BIOSORPTION OF COLOUR IN LANDFILL LEACHATE USING RAW HYDRILLA SP.

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SCHOOL OF CIVIL ENGINEERING

UNIVERSITI SAINS MALAYSIA

2022

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By

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This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfilment of the requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)

(CIVIL ENGINEERING)

School of Civil Engineering
Universiti Sains Malaysia

June 2022

UNIVERSITI SAINS MALAYSIA

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2021/2022

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title: Ranking of preferred criteria of floor finishes for bathroom by the house owners in East Coast of the Malaysia

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ACKNOWLEDGEMENT

First of all, I would like to express my deep and sincere gratitude to my supervisor, Professor Dr. Hamidi Abdul Aziz for the thoughtful guidance, encouragement and constructive comments throughout this research. This project would not have been possible without his guidance and assistance from the beginning.

Next, I would like to thank all the Environmental Laboratory staff, Mrs Shamsiah, Mr Zaini, Mr Faris and Mr Nizam. I truly appreciated their help by providing all the necessary tools and equipment needed throughout the research testing in the environmental lab.

Besides, I am also grateful to have a PhD student in the Environmental Laboratory, Ms Fatehah Ramli, who assisted me during the lab testing procedure. She has briefly explained the methodology and batch study to carry out in this research. She also helps to arrange appointment with laboratory from other schools in order to carry out the test needed, which is not available in the School of Civil Engineering.

In addition, I sincerely indebted to my colleagues, Shafiqah Rosslan and Amir Idham, for helping me during the lab works. Finally, not forget all the laboratory staff from the School of Chemical Engineering and School of Material and Mineral Resources for their assistance in the BET and FTIR analyses.

ABSTRAK

Kajian ini dijalankan bagi mengkaji prestasi Hydrilla Sp. mentah sebagai biosorben yang baru yang tidak dirawat dalam merawat air larut resap di tapak pelupusan. Air larut resap mengandungi kepekatan warna dan bahan yang tercemar yang sangat tinggi yang boleh menjejaskan kualiti air dan menjadikannya tidak menyenangkan kepada alam sekitar. Sampel air larut resap yang mempunyai nilai warna yang tinggi diperoleh dari tapak pelupusan sampah yang terletak di Alor Pongsu, Kerian, Perak, yang masig belum dirawat. Air larut resap akan dikategorikan terlebih dahulu. Hydrilla disediakan dengan membasuhnya terlebih dahulu dan dikeringkan kemudian dikisar antara 0.7mm sehingga 1.18mm. Biosorben dicirikan melalui potensi BET, XRD, FTIR, dan zeta. Kajian kelompok dilakukan pada dos penjerap yang berbeza (1g, 2g, 3g, 4g, dan 5g) dan nilai pH (pH6.76 dan pH7). Penjerapan diukur oleh Spektrofotometer (DR 2800 HACH, Amerika Syarikat). Keputusan menunjukkan bahawa Hydrilla mengandungi kumpulan -OH, -COOH dan -NH yang boleh menyumbang kepada kecekapan biosorpsi di mana daya tarikan elektrostatik antara sorben dan sorbat berlaku. Hasilnya menunjukkan bahawa hasil optimum untuk merawat larut resapan berlaku pada 2g Hydrilla. Walau bagaimanapun, memandangkan Hydrilla mempunyai warna tersendiri yang menambah warna dalam larut lesap, persembahannya tidak dinilai dengan banyak keputusan negatif. Walau bagaimanapun, Hydrilla boleh diperiksa lebih lanjut pada masa hadapan dengan pengaktifan haba dan pengkarbonan untuk menjadikannya sebagai karbon teraktif. Terdapat juga kemungkinan untuk mengujinya untuk penyingkiran logam yang mungkin tidak dipengaruhi oleh warna Hydrilla.

ABSTRACT

This study was conducted to investigate the performance of untreated raw Hydrilla Sp. as a new biosorbent in treating landfill leachate. Leachate water contains very high concentrations of colours and other contaminants which can affect water quality and make it unpleasant to the environment. High coloured leachate samples were obtained from the Alor Pongsu Landfill Site, Kerian, Perak, which is currently not treated. The leachate was first characterised. The Hydrilla sp was prepared by pre-washing and drying, followed by grinding into 0.7mm to 1.18mm as working sizes. The biosorbent was characterised by means of BET, XRD, FTIR, and zeta potential. Batch studies were performed at different adsorbent dosages (1g, 2g, 3g, 4g, and 5g) and pH values (pH6.76 and pH7). The adsorption was measured by a Spectrophotometer (DR 2800 HACH, USA). The results show that hydrilla contains -OH, -COOH and -NH groups which could contribute to the biosorption efficiency where the attraction electrostatic between sorbent and sorbate occurred. The result indicated that the optimal result for treating leachate occurred at 2g of Hydrilla. However, since the Hydrilla has its own colour that added to the colour in leachate, the performances were hardly evaluated with a lot of negative results. Nonetheless, the Hydrilla could be further examined in future by heat activation and carbonation to make it as an activated carbon. There is also possibility to test it for metal removals which may not be influenced by the Hydrilla colour.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

A landfill is a location where solid and hazardous wastes are deposited there to isolate them from the environment. Household waste is disposed of in landfills, which usually consists of organic waste like food, paper, or plastic as well as commercial garbage. To safeguard the ecosystem from pollutants of trash that might be present in the stream, landfills are also created and maintained. There are two types of pollution that come from waste which are water pollution and air pollution. Leachate, which is the liquid that drains from a landfill, can cause water pollution. Air pollution may result from the fermentation of organic materials to produce biogas. Wastes buried in landfills take a longer time at a slow rate to be broken down and become a problem for the next generations.

According to Malaysia National Solid Waste Management Department (JPSPN, 2015), there are 296 landfills in Malaysia where 165 landfills are in operation all over Malaysia, and 131 are already closed. For areas in peninsular Malaysia, Perak recorded the highest number of landfills still operating at 17 landfills. Followed by Pahang, Johor and Kelantan, which is 16, 14, and 13 landfills, respectively. For West Malaysia, Sarawak has the highest number of landfills in operation, which is 49. As for Sabah, 19 landfills are still in operation.

Colour, pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), ammoniacal nitrogen, and total suspended solid are the common leachate parameters that are used as indicators to identify leachate contamination in any water sample tested in a laboratory. Heavy metals, organic and inorganic salts that have been chlorinated, organic matter that is both biodegradable and not, and ammonia nitrogen are all present in high concentrations in leachate (Renou et al., 2008). To determine the level of environmental risk posed by the leachate, the results obtained can be compared to the standards of various regulatory limitations. The community is constantly negatively impacted by MSW landfills, which raises worries and fears about things like water resource degradation brought on by landfill leachate contamination as well as a gas explosion and smell from these landfills. Leachate's subsequent release from landfill borders and discharge into the surrounding environment poses a major environmental risk as well as a danger to people's health and safety.

1.2 Problem Statement

One of the main problems with landfills is leachate as it contains huge concentrations of environmentally hazardous compounds. The organic waste generates bacteria that decompose the waste, and the decaying waste creates weakly acidic compounds that interact with the waste's liquids to produce leachate and landfill gas. There are so many landfills without proper treatment or design, and the leachate is just discharged into rivers which can cause problems in the future. To prevent pollution of the groundwater, soil, and air, proper and timely monitoring of the landfill and its leachate is necessary.

There have been several physical, chemical, and biological treatment techniques developed, even so, none of these techniques alone can be hailed as the most effective because landfill leachates also differ in composition, volume, and mobility. However, because to its low cost, great effectiveness, and environmental friendliness, bioremediation or treatment utilising biological processes is of significant interest.

Despite being quite effective, physical, and chemical procedures are expensive, and some of the chemical ones have long-term environmental risks (Salam and Nilza 2021). Malaysia's Alor Pongsu Landfill Site (APLS) is categorised as an anaerobic stabilised landfill. It may be located at 5°04' N and 100°35' E in Alor Pongsu, Perak, Malaysia. Since its inception in 2000, APLS has been in operation for more than 16 years. Additionally, the site receives an annual average of 660,000 metric tonnes of solid trash, or about an average days' worth of household waste. Recycling of solid trash was carried out here. APLS is also known as enhanced anaerobic sanitary landfill leachate (class III) (Zakaria and Aziz 2018).

The use of biosorbent in landfill leachate has not been widely reported, and its usage in Malaysia is currently not done. Adsorption is a phenomenon that occurs on surfaces frequently and is used to remove both organic and inorganic compounds. As a result of physical and chemical linkages, species are drawn to the surface of a highly porous material (Foo and Hameed 2009). Kurniawan et al. (2006) stated that adsorption is considered as a successful and essential method for treating wastewater. The removal of organic components and ammonia nitrogen from landfill leachate using adsorption has so far produced successful results (Foo and Hameed 2010). Activated carbon, chitosan, clay, as well as other materials had been utilised to remediate leachate in previous research.

In this project, the performance of raw Hydrilla Sp. as biosorbent for leachate treatment will be investigated. The biosorbent material can be utilized from sustainable biomass such as agricultural waste. When a liquid molecule attaches to a solid surface, adsorption takes place because adsorbents have such a high surface area, the adsorbate can be absorbed. Numerous metals and metalloids may collect in Hydrilla, and it does so in large amounts (Shrivastava and Srivastava 2021).

1.3 Objectives

The aim of this project is to treat the colour of the landfill leachate from the Alor Pongsu Landfill Site by using a new absorbent (Hydrilla sp.). The specific objectives are:

i. To prepare and characterise the Hydrilla sp. absorbent by FTIR, BET, and Zeta Potential analyses.
ii. To evaluate the performance of absorbent in the treatment in terms of colour, dosage and contact time.
iii. To determine the adsorption isotherm of raw Hydrilla sp.

1.4 Scope of Study

Three leachate samples were taken from the Alor Pongsu landfill site located in Bagan Serai, Perak, on January 26th, March 11st and March 16th, 2022. They were then first characterised in terms of colour, pH, BOD, COD, ammoniacal nitrogen and total suspended solids. Raw hydrilla species, created in the lab with particle sizes ranging from 0.7 mm to 1.18 mm, were utilised as an adsorbent. Physical activation was carried out at 105 °C. In batch research, the performance and the adsorption isotherm were determined. The Hydrilla Sp. was characterised in terms of Fourier Transform Infrared Spectrophotometer (FTIR), Brunauer Emmett Teller (BET), and zeta potential. The performances of untreated Hydrilla Sp. were evaluated based on dosages, pH values and colour in a batch study. The adsorption isotherm (name of model Langmuir or Freundlich) was also determined. Colour was taken as the targeted polluted due to its high-level present at the APLS.

1.5 Organisation of the FYP

This thesis contains five chapters namely introduction, literature review, methodology, results, and discussion, as well as conclusion and recommendations.

Chapter 1 introduces the background of study, problem statement, objectives of the research, and scope of study.

Chapter 2 gives the relevant literature review which discuss about technical terms, findings, topics, and results related to the previous research. For researchers to better comprehend the subject and move forward with their individual research, it can provide some ideas and guidelines.

Chapter 3 describes the framework of the research and its methodology. This chapter provides a thorough explanation of the methods used to get the anticipated results and approaches to carry out the project's goals and experimental procedures for batch study setup. There is a comprehensive description of the specific tools, procedures, or supplies employed in this study.

Chapter 4 presents the results and discussion obtained from the research. The purpose of the data analysis, whether quantitative or qualitative, is to condense a large amount of data to address the research questions, validate the theory, look at the problems that were faced, and investigate hypotheses. In this chapter, the findings will be examined and analysed to address the study's goals.

Chapter 5 summarise all the results as a conclusion for the study. All goals and anticipated results will be discussed, and the research question will be addressed. Actionable recommendations are offered, taking into account the limits of both the results and the relevant literature.

CHAPTER 2

LITERATURE REVIEW

2.1 Landfill Leachate

When waste decomposes in a landfill and water filters through it, a liquid called leachate is created. The amount of environmentally hazardous elements in this liquid makes it extremely poisonous. Leachate from landfills is a liquid made up of absorbed substances, such as soluble solids or any other unfavourable elements that may have been present in the dump. Leachate typically develops from the landfill's bottom through the unsaturated soil layers to the groundwater, where it subsequently flows through hydraulic connections to the surface water (Johannessen, 1999). The variety and depth of waste, the accessibility of moisture and oxygen, as well as the construction, use, and age of the landfill, all have a significant impact on leachate (Reinhart et al., 1998).

The leachate that is created is typically highly toxic because the waste material might contain a variety of chemicals, organic and inorganic compounds in significant quantities, and these compounds also degrade (Salam and Nilza 2021). Leachates are made up of both organic and inorganic contaminants, some of which are extremely poisonous and dangerous to the environment. Depending on the kind of waste that has been dropped and accumulated, landfill leachate's actual composition varies.

Microbes were crucial to the biodegradation and bioremediation of leachates and landfill trash. As a result of the various bacteria' metabolic activity utilising the organic material in the waste and leachate, gases including CH_4 and CO_2 were produced. The features of the waste materials, moisture content, temperature, pH, and the presence of inhibitors are only a few of the variables that affect the biodegradation processes of waste material (Joshi and Pant 2018). In landfills, MSW is degraded via a variety of anaerobic methods. The four phases of MSW degradation are hydrolysis, acid fermentation, acetogenesis, and methanogenesis which are all supported by bacteria. Each of these procedures involves a different type of microorganism. In Malaysia, it was noted that only 11 of the 166 active landfills are clean and capable of preventing landfill gas and leachate from escaping into the environment (Johari et al., 2014). The main components of the discharge from a sanitary landfill are leachate, which contains methane and heavily contaminated wastewater. Leachate has high amounts of both biodegradable and nonbiodegradable materials, including organic waste, phenols, ammonia nitrogen, phosphate, heavy metals, and sulphur dioxide, in addition to having a strong hue and unpleasant smell (Kamaruddin et al., 2015).

Table 2.1: Total Number of Landfill Sites in Malaysia.

States	Landfills in Operation	Landfills Already Closed
Johor	14	23
Kedah	8	7
Kelantan	13	6
Melaka	2	5
Negeri Sembilan	7	11
Pahang	16	16
Perak	17	12
Perlis	1	1
Penang	2	1
Sabah	19	2
Sarawak	49	14
Selangor	8	14
Terengganu	8	12
Federal Territories	1	7
Total	**165**	**131**
	296	

2.1.1 Characteristic of Leachate

A high concentration of pollutants in leachate has the potential to seriously harm the ecosystem. Total dissolved solids (TDS), organic contaminants and substrates, inorganic compounds, heavy metals like lead, nickel, copper, cadmium, and zinc, and colour are the four basic types of pollutants that can be found in municipal landfill leachate. (Mojiri et al., 2016). According to Vaccari et al. (2019), leachate is characterised by low pH levels, high concentrations of volatile acids, and simply decomposed organic matter in young landfills. Leachate methane production and pH are high in mature landfills (methanogenic phase), and the predominant organic components are humic and fulvic fractions. The BOD_5/COD 0.1 ratio was used to classify the leachate from the Alor Pongsu Landfill as stabilised landfill leachate (Zakaria and Aziz 2017). When compared to the permitted discharge limits for leachate, it can be shown that most of the metrics exceeded these limitations. So, before leachate can be released into the environment, it must first undergo proper treatment. Table 1.2 summarise the characteristics of leachate at Alor Pongsu Landfil.

Table 2.2: Characteristic of leachate at Alor Pongsu Landfill (2015- 2016)

No.	**Parameter**	**Unit**	**Min**	**Max**	**Mean**	**Standard Deviation**	**MEQA***
1	Temperature	◦C	25.9	31.6	29.8	1.51	40
2	pH		7.85	8.64	8.13	0.20	6.0-9.0
3	Colour	PtCo	10,650	20,300	14,984	2281	-
4	COD	mg/L	2950	4675	3852	582	400
5	NH3-N	mg/L	1040	1690	1241	214	5
6	BOD5	mg/L	113	343	196	63	20
7	BOD5/COD		0.03	0.08	0.05	0.02	-
8	DO	mg/L	0.09	3.00	0.85	0.84	-
9	TDS	mg/L	1800	9257	6237	2803	-

*Environmental Quality (control of pollution from solid waste transfer station and landfill) Regulation 2009 under the Laws of Malaysia Environmental Quality Act (MEQA) 1974 (MDC, 1997) [10]

2.1.2 Leachate Treatment

Physical and chemical, biological, and combination approaches are frequently used to treat leachate from landfills. Due to operational expenses and secondary pollutants, physical and chemical treatment techniques are frequently used as a pre-treatment and a post-treatment strategy in the leachate treatment process (Kurniawan et al., 2006). Figure 2.1 shows the most reported landfill leachate treatment methods.

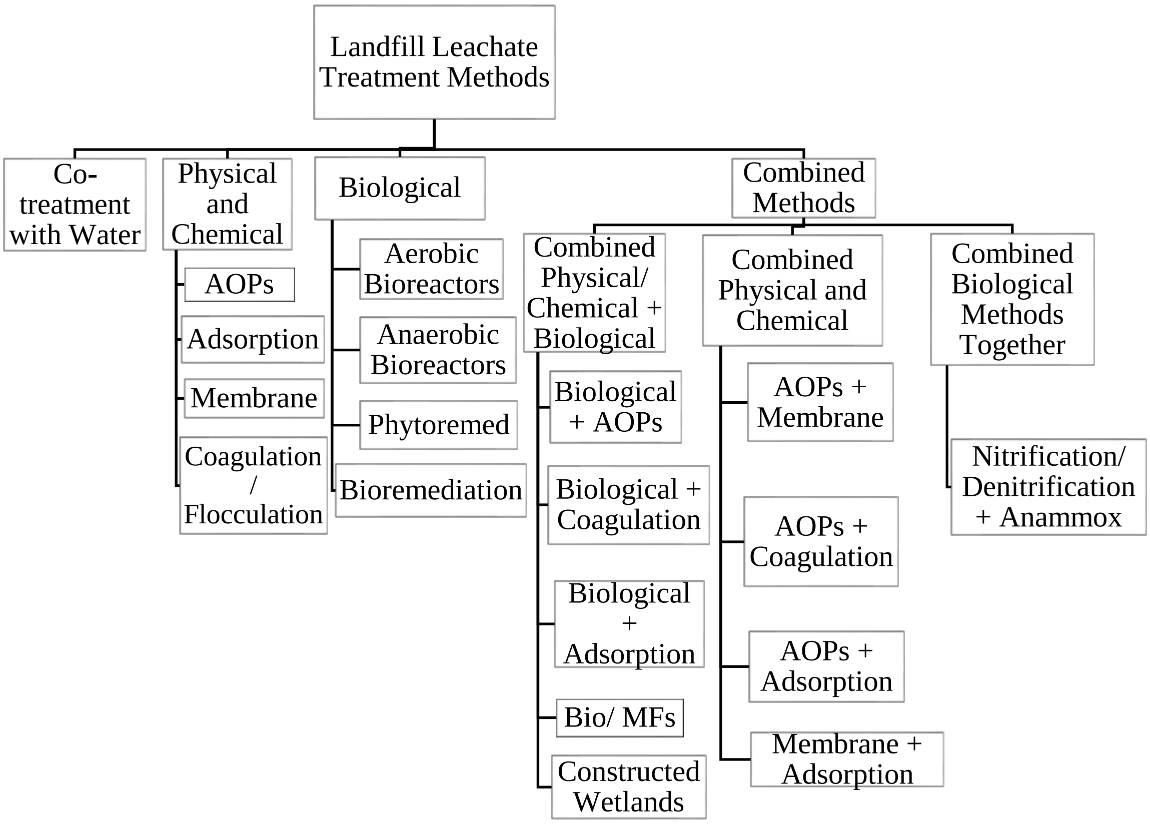

Figure 2.1: The Most Reported Landfill Leachate Treatment Methods

For the treatment of landfill leachate, adsorption has been widely used. The advantages of this approach include its simplicity, convenience of use, insensitivity to harmful compounds, and capacity to remove a range of contaminants (Chávez et al., 2019). Leachate from landfills is commonly treated using biological methods. However, the majority of the refractory pollutants in landfill leachate cannot be removed by a biological process alone. Therefore, to increase biodegradability ratios and boost biological performance in the treatment of landfill leachate, researchers (Mojiri et al., 2016b) have proposed integrated biological methods and physical/chemical procedures. There are five frequently used combination therapy approaches.

Microorganisms' metabolic processes lead to the biological breakdown of pollutants. Due to their affordability, biological approaches are frequently employed to get rid of nutrients like ammonia and organic compounds. However, these methods might not be able to get rid of heavy metals and nonbiodegradable organics as effectively (Miao et al., 2019). The most often used biological processes are aerobic ones. In aerobic reactors, vast pre-existing bacterial populations such as activated sludge are continuously aerated (Torreta et al., 2017). Due to the high COD and high BOD/COD ratio of landfill leachates, anaerobic methods typically outperform aerobic treatment techniques in the treatment of landfill leachate. When using biological treatment techniques, flocculation and coagulation can be used as pre- and posttreatment. Coagulation and flocculation used as a pre-treatment improves biodegradability and lowers metals, colour, and COD in landfill leachate. These benefits can improve the biological approaches for treating landfill leachate. Metals, COD, and organic contaminants that are recalcitrant to other methods of removal can be eliminated by using coagulation and flocculation as a post treatment.

The microbial removal of ammonium occurs during the denitrification and nitrification processes. In a typical nitrification-denitrification process, ammonia is converted to nitrate under aerobic conditions, which is then reduced to N2 under anoxic conditions (Thakur and Medhi 2019). Because other pollutants can affect the process, this phase is typically incorporated into other treatment methods.

Biosorption is the process of removing chemical species from biological or natural materials acting as sorbents. This is accomplished through extracellular and intracellular bonding, interactions that depend on the type of organic compound, the structure of the adsorbent material, and the metabolism and transport process of microorganisms. Adsorption, absorption, ion exchange, precipitation, and surface complexation are some of the mechanisms that are involved in the biosorption process (Gorduza et al., 2002).

2.2 Biosorption

Biosorption is classified as a typical adsorption process in which the ability of a biomaterial to bind pollutants or accumulate heavy metals to the surface of cellular walls in the equilibrium process is discovered (Holkar et al., 2016). Metal ions can be removed from contaminated solutions via biosorption in an economical and environmentally beneficial way. The main benefits of biosorption over traditional treatment techniques include low cost, high efficiency of metal removal from diluted solution, sminimisation of chemical and/or biological sludge, no additional fertiliser requirement, regeneration of biosorbent, and potential for metal recovery. Natural, non-synthetic, and environmentally acceptable sources are typically used to make biomaterials for biosorption (Anastopoulos and Kyzas 2015). At the end of the process, the biomaterials produce sludge-free effluents and can be reused for multiple cycles of treatment (Bagda et al., 2017).

2.3 Introduction to Hydrilla

This research is to investigate the performance of raw Hydrilla Sp. for biosorption of colour from landfill leachate. Depending on the water depth, the submerged plant known as Hydrilla Sp. (*Hydrilla verticillata*) has stems that branch above and root freely from the bottom nodes. Particularly, Hydrilla has extraordinary traits such as a wide range of vegetative reproduction and dispersal techniques, and a high resistance to temperature fluctuation (Bianchini et al., 2010). Because Hydrilla Sp. is effective at removing and remediating pollutants, it has been utilised for wastewater treatment. It has a treatment efficiency of 86 and 45% for phosphate and the biochemical oxygen demand (BOD), respectively (Vanichkul et al., 2015). It develops quickly in shallow water and gathers a variety of necessary heavy metals, including Fe, Ni, and Cu.

Long, slender stems of the hardy, quickly propagating perennial herb Hydrilla can grow up to 7 metres in length (23 ft). The Hydrilla species can survive in a wide range of chemical and physical water conditions, reproduce easily, spread far, and withstand a lack of readily available food. In addition to reducing water flow, clogging culverts and pipes, and changing the pH, dissolved oxygen content, and temperature of water, hydrilla can also create dense mats. Since leachate is considered as a very hazardous and solid waste management becomes an essential issue, raw Hydrilla Sp. is selected as the media to treat leachate in this research. This research is important to find another alternative solution using the waste one. The Hydrilla sp. should be characterised first before conducting the experiment and must be sent for analysis in terms of size and surface area. Figure 2.2 shows the Photo of Hydrilla Sp.

Figure 2.2: The Most Reported Landfill Leachate Treatment Methods

2.3.1 Properties of Hydrilla Sp.

The thin cuticles on the whorled leaves of Hydrilla Sp. Provide a significant surface area for the direct uptake of metals from aquatic systems. Water quality can be maintained by using Hydrilla Sp. To remove metal from a body of water. (Lafabrie et al., 2013). Hydrilla Sp. Plants possess high tolerance to several metals (loid)s (As, Cd, etc.) and accumulate them in significant quantities. Additionally, plants can absorb a significant amount of metal(loid)s in a short amount of time due to the uptake of metal(loid)s from both roots and leaves as well as movement in both acropetal and basipetal directions. Further uses for the used biomass from Hydrilla sp. include composting, briquetting, pyrolysis, and gasification.

Plants of the genus Hydrilla Sp. are capable of switching from C_3 to C_4 photosynthesis in response to environmental challenges such high temperatures, prolonged photoperiods, and alterations in the supply of carbon dioxide (CO2). In aquatic situations, low light and low dissolved CO_2 and O_2 levels are limiting factors for photosynthesis.

2.3.2 Hydrilla Sp. Applications

The thin cuticle on the whorled leaves of Hydrilla Sp. provides a significant surface area for the direct uptake of metals from aquatic systems. Hydrilla Sp. is used to remove metal from water bodies, preserving the water's purity and preventing metal transfer to higher organisms in the food chain (Lafabrie et al., 2013). In a field investigation by Lafabrie et al. (2013), it was discovered that a considerable amount of metals (Cd, Hg, Zn, and Ni) were accumulating in the tissues of Hydrilla as a result of uptake from polluted sediments in an estuary creek in Alabama, USA. Controlled field tests have added to the body of evidence supporting Hydrilla's utility in the removal of metal(loid)s. Recently, Hydrilla plants were employed in Florida, USA, in a created wetland along with other plants and algae to clean storm/runoff water from metropolitan areas. The system was found to be effective at reducing Cd, Pb, Cr, and Cu to levels below detection limits (1 ppb), in addition to total suspended solids, P, and N. (Wang et al., 2021).

2.4 Summary of Literature Review

Landfilling is the most widely used technique worldwide, including in Malaysia. Even though the landfill system has benefits such being simple to use and affordable, it also contributed to the leachate issue. Leachate is complicated and challenging to handle because of the numerous sources of MSW. Determining the leachate treatment procedure requires an understanding of the leachate properties, leachate phases, composition, and other leachate components. Before discharge, a variety of therapy modalities have been developed to guarantee eligibility. Additionally, the majority of Malaysia's landfill leachate is classified as stabilised leachate, which is typically not amenable to biological treatment. The most typical approach for treating stable leachate is physical-chemical treatment. One of the finest therapeutic choices is coagulation-flocculation (C-F), which is a quick and affordable procedure.

CHAPTER 3

METHODOLOGY

3.1 Flow Chart (Methodology)

Figure 3.6.1 shows the flow chart of the methodology for the project. The flow chart consisted of characterisation of leachate and characterisation of raw Hydrilla Sp. Then, the samples were tested in batch studies and further, the adsorption isotherms were employed to correlate the experimental data from batch studies.

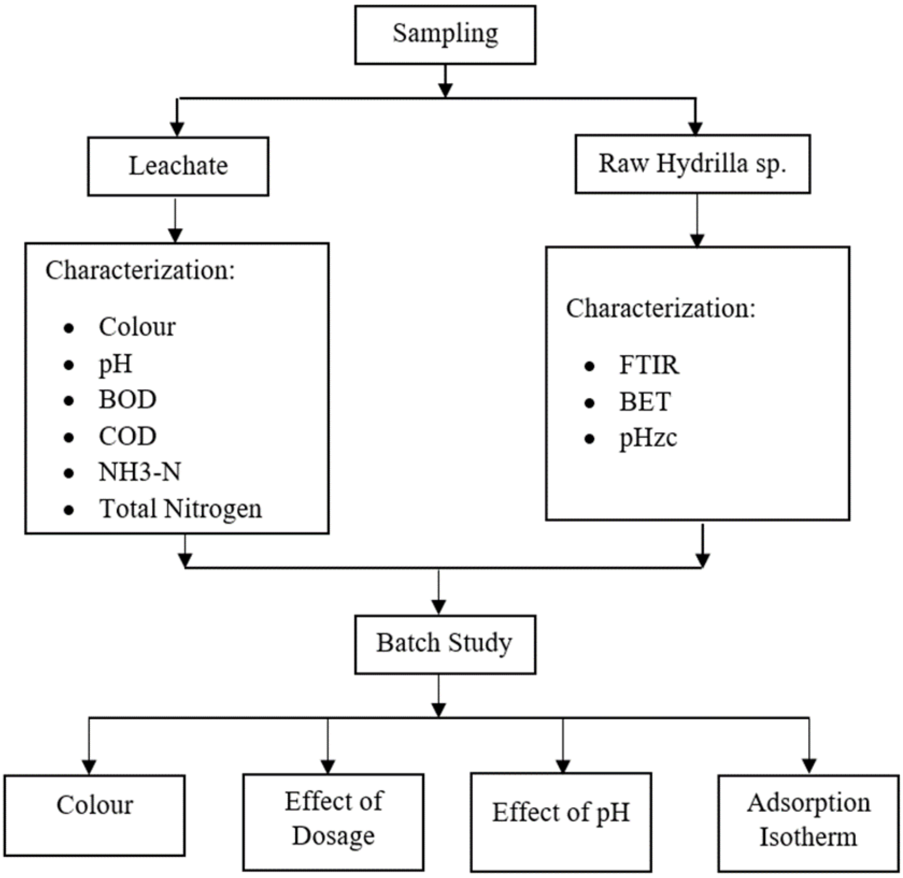

Figure 3.1: Flow Chart (Methodology)

3.2 Leachate Sampling

Raw leachate samples were collected from Alor Pongsu Landfill Site (APLS). It was located in Alor Pongsu, Perak, Malaysia, at coordinates of 5°04’ N, 100°35’ E. The samples were collected in HDPE plastic bottles, transported to the laboratory and stored at 4°C to minimise the biological and chemical reactions. The leachate had been collected three times throughout the project period. Figure 3.1 shows the leachate sampling at the Alor Pongsu Landfill Site. Figure 3.2 shows the sampling point in Alor Pongsu Landfill Site.

Figure 3.2: Leachate Sampling at Alor Pongsu Landfill Site

Figure 3.3: Sampling Point in Alor Pongsu Landfill Site

3.3 Leachate Characterisation

According to the Standard Methods for the Examination of Water and Wastewater, the leachate samples were examined for pH, temperature, dissolved oxygen (DO), ammoniacal nitrogen (NH_3-N), chemical oxygen demand (COD), total suspended solids (TSS), and colour (APHA, AWWA, WEF, 1992). Figure 3.3 showed the characterisation of landfill leachate on-site using YSI meter.

Figure 3.4: Characterisation of Landfill Leachate on site using YSI meter

3.3.1 pH

While the pH of the leachate in the lab was measured using a pH metre, the pH of the leachate on-site was measured using a YSI Pro Plus Multi-Parameter Water Quality Meter (model number). Before and after the test, the pH meter's electrode was cleaned with distilled water and dried with a piece of tissue paper. By submerging the pH metre electrode in the leachate, the pH value for the sample was calculated**.** The average pH value of raw leachate in Alor Pongsu was 7.84.

3.3.2 Colour

Colour was measured for the treated and untreated leachate using a spectrophotometer (DR 2800 HACH, USA). YSI Pro Plus Multi-Parameter Water Quality Meter was used to measure the pH of the leachate on-site, and a pH meter was used to measure the pH of the leachate in the lab (model number). Prior to and during the test, the electrode of the pH meter was cleaned with distilled water and dried with a piece of tissue paper. Immersing the pH meter electrode in the leachate yielded the leachate's pH value. The average value recorded for colour was 13,470 PtCo.

3.3.3 Temperature

In wastewater applications, temperature measurements served as a crucial backup to data including pH, dissolved oxygen, suspended solids, and turbidity. Temperature was a crucial factor since it had an impact on how well effluent could be treated. The YSI Pro Plus Multi-Parameter Water Quality Meter was used to measure the temperature of the leachate for in-situ sampling. The temperature of raw leachate in Alor Pongsu was 31.0 ^{o}C depending on the sampling time.

3.3.4 Ammoniacal Nitrogen

To calculate the ammoniacal nitrogen concentration, the Nessler method was utilised. Nessler reagent, a dispersant for polyvinyl alcohol, and a mineral stabiliser were the chemicals employed. 25 ml each of sample and deionised water were placed in two graduated cylinders. The dispersing agent was then applied in three drops to each cylinder, stopped, and repeatedly inverted to mix. Then, each cylinder received 3 droplets of polyvinyl alcohol, and the stoppers were repeatedly flipped to mix the drops. Additionally, 1ml of Nessler reagent was pipetted into each cylinder, and a one-minute reaction was started by pressing the time icon on the spectrophotometer's panel. Each solution was added to a circular sample cell using the graduated cylinder. After inserting the blank into the cell holder, the spectrophotometer was zeroed while the timer was running. After being cleaned, the prepared sample was put into a cell holder for measurement. Ammoniacal nitrogen was determined at the HACH DR2800 spectrophotometer. The unit for ammonia nitrogen was mg/L. The value for

3.3.5 Chemical Oxygen Demand

Chemical oxygen demand (COD) is to determine the organic strength of wastewater and the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals. The blank solution was prepared to measure COD. The blank solution consisted of 1.5ml of potassium dichromate (K2Cr2HgSO2), 2.0ml of distilled water and 3.5ml of silver sulphate (Ag2SO4). After that, all the tubes were put in a COD reactor at 150°C for 2 hours and then let cool for 1 hour. Lastly, the COD was measured using DR 2800 HACH, USA spectrophotometer in mg/L unit.

3.3.6 Biochemical Oxygen Demand

The amount of oxygen needed by bacteria to stabilise organic materials is measured by a process called biochemical oxygen demand (BOD). The following procedures were used to prepare the unseeded dilution water: A volumetric flask was filled with 5ml of the sample and the remaining volumes were filled with unseeded dilution water. The mixture was then divided across three Winkler bottles. Five days at 20°C were used to measure the zero-day dissolved oxygen (DO). The residual DO in all remaining bottles was assessed after five days.

3.3.7 Suspended Solids

Total Suspended Solids (TSS) were insoluble solids in water that a filter could capture. A spectrophotometer was used to quantify TSS in the treated and untreated leachate (DR 2800 HACH, USA). In order to zero the spectrophotometer, a cell containing 10 mL of distilled water was first added to create a blank solution. Then, each cell was added 10 mL of untreated leachate before being analysed with a spectrophotometer. Results were displayed in mg/L TSS. The aforementioned steps were repeated for the experiment with treated leachate.

3.4 Batch Study

The ability of raw and heat activated zeolite to adsorb ammoniacal nitrogen, COD, and the actual colour of the leachate was tested using the shaking method. The effects of pH and adsorbent dose on the adsorption processes were investigated. In this study, the orbital shaker was employed.

3.4.1 Colour

15ml of raw leachate sample was poured into the 1000ml volumetric flask, and the rest was filled with distilled water. The solution was inverted a few times and transferred into five conical flasks. Biosorbent with different dosages was added into five conical flasks, respectively. Next, the mixture was shaken with an orbital shaker at 130rpm for 1 hour. The solution was separated from the absorbent using filter paper, and the colour was determined using a spectrophotometer (DR 2800 HACH, USA).

3.4.2 Effect of Dosage

Conical flasks were used for a series of batch equilibrium investigations. Five 250 ml conical flasks, each containing diluted leachate, were filled with various weights of raw Hydrilla Sp., ranging from 1g to 5g. The flasks were shaken for 1 hour at room temperature and 130 rpm. Filter paper was used to separate the solutions from the adsorbent. The colour and the total suspended solid is determined.

3.4.3 Effect of pH

Raw leachate sample of 15ml was poured into the 1000ml volumetric flask, and the rest was filled with distilled water. NaOH solution was added to change the pH value from 6.76 to pH 7 to find the effect at pH neutral. The solution was inverted a few times and transferred into five conical flasks. Biosorbent was added into five conical flasks, respectively. Next, the mixture was shaken with an orbital shaker at 130rpm for 1 hour. The solution was separated from the absorbent using filter paper, and the colour was determined using a spectrophotometer (DR 2800 HACH, USA).

3.5 Hydrilla Sp. Characterisation

The Hydrilla Sp. was taken from ex-mining ponds along Jalan Batu Sinar (4°19’47.2”N 101°06’22.3”E) in Malim Nawar located in Kampar, Perak. Hydrilla Sp. was cleaned with water and must be dried in an oven at 105°C for 24 hours. Next, the Hydrilla Sp. was ground into powder at a size between 0.7mm to 1.18mm. The powder Hydrilla Sp. was cleaned with distilled water using an orbital shaker at 130rpm for 1 hour. The Hydrilla Sp. was put in the oven for 24 hours to let it dry. Raw Hydrilla Sp. will be characterised in terms of FTIR, BET and Zeta Potential.

3.5.1 Fourier Transform Infrared Spectrophotometer (FTIR)

The functional group implicated in biosorption will be found using FTIR. Fourier transforms infrared spectroscopy (FTIR) is a method used to obtain the infrared spectrum of a solid, liquid, or gas's absorption, emission, and photoconductivity. In PHB, it is used to identify a number of functional categories. Between 4000 and 400 cm1, the FTIR spectrum is captured.

3.5.2 Brunauer Emmet Teller (BET)

By employing a completely automated analyser to detect nitrogen multilayer adsorption as a function of relative pressure, Brunauer-Emmelt-Teller (BET) analysis provides an accurate assessment of the specific surface area of materials. The method included evaluations of the exterior area and pore area in calculating the total specific surface area in m^2/g. This information was crucial for understanding the impacts of surface porosity and particle size in numerous applications. BET method (ASTM D3037) was used to measure the total surface area, pore volume and pore size available for the adsorption. Before analysis, the sample was vacuumed at 300°C, allowed to degas for two hours, and then cooled in liquid nitrogen. The examination of the media's surface area, pore volume, and pore size were revealed by repeatedly measuring known volumes of nitrogen desorption-adsorption into and out of the sample while also monitoring the equilibrium pressure.

3.5.3 Zeta Potential

The surface charge of the biosorbent being used is to be ascertained using zeta potential. The electrochemical equilibrium at the particle-liquid interface is measured by the zeta potential. It currently counts among the fundamental factors that are known to influence the stability of colloidal particles since it quantifies the strength of electrostatic attraction or repulsion between particles. Its measurement provides in-depth understanding of the factors that contribute to flocculation, aggregation, or dispersion and can be used to enhance the creation of dispersions, emulsions, and suspensions. A 25 °C Malvern Zetasizer Nano ZS (Malvern Instruments, Malvern, UK) equipment was used to measure the zeta potential. Using a syringe, 1 mL of supernatant was introduced into the capillary cell. The dynamic light scattering/light dispersion technique was used to measure the electrophoretic mobility of the particle. This technique, also known as photon correlation spectroscopy or quasi-elastic light scattering, is used to measure the size of particles, particularly those that are smaller than one micron. The material was examined using the Malvern Zetasizer manual's recommended protocols. Laser Doppler electrophoresis is often used to detect this minute movement caused by the mobility of the particles in the presence of an applied electric field.

3.6 Adsorption Isotherm

Investigated were the adsorption capabilities at various medium dosages and leachate pH. Modeling was done on the experiment's adsorption isotherm data. The experimental adsorption isotherm data sets from the batch studies were correlated using the Langmuir and Freundlich adsorption isotherms. Then, compared the linearized models. Because of the streamlined mathematical equation, the linear forms of the isotherms models were chosen to identify the best fit isotherm parameters. The best fit isotherms model was found to have fewer departures from the fitted plot.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Landfill Leachate Characterisation

This chapter shows the results obtained and a discussion of the findings. In this study, the leachate from Alor Pongsu Landfill Site (APLS) was characterised according to the parameters such as pH, colour, temperature, dissolved oxygen, ammoniacal nitrogen, and chemical oxygen demand, biochemical oxygen demand, and suspended solids. The measurements of samples were conducted three times according to the standard methods for the examination of water and wastewater to obtain the average reading. Table 4.1. shows the readings and average reading of the leachate sample taken in this study from the Alor Pongsu landfill site.

Table 4.1: Characteristics of raw leachate at Alor Pongsu Landfill Site (APLS)

No.	Parameters	Reading 26/01/22	Reading 11/03/22	Reading 16/03/22	Average Reading	Standard (Discharge Limit)
1	pH	7.81	7.78	7.93	7.84	6.0-9.0
2	Colour (PtCo)	13,560	13,025	13,825	13,470	-
3	Temperature (°C)	31.0	31.1	30.8	31.0	40
4	NH_3-N (mg/L)	1,340	1,339	1,340	1,340	5
5	DO (mg/L)	1.05	1.18	1.14	1.12	-
6	BOD_5 (mg/L)	139	160	172	157	20
7	COD (mg/L)	3,448	3,349	3,544	3,447	400
8	TSS (mg/L)	567	630	582	593	50

Standard Based on Environmental Quality (Control of Pollution From Solid Waste Transfer Station and Landfill) Regulations 2009 (PU(A) 433) Second Schedule (Regulation 13)