore, to overcome this problem, many researchers have

studied the potential of bio-coagulant in treating water and wastewater. This type of coagulant is more environmentally friendly and cheaper compared to chemical coagulant. Therefore, in this study, the potential of local bio-coagulant, *Azadirachta Indica* was proposed and studied.

1.1 Problem Statement

Landfilling is the primary method of solid waste disposal in Malaysia. However, most landfill sites are unequipped and lack a proper leachate treatment system (Aziz et al., 2018). The volume of leachate generated by landfills in Malaysia is estimated to be over 3 million litters per day, and it is increasing due to the country's climate (Agamuthu, 2011). The characteristics of Malaysia's climate which the amount of leachate produced onsite is also affected by uniform temperature, high humidity, and abundant rainfall.

Furthermore, leachate itself contain more than 200 hazardous elements which can threaten the environment and human health such because it contains a significant amount of ammonia($NH_3 - N$) which has negative health consequences such as respiratory issues, aberrant tissue development in the gills, liver, and kidneys, and mortality as mention by Ortisz-Pujols (2014) due to plants and invertebrates are more ammonia tolerant than animals, while invertebrates are more tolerant than fish. Fish hatching and growth rates may be affected (Ip and Chew, 2010). Furthermore, ammonia is a poisonous substance that is hazardous to most living creatures on the water's surface, contributes to eutrophication, and depletes dissolved oxygen (Aziz et al., 2011). The presence of a lot of organic matter and pollutants in landfill leachate, as well as a high concentration of colour and turbidity, indicates that this landfill by-product contains a lot of organic matter and pollutants that can be damaging to the ecosystem and human life. Therefore, an intensive leachate treatment is needed to control the pollutant and effectively manage the landfill site. In this study, the potential of green local bio-coagulant *Azadirachta Indica* (b-Ai) focused on to treat landfill leachate.

Other than that, excessive turbidity, or cloudiness, is unsightly, could be dangerous for environment, and human health. High turbidity can negatively affect recreation by drastically reducing the aesthetic appeal of lakes and streams. Pathogens may find food and refuge in turbidity. The causes of excessive turbidity, if not eliminated, might encourage the renewal of bacteria in the water, resulting in waterborne disease outbreaks that have significantly increased occurrences of intestinal illness throughout the world and the United States. Numerous studies demonstrate a substantial correlation between the removal of turbidity and the removal of protozoa, even though turbidity is not a direct signal of health danger. By decreasing their exposure to attack by disinfectants, the turbidity particles act as a "shelter" for microorganisms. It has been suggested that microbial adhesion to particulate matter promotes bacterial survival. Fortunately, when carried out correctly, conventional water treatment techniques can successfully

eliminate turbidity (U.S. Environmental Protection Agency, 2022). In this study, effectiveness of bio-coagulant was tested in leachate turbidity removal.

1.2 Objective of Research

This study focused on the improvisation of natural bio-coagulant *Azadirachta Indica* used as coagulant in remediate landfill leachate treatment (with high turbidity). These lead to the following objectives:

1. To determine the physical and chemical characteristic of landfill leachate at Kayu Madang Landfill Site.
2. To evaluate the influence of dosage, pH, and reaction time on bio-coagulant *Azadirachta Indica* performance as coagulant in landfill leachate treatment.
3. To compare the performance of bio-coagulant *Azadirachta Indica* with commercial coagulant alum and natural zeolite in landfill leachate treatment (turbidity removal).

1.3 Scope of Research

Landfill leachates were obtained from Kayu Madang Landfill Site, Telipok, Sabah. The characterization of landfill leachate was done for three months starting from February until April 2022. Colour, pH, turbidity, and suspended solids of leachate were all measured here. In this study, the potential of b-Ai and the influence factors toward performance of coagulation-flocculation process of b-Ai such as pH, dosage of coagulant and reaction time were evaluated. The potential of alum and natural Zeolite that influence factors toward performance of coagulation-flocculation process of alum such as pH, dosage of coagulant and reaction time were evaluated. A comparison performance of b-Ai, conventional coagulant alum and natural Zeolite was done. Accordingly, a parameter which was turbidity were used as indicator to evaluate the efficiency of the treatment.

1.4 Organisation of the thesis

This thesis is divided into 5 Chapters. Chapter 1 provides a brief introduction and ideas about this research, including the study's background, problem statement, research objectives, scope of the study, and thesis structure. Subsequently, Chapter 2 contains a literature review with 9 subtopics. Next, the third chapter elaborates on the methodology used in this study in detail. Chapter 4 reports all the data and findings along with the relevant discussions. Finally, the conclusions are stated in Chapter 5, as well as recommendations for future research.

CHAPTER 2: LITERATURE REVIEW.

2.0 Introduction

The term "environmental pollution" refers to air pollution, water pollution, soil pollution, noise pollution, and other types of pollution. In line with that, Malaysia is also affected by these problems. The improper disposal of solid waste is the country's most serious pollution concern (Badgie, 2011) and it can be concluded as Municipal Solid Waste (MSW) which is characterized as garbage. MSW contains highly heterogeneous mixed of residential, commercial, and industrial areas such as clothing, disposable tableware, yard trimmings, cause, metal, plastic, and rubber Hogland (2013). Office disposable tables, paper, and boxes are found in the MSW industrial and institutional area, while the MSW industrial and institutional category contains restaurant trash, classroom waste, wood pallets, plastics, and office paper. Although the content of MSW can vary greatly, it is generally agreed that organic elements dominant most of the waste. According to JPSPN (2012), waste generated in Malaysia was 14,075,495 tonnes and 0.70 Kg per capita in 2015. Increase by 5.19% annually based on JPSPN data. In Sabah, total waste generated in 2011 is measured as 2,062,390 tonnes (Kementrian Perumahan dan Kerajaan Tempatan, 2013) as mentioned on table 1 and the value increasing every year.

Table 1 Summary of solid waste collection in Malaysia and Sabah (JPSPN, 2012)

Country/Year	2015	2016	2017	2018	Estimates Waste (Kg/Day/Capital)
Malaysia	14,075,495 tonnes	14,806,590 tonnes	15,575,280 tonnes	16,384,120 tonnes	1.17 Kg
Sabah	2010	2011	2012	2013	0.71 Kg
	1,481,000 tonnes	2,062,390 tonnes	2,136,420 tonnes	2,062,390 tonnes	

2.1 Landfills

Landfill sites exist throughout Malaysia, and across the globe. Some sites practise land raising, which involves piling trash directly on the ground, while others practise landfilling, which involves filling a hole in the ground with trash. The garbage in these piles is a mix of residential and commercial waste. This is the reality of human waste, which cannot be changed. Waste is a difficult issue that civilisation must address. To maintain regulatory compliance, landfills are located, designed, managed, and monitored. They're also made to keep the environment safe from toxins in the waste stream. Landfills are not permitted to be erected in 'environmentally sensitive' locations, and they are placed using on-site environmental monitoring equipment. These monitoring devices seek for evidence of contamination in both groundwater and landfills (Unisan, 2020). Table 2 shows the summary of operational stage of landfill by state.

Table 2 Site Operational in Malaysia

State	Operating Sites					Sites that have ceased operations
	Site operation stage		Transfer Station	Incinerator	Total	
	Sanitary	Not Sanitary				
Johor	1	13	1	-	15	23
Kedah	1	6	-	1	8	8
Kelantan	-	11	-	-	11	8
Melaka	1	-	-	-	1	7
Negeri Sembilan	1	5	-	-	6	13
Pahang	2	14	-	2	18	16
Perak	-	17	-	1	18	13
Perlis	-	1	-	-	1	1
Pulau Pinang	1	1	1	-	3	1
Sabah	1	18	-	-	19	2
Sarawak	3	46	-	-	49	14
Selangor	3	5	1	-	9	14
Terengganu	-	9	-	-	9	11
WP Kuala Lumpur	-	-	1	-	1	10
WP Labuan	-	1	-	-	1	-
Total	14	147	4	4	169	114

Based on the distribution of data from Table 3, there are states that do not have sanitary landfills, namely Kelantan, Perak, Perlis, Terengganu, WP Kuala Lumpur, and WP Labuan. These states are using open dumping as the solution. As a result, uncontrolled solid waste management in these states is leading to environmental pollution and high toxicity leachate produced.

Table 2 Landfill site operational stage in Sabah

No	Landfill Site	Site Operation stage
1	Beaufort	Not Sanitary
2	Beluran	Not Sanitary
4	Keningau	Not Sanitary
5	Kinabatangan	Not Sanitary
6	Kota Kinabalu	Sanitary
7	Kota Marudu	Not Sanitary
8	Kuala Penyu	Not Sanitary
9	Kunak	Not Sanitary
10	Lahad Datu	Not Sanitary
11	Lembaga Bandaran Kudat	Not Sanitary
12	Papar	Not Sanitary
13	Ranau	Not Sanitary
14	Sandakan	Not Sanitary
15	Semporna	Not Sanitary
16	Sipitang	Not Sanitary
17	Tambunan	Not Sanitary
18	Tawau	Not Sanitary
19	Tenom	Not Sanitary

The sanitary landfill is a method of disposing of waste on land without endangering the environment and public health. It does this by effectively using engineering skills to confine waste in the smallest practical area and then reducing the volume by covering with a layer of earth to ensure the least exposure to air (Ali, 2020).

The Kayu Madang landfill is nearing capacity, according to information gathered during the interview. Furthermore, (Mapa et al., 2017) state that, despite being Sabah's only sanitary landfill, Kayu Madang located in Kota Kinabalu is still unable to deal with solid waste challenges in a long-term manner. The amount of waste sent to the Kayu Madang landfill is simply excessive, and the landfill is unable to handle the increased waste generation. As a result, relying solely on technology sanitary landfills will not ensure long-term solid waste management.

Furthermore, the study's assertion that solid waste concerns should not be studied only from a technological perspective is reinforced. Even in sophisticated countries like Japan, the government does not rely only on technology to deal with increased garbage creation. Instead, it has concentrated on building a comprehensive solid waste management policy that prioritises waste minimization to reduce trash creation and, as a result, construction costs (Hotta et al., 2014). Furthermore, the study concluded that the Kota Kinabalu local government's efforts to extend the life of the Kayu Madang Landfill failed, indicating a lack of proper waste disposal policy. One of KKCH's strategies is the implementation of a technology known as the Material Waste Facility (MRF), which was thought to be capable of recycling up to 40% of waste disposed in landfills while also accounting for 30% of disposal waste.

This technology, however, had to be turned off due to the MRF operator's financial difficulties. The closing of this plant had an indirect effect on the landfill's trash recovery operation. The MRF's collapse revealed that depending entirely on technology does not guarantee long-term solid waste management. Aside from that, because Sabah lacks the existing solid waste management system requires a specific solid waste management organisation to deal with specific solid waste management challenges. policy in Kota Kinabalu may be less comprehensive. This is due to the difficulty of developing a policy on solid waste management in its entirety in the absence of a specific solid waste management institution to handle specific solid waste management issues in Sabah. Although the Kota Kinabalu local government oversees solid waste management, due to other obligations, they may not be able to pay their complete attention to it (Moh et al., 2017).