TREATMENT OF YOUNG LEACHATE USING ELECTROCOAGULATION PROCESS

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By

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ABSTRAK

Tapak pelupusan sampah adalah salah satu kaedah terkenal dalam menguruskan sampah perbandaran kerana senang diuruskan dan murah. Antara masalah utama tapak pelupusan sampah adalah penghasilan larut resapan bergantung daripada jumlah bahan organik, ammonia, nitrogen dan logam berat. Larut resapan muda berpotensi berada dalam keadaan asid disebabkan oleh kandungan asid lemak tepu dengan nilai pH di antara 6-7 atau kurang. Larutan resapan mengandungi pelbagai pencemar organik dan bukan organik dan diketogikan sebagai pencemar bermasalah dan berbahaya kepada ekosistem kerana boleh meresap ke dalam tanah dan mencemarkan air bawah tanah. Dalam kajian ini, elektrogumpalan telah digunakan sebagai kaedah rawatan alternatif untuk merawat larut resapan. Kaedah ini menggunakan peralatan yang mudah dan senang dikendalikan. Objektif keseluruhan untuk kajian ini adalah untuk menentukan keadaan optimum yang mempengaruhi kadar keberkesanan kaedah elektrogumpalan dalam merawat larut resapan. Terdapat tiga faktor yang dipertimbangkan semasa ujian ini iaitu voltan, masa rawatan dan penambahan garam sebagai elektolite. Karbon digunakan untuk kedua-dua elektrod dengan penambahan natrium klorida atau tiada penambahan natrium klorida dalam larutan resapan. Julat voltan yang digunakan adalah 3V, 6V dan 9V dan julat masa rawatan adalah 10 minit, 20 minit, 30 minit dan 40 minit. Kesan penyingkiran yang dianalisis adalah warna, kekeruhan, keperluan oksigen kimia dan jumlah partikel terampai. Penyingkiran optimum warna, kekeruhan, keperluan oksigen kimia dan jumlah partikel terampai adalah 97.34% dengan menggunakan 6V dan 10 minit masa rawatan, 42.54% dengan menggunakan 3V dan 30 minit masa rawatan, 54.98% dengan menggunakan 9V dan 40 minit masa rawatan dan 86.76% dengan menggunakan 6V dan 30 minit masa rawatan masing-masing. Oleh itu, elektrogumpalan terbukti dapat merawat larutan resapan dengan berkesan.

ABSTRACT

Landfilling is one of the most popular methods of municipal solid waste disposal due to its simplicity in terms of disposal and low cost. One of the main problems with the solid waste landfill sites is leachate depending on large amount of organic matter, ammonia, nitrogen and heavy metals. Young leachate tends to be acidic due to presence of volatile fatty acid with pH normally in the range of 6-7 or lower. Leachate contains a variety of organic and inorganic contaminants and is classified as problematic and extremely dangerous pollutants to ecosystem as it can percolate through permeable soil and can pollute groundwater. In this study, electrocoagulation process was used as an alternative to treat leachate. This method is characterized by simple equipment and easy operation. The overall objectives of this study was to determine the optimum treatment condition that influence the efficiency of electrocoagulation method to treat leachate wastewater. There are three control parameters that need to be considered during this test such as voltages, treatment time and the present of sodium chloride as electrolyte. Carbons were used as electrode for both cathode and anode with or without sodium chloride. The ranges of voltages applied were 3V, 6V, and 9V and the ranges of treatment time were 10 minutes, 20 minutes, 30 minutes and 40 minutes. The research work involve the analysed of effects on colour, turbidity, Chemical Oxygen Demand (COD), total suspended solids (TSS). The optimum removal of color, turbidity, COD and total suspended solids were 6V with 10 minutes treatment time, 3V with 30 minutes treatment time, 9V with 40 minutes treatment time and 6V with 30 minutes treatment time respectively. Therefore, the percentage efficiency of pollutant removal on color, turbidity, COD and total suspended solids were 97.34%, 42.54%, 54.98% and 86.76% respectively. Therefore, electrocoagulation is proven in treated young leachate effectively.

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LIST OF ABBREVIATIONS

APHA	American Public Health Associations
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
Al	Aluminium
Fe	Iron
NaCl	Sodium chloride
TSS	Total suspended solids
Pt-Co	Platinum Cobalt
NTU	Nephelometry Turbidity Unit

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Increasing the population density and rapid urbanization lead to more production of domestic waste and needs to be managed efficiently. The land filling has been to be main method of the waste management. The current landfill technology is primarily determined by the need to prevent and control leachate problem. Leachate depends on several factors including waste composition, specific climatic conditions and moisture contents inside of the waste. However, leachate becomes an issue as a wastewater sources since it may cause serious pollutions to ecosystem. When the waste degrades and rain rinses the resulting product out, leachate is formed. The moisture content inside the waste itself also affect the amount of leachate produce.

Commonly, leachates may contain organic contaminants in large amounts and can be measured as Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), inorganic contaminants, ammonia, suspended solids and high concentration of heavy metal. Young leachate tend to be acidic due to presence of volatile fatty acids with pH normally in the range of 6-7 or lower (Aziz et al., 2010). Therefore, treating of leachate wastewater is very important for prevent the contaminants from entering and pollute the subsoil and groundwater. If not properly treated and safely disposed, landfill leachate could be a potential source of surface and groundwater contamination as it may percolate through soils and subsoil (Tatsi et al., 2003).

Various methods of leachate treatment have been proposed such as aerobic and anaerobic biological degradation, chemical oxidation, chemical precipitation, coagulation-flocculation, activated carbon adsorption and membrane processes (Tatsi et al., 2003) but the applicability of each method highly depends on the specific characteristic of the leachate. Electrocoagulation (EC) is an electrochemical wastewater treatment technology that has been used in treating effluents containing suspended solids, oil and grease, and even organic and inorganic pollutants that can be flocculated. Electrochemical methods have been successfully applied in the purification of wastewater from dye production, alcohol production, olive oil production, tanneries and landfill leachate. (Vlyssides et al., 2001).

Electrocoagulation is a treatment process of applying electrical current to treat and flocculate contaminants without having to add coagulant. The mechanisms in the electrocoagulation process include coagulation, absorption, adsorption, precipitation and floatation. Electrocoagulation is known process to remove large organic molecules from water. Carbon electrodes are used for both cathode and anode for this study due to its efficiency in wastewater treatment and relative low cost compared to other materials (Chen, 2004).

It is also a technique to create conglomerates of the suspended, dissolved or emulsified particles in aqueous medium using electrical current causing production of metal ions at the expense of sacrificing electrodes and hydroxyl ions as a result of water splitting. As a result, the suspended solids will form flocs and sediment under gravity. Thus, the aggregates formed can be removed by decantation or floatation from the wastewater (Chou 2010).

Due to its effectiveness and ease in operation, electrocoagulation process has been received significant attention for wastewater treatment. Therefore, electrocoagulation had treated various types of wastewater such as textile wastewater (Verma, 2017), p-chlorophenol and p-nitrophenol (Borras et al., 2003), olive oil wastewater (Gotsi et al., 2005), restaurant wastewater (Chen et al., 2000) and paint wastewater (Bouranene et al., 2015).

1.2 Problem Statement

Young leachate can be defined as leachate that had been generated in the aerobic and acid phases that normally the age is less than 2 years. It tend to be acidic to the presence of volatile fatty acid. The young leachate were collected from the local waste collection truck within the residential area in Simpang Ampat, Semanggol, Perak. The waste truck will collected the waste three times in a week. Normally, the waste truck will collect waste by Tuesday, Thursday and Saturday. All the waste will disposed to nearest landfill site that is located in Lembah Beriah, Perak.

By using waste compaction truck, the waste can be collected and compacted maximum up to 4.5 tonnes. However, while compacting the waste, the leachate will produced out of the compacted waste. The production of leachate during waste collection will become nuisance to the environment as it will give bad odour. As we known, the young leachate contains many organic and inorganic contaminants before treated and become harmful to the environment.

Therefore, the purpose of this study was to determine the optimum treatment condition that influence the efficiency of electrocoagulation method to treat leachate wastewater. There are three control parameters that need to be considered during this test such as voltages, treatment time and the present of sodium chloride as electrolyte. Effective and economical treatment methods are required to improve effluent characteristics for discharge into river or stream according to the standard.

1.3 Objectives

This study were carried out in order to achieve the following objectives:

(a) To determine the efficiency of removal colour, turbidity, Chemical Oxygen Demand (COD) and total suspended solids from young leachate using electrocoagulation process.

(b) To determine the effect of sodium chloride in the electrocoagulation process.

(c) To establish the optimum treatment condition that influence the electrocoagulation process.

1.4 Scope of Work

Young leachate used in this study was collected from the local waste collection truck that collect waste in the residential area in Simpang Ampat, Semanggol, Perak. Samples were collected by using high density polyethylene bottles on 27_{th} February 2018, 12.30pm. The samples are classified as raw wastewater. All samples were brought to the environmental lab and stored at $4^{o}C$ for test and analysed purpose. The leachate were measured its characteristics before and after the coagulation process in term of pH, colour, turbidity, Chemical Oxygen Demand (COD) and total solids. All the method for the measurement is used according to the standard method for the examination of water and wastewater recommended by American Public Health Association (APHA), 2015.

There are several stages of electrocoagulation process in the laboratory experimental which was started with the determination of leachate characteristic without any treatment applied on it. Next stage is the determination of leachate characteristic upon coagulation process is applied by using carbon electrode on both cathode and anode. Last stage is to determine the optimum treatment condition that influence the coagulation process such as voltage, treatment time and the present of electrolyte.

This study were highlighted on the treatment of young leachate by using electrocoagulation process on its efficiency in produce better quality of wastewater before discharging into river or stream according to specific characteristic such as pH, colour, turbidity, Chemical Oxygen Demand (COD) and total solids. Carbon electrode will used for both cathode and anode throughout the experimental process. However, there were three parameters that were considered during this test were voltages, treatment time and the present of electrolyte.

The ranges of voltages applied were 3V, 6V and 9V and the ranges of treatment time were 10 minutes, 20 minutes, 30 minutes and 40 minutes. The tests were repeated with the same type of electrode but different in the existing of sodium chloride that act as electrolyte. Carbon electrode have been choosing to investigate the efficiency of treat and remove the pollutants due to its efficiency in removing the grease from the previous paper. Therefore, this study is conducted with three parameters to analyse and determine the optimum parameters needed for treat the leachate as it will turn into profit as its require small amount of chemical involved during the treatment phase.

1.5 Outline of Thesis

This thesis consists of five chapters namely Introduction, Literature Review, Methodology, Results and Discussion and finally Conclusion and Recommendation. The outline of each chapter were described below:

Chapter 1: Introduction started with the inauguration of the background of the study and the problems listed under the study. As well as the objectives and the scope of the work.

Chapter 2: Literature Review will discuss on the previous study and research that were conducted by other researcher according to the related topic that lead to the wastewater treatment by using electrocoagulation method.

Chapter 3: Methodology will be explained in further detailed the flow of experimental work that will be done in order to achieved the objective of this project.

Chapter 4: Result and Discussion is the most significant part in this thesis that will highlighted the outcome of the experimental work when the result is obtained. The result obtained later will discuss with the supporting evidence and reports.

Chapter 5: Conclusion and Recommendation is the final chapter that will conclude the study and recommendation for the future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this literature review chapter, its aim to expose the main objective, discuss the basic knowledge and literatures cited regarding young leachate, electrocoagulation, mechanism of electrocoagulation, factors affecting electrocoagulation process and the advantages and disadvantages of electrocoagulation in treated wastewater before discharging to river or stream.

2.2 Landfill

A landfill is defined as a system that is designed and constructed to discarded waste by burial in land to reduce and minimize the nuisance to the environment. Landfill is the main disposal methods used in solid waste management systems. More than 80% of MSW is disposed without any treatment by landfills. Based on Action Plan 1988-Malaysia, there were four levels improvement aimed for landfill (Manaf et al., 2009) which were:

- Level 1: controlled dumping
- Level 2: sanitary landfill with daily cover
- Level 3: sanitary landfill with leachate circulation
- Level 4: sanitary landfill with leachate treatment facilities

There are five categories of landfill structure. Generally, landfill structure affects the characterization of leachate production. The landfill structure will effect on the decomposition of organic matter especially BOD_5 concentration from the landfill leachate. (Aziz and Mojiri, 2015). Therefore, the Table 2.1 show the categorization of landfill structure.

Table 2.1: Categorization of landfill structure.

No.	Category	Details
1	Anaerobic landfill	Disposed solid waste are filled in digged area of plane field or valley. The waste are filled with water under anaerobic condition
2	Anaerobic sanitary landfill	Anaerobic landfill with cover like sandwich shape. Conditions of disposed wastes are similar as type 1
3	Improved anaerobic sanitary landfill	This kind has leachate collection system in the bottom of the landfill site. Other parameters are same as anaerobic sanitary landfill. The conditions are still anaerobic and moisture content is much less than anaerobic sanitary landfill.
4	Semi-aerobic landfill	Leachate collection pipe is larger than the one of improved sanitary landfill. The openings of the pipe are surrounded by air and the pipe is covered with small crushed stones. Moisture content in disposed solid waste is low. Oxygen is supplied to solid waste from leachate collection pipe.
5	Aerobic landfill	Besides of the leachate collection pipe, air supply pipes are attached and air is obligated to enter the solid waste of which condition becomes more aerobic than semi-aerobic landfill.

Source: Environmental Control Pollution Centre, Osaka Prefecture (2009)

2.3 The Generation of Leachate

The leachate could be produced by two main factors. First factor is from the external water enters the waste and the second factors of leachate production is from the moisture content of waste itself that will generated leachate. It is a complicated wastewater that contains high concentration of pollutants and unwanted effects to the environment (Solak et al., 2009; Renou et al., 2008; Bashir et al., 2009 and Mojiri et al., 2014a).

2.3.1 External Water

A huge amount of leachate generated by the direct water such as from precipitation, surface run-off and infiltration of water into the waste. Precipitation that infiltrate through landfill throughout many years will contact with various substances such as paper, plastic, metal, oil and etc. after that, the water will leaches and dissolves various constituents until it contains a load of organic and inorganic compound, heavy metals, suspended solids and high in fat, oil and grease. The frequency, quantity and duration of rainfall affect the quantity of leachate production. In addition, the humid climate is a strong influence for the leachate generation.

The groundwater and surface water will flow into waste by inflow or infiltration depend on the landfill site condition. If the landfill is built under a sloping field that contain surface water, water will drop down into the landfill follow the slope. In the other hand, if the landfill site is below the groundwater table, it will have high possibility of groundwater infiltrate into the landfill (Ghosh et al., 2017)

2.3.2 Moisture Content from the Waste Itself

The wet waste such as food waste contains high moisture content. The amount of moisture content by weight or volumetric basis is expressed in term of percentage of municipal solid waste either in wet or dry state is the moisture content of refuse. Moisture content of waste is added to refuse beyond its holding capacity indicates the volume of leachate produced from the waste. The waste moisture was produced during the waste placement or during the waste collector from the compaction process of waste truck. Water squeezed out of waste by compaction total of 22 to 45% of overall leachate amounts (Yang et al., 2015). It is important to estimate the amount of leachate produced from waste itself in order to estimate the amount of moisture content that will be added to the landfill before any leachate is produced and drained off through the bottom part of landfill design.

2.4 Characteristic of Leachate

Leachate can be defined as a liquid that passes through a landfill and has extracted dissolved and suspended matter from it depend on waste type and the waste age. Leachate results from precipitation and from the waste moisture that exists when it is composed that will entering the landfill (Raghab et al., 2013). The characteristic of leachate were influenced by the type of MSW, landfill age, moisture content, site hydrology the stage of decomposition in the landfill, pH, and biochemical or chemical oxygen demand (BOD/COD) ratio and could be classified as young and matured (Aziz et al., 2014) .Leachate can be categorize into two types that is mature leachate and young leachate. Mature leachate generated in the methanogenic phase with the age normally more than 5 years. However, young leachate can be defined as leachate that had been generated in the aerobic and acid phases that normally the age is less than 2 years. Table 2.2 summarizes the typical characteristics of leachate according to age of landfill.

Table 2.2: Characteristics of Leachate at Different Ages of Landfill (Renou et al., 2008)

Constituent/leachate type	Young (<5 years)	Intermediate (5-10 years)	Stabilized (>5 years)
pH	<6.5	6.5 – 7.5	>7.5
COD (mg/L)	>10000	4000 – 10000	<4000
$BOD_{5/}$ COD	>0.3	0.1 – 0.3	<0.1
Organic compounds	80% volatile fatty acid (VFA)	5-30% VFA + humic and fulvic acids	Humic and fulvic acids
Heavy metals	Low to medium	Low	Low
Biodegradability	Important	Medium	Low

The characteristic of leachate can be analysed either by physical, biological or chemical method. First is pH. pH is a measure of hydrogen ion concentration. It used a measure of the acidity or alkalinity in aqueous solutions by using a pH meter. A pH value is a number from 1 to 14, with 7 as the middle (neutral) point. Values below 7 is acid. While the value above 7 indicate alkaline (Westcott, 1978)

Next is temperature. It is the degree of hotness or coldness present in the object or substances. It also defined as a measure of the average kinetic energy of the particles in a sample of matter, expressed in terms of units or degrees designated on a standard scale (Ou et al., 2006). Whereas colour is a measure concentration of dissolved and particulate material and referred as Hazen scale or Platinum Cobalt scale.

Turbidity is the degree to which a transparent liquid scatters light, usually a measure of the amount of suspended material in the liquid. Turbidity is measure of the light-transmitting properties of water and is comprised of suspended and colloidal material. Suspended solids and colloids cause turbidity in water (Lawler, 2016).

Lastly is COD and total suspended solids. Chemical Oxygen Demand (COD) measure the amount of oxygen that is consumed by the reaction of organic carbon with bacteria or chemicals (Hu and Grasso, 2005). COD indicates the amount of pollutant in the wastewater. The higher the chemical oxygen demand, the higher the amount of pollution in the test sample and total suspended solids (TSS) are particles that are larger than 2 microns found in the water column (Lloyd, 2003). Anything smaller than 2 microns (average filter size) is considered a dissolved solid. Most suspended solids are made up of inorganic materials, though bacteria and algae can also contribute to the total solids concentration. High concentrations of suspended solids can lower water quality by absorbing light. Waters then become warmer and lessen the ability of the water to hold oxygen necessary for aquatic life.

2.5 Electrocoagulation

Electrocoagulation is one of the treatment process for wastewater by applying electrical current to treat and flocculate contaminants without having to add any coagulants. This treatment consists of a beaker that act as electrolytic cell. It also consists of a pair of carbon electrode, that are arranged in a pairs namely cathode and anode. The selection of electrode materials is very critical and the aluminium (Al) and iron (Fe) is the most commonly used as this electrode are cheap and easy to get (Mouedhen et al., 2009).

The electrocoagulation process can be used for the drinking water and wastewater treatment. Electrocoagulation consists of generating coagulant species in situ by electrolytic oxidation of sacrificial anode materials through the electrodes triggered by applied electric current. The metal ions generated by electrochemical dissolution of a consumable anode spontaneously undergo hydrolysis in water, depending on the pH, forming various coagulant species including hydroxide precipitates (able to remove pollutants by adsorption/settling) and other ions metal species. Al and Fe materials are the most commonly used as electrode materials due to various advantages such as their availability, i.e. abundance on the earth and low price, their non-toxicity, as iron and aluminium hydroxides formed by precipitation are relatively non-toxic, and their high valence that leads to an efficient removal of pollutant (Hakizimana et al., 2017).

The electrochemically generated metallic ions hydrolyse at the anode to form a series of polyhydroxides and metal hydroxides. This series are able to destabilize dispersed particles in the wastewater such as heavy metal to be treated and later will aggregates to form flocks. Therefore, the flocks formed can be removed by floatation or decantation from the wastewater (Chou 2010). Electrocoagulation process has been effectively for the various type of wastewater such as restaurant wastewater (Adjeroud 2015),electroplating wastewater (Verma et al,. 2013) and laundry wastewater (Janpoor et al, 2011), municipal wastewater (Al-Shannag et al., 2013), baker's yeast wastewater (Al-Shannag et al., 2014), Stronium (Kamaraj et al., 2013) and heavy metal ions (Al-Shannag et al., 2015). Electro-coagulation (Holt et al., 2005) is an electrochemical technology of treating polluted water at the expense of sacrificial anodes at an optimized potential.

2.5.1 Electrocoagulation Mechanism

The electrocoagulation mechanism is highly influent by the chemistry of the aqueous solution, especially conductivity and also on the other characteristics such as particle size, pH and chemical constituents concentrations (Xu and Zhu, 2004). During the electrocoagulation process, there will be reaction occurring at the both electrode of cathode and anode simultaneously. The mechanism of electrocoagulation can be divided into the main mechanisms that cause destabilisation of pollutants and side reactions such as hydrogen formation.

The electrocoagulation process is the process without addition of coagulant. This is because electrode that made of metal either aluminium or iron will produce coagulants into the water. There can be inert electrode, that generally cathodes, which are sometimes used as counter-electrodes in the system. However, the carbon is rarely used for the electrocoagulation process.

2.5.2 Factors Affecting Electrocoagulation Process

There are numerous parameters that will affect the efficiency of the electrocoagulation process in removing pollutants from the wastewater. Therefore, the factors that will affect the removal of pollutant in wastewater are voltages, treatment time and the presence of electrolyte.

The first factors is the effect on voltages. Voltages is directly proportional to the amount of electrochemical reactions that occur on the surface of electrode. Low voltage produces low bubble density resulted to a low upward momentum flux and produce low slow mixing. However, as the voltage increases, the bubble density and the speed of mixing increase. Therefore, the operational voltage has a strong influence on the efficiency of pollutant removal (Chen et al., 2002).

The second factor is the effect on treatment time. The treatment time is proportional to the amount of coagulants produced in the electrocoagulation process and the other reactions taking place during the process (Hosain et al., 2013).

Last factors that affect the electrocoagulation is the presence of sodium chloride that act as electrolyte. Sodium chloride (NaCl) is usually employed to increase the conductivity of the water or wastewater to be treated. Wastewater conductivity affects the Faradic yield, cell voltage and therefore energy consumption in electrocoagulation cells. The addition of NaCl can also reduce the electrical energy consumption of electrocoagulation, as it increases the conductivity of the wastewater. Compared with no addition of electrolyte, NaCl addition in the 'g/L' range usually saves much electrical energy, and hence decreases operating costs.

2.5.3 Advantages and Disadvantages of Electrocoagulation

Consequently, adequate scale-up parameters, a systematic approach for process optimization and performance prediction of the electrocoagulation reactor are yet to be established. Advantages and benefits of using electrochemical techniques include environmental compatibility, versatility, energy efficiency, safety, selectivity, amenability to automation and cost effectiveness (Mollah et al., 2004). In addition, the following advantages can be added for the treatment of pollutants with the electrocoagulation process: compact and simple reactors due to rapid reactions instead of using chemicals (coagulants, oxidants) and microorganisms; and the systems employ only electrons to facilitate water treatment.

On the other hand, electrocoagulation has several disadvantages. For example, the sacrificial electrodes are dissolved and hence lost into wastewater streams as a result of oxidation and need to be regularly replaced periodically; the use of electricity may result in high electrical energy costs, and electrical energy costs are very high in some countries; operation costs (sludge disposal, electrical energy consumption and electrode replacement) may become high, depending on the case in question; an impermeable oxide film may be formed on the cathode, leading to loss of efficiency; and high conductivity of the wastewater suspension is required. In some cases electrolytes have to be added to the wastewater; gelatinous metal hydroxides may tend to solubilize in some cases; the presence of high electrolyte concentrations (chloride) may result in the formation of toxic, organically bound halogens (AOX, EOX, POX); and in some cases pretreatment (pH adjustment, equalization, etc.) may be required prior to electrocoagulation.

2.6 Summary of Literature Review

This chapter conclude the overall literature review that had been used in this study in term of landfill and categorization of landfill structure, generation of leachate, characteristic of leachate and the electrocoagulation process as one of the treatment to remove pollutant in leachate. The generation of leachate could be produced by two main factors mainly the external water and the leachate production from the moisture content itself. Whereas, the characteristic of leachate is depend on the age of leachate based on physical, biological and chemical characteristic. Lastly, electrocoagulation process can be used for the drinking water and wastewater treatment and the removal of pollutant by using this method is affected by voltages, treatment time and present of coagulant that influenced the percentage of pollutant removal.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter represents the method, material and apparatus that were used during the study including the materials used and experimental setup.

The overall experimental activities carried out in this study is shown by using schematic flow diagram in Figure 3.1. This study started with the collection of leachate from the collection truck and the determination of leachate characteristic before coagulation process. Next stage is the determination of leachate characteristic upon coagulation process prior to three parameters such as voltages, treatment time and the present of sodium chloride. Last stage is the determination of the optimum treatment condition that influence the coagulation process of young leachate wastewater.

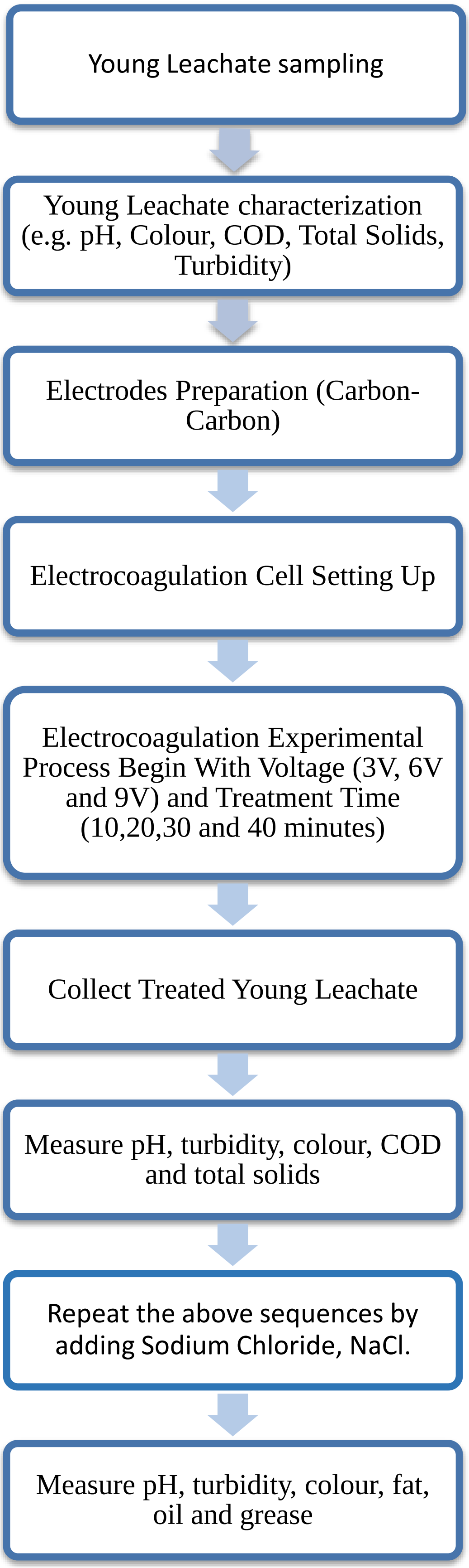

Figure 3.1: Flowchart for methodology

3.2 Leachate Wastewater Description

The leachate used in this study was taken from the local waste collection truck in Simpang Ampat, Semanggol, Perak. There are many type of waste collection truck such as rolls-off and rear loaders Figure 3.2 shows the process of taking leachate from the collection truck by using 20L high density polyethylene bottles to prevent the sample from contaminant. The waste collection truck is collect different waste from several type of residential within the area of waste collection trip.

Figure 3.2 Image of Sampling.

A controlled of young leachate started from the waste generated from the respective population on that area. Normally, the waste is collect by using waste collection truck. Trucks and separate vehicles from different parts of the city collect and bring the waste to this landfill site and dump it. Different type of waste collection truck has different capacity to load the waste. The amount of leachate production is influence by type and the volume of waste. When the truck can load more volume of waste and the waste consists of high moisture content, it will produce high volume of leachate.

3.3 Leachate Sampling

Samples were collected on Tuesday, 20 February 2018 at 12.30 pm. The types of leachate collected were fresh leachate or known as young leachate. The leachate were collected directly from the waste collection truck outlet piping. Sample collection and handling procedure were perform according to the standard procedures recommended by American Public Health Associations (APHA), 2005. All samples were transported to the environmental laboratory and kept in refrigerator with the temperature 4^{o}C for future use.

3.4 Leachate Sampling Analysis

Young leachate characteristic were monitored before and after the coagulation process in the laboratory.

3.4.1 Laboratory Leachate Sampling Analysis

Samples were analyse before and after the treatment in the laboratory in term of pH, temperature, color, turbidity, chemical oxygen demand (COD) and total suspended solids (TSS). All the measured process in the laboratory is according to the standard method for the examination of water and wastewater recommended by American Public Health Associations (APHA), 2005. Therefore, the physical, biological and chemical characteristic had been observed is shown based on the standard method and requirement that are tabulated in Table 3.1.

Table 3.1: Parameter of Leachate Characteristics

Parameter	Unit	Method No.	Equipment	Chemical	Remarks
pH	-	Standard Method (APHA), 2005 Part 4500-H	YSI Proffesional Plus Quatro, Eutech pH700	-	pH meter was calibrated by using three buffer solutions (pH 4, pH 7 and pH 10)
Temperature	^{o}C	Standard Method (APHA), 2005 Part 2550	YSI Proffesional Plus Quatro, Eutech pH700	-	-
Color	mg/L PtCo	Standard Method (APHA), 2005 Part 2120	HACH spectrophotometer DR-2800	-	-
Turbidity	NTU	Standard Method (APHA), 2005 Part 2120	HACH turbidity meter 2100N	-	-

COD	mg/L	Standard Method (APHA), 2005 Part 5220 C	Titrimetric method	1) Potassium Dichromate 2) Ferrous Aluminium Sulphate	-
TSS	mg/L	Standard Method (APHA), 2005 Part 8006	HACH spectrometer DR-2800	-	-

3.5 Experimental Setup

The treatment of young leachate by using electrocoagulation process need a reactor, a pair of electrode, electrode clamps, DC power supply, magnetic stirrer and magnetic bar. 100 ml glass beaker will be used as electrolytic cell. 50 ml volume of leachate will be used during the experiment according to the specific parameter.

The types of electrodes used in this study were carbon electrode. This type of electrode will be applied for both cathode and anode electrode. Carbon were used as they are cheaper and known as effective in removing grease in wastewater. The image of carbon electrodes from pencil were shown in Figure 3.3. The electrodes were placed in a glass beaker that act as electrolytic cell. Two electrodes were set up by a space of 2cm between cathode and anode in vertically position with electrodes clamp attach to ensure the electrode is in the fixed position when immersed in the leachate water.

Figure 3.3: Carbon electrodes from pencil

The tests begin with the both of electrodes were connected to a direct current power supply that provide electrical current to the electrocoagulation process. The tests also used magnetic stirrer and magnetic bar to enhance the pollutant removal. The schematic diagram of experimental set up is shown in Figure 3.4 is based on (Aziz and Mojiri, 2015) with some modification . All the tests were performed with different voltages from 3V, 6V and 9 V. Then, the whole process of the test was repeated with the present of sodium chloride that act as electrolyte.

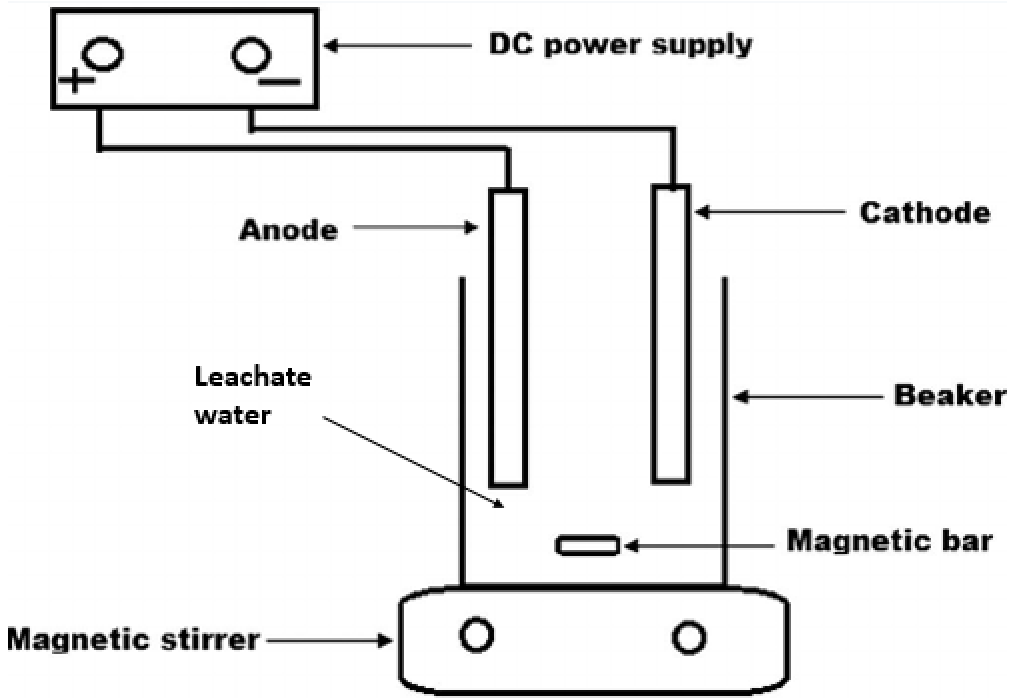

Figure 3.4: Schematic diagram of experimental set up

There are three factors that need to be considered during conducted this test such as voltages, treatment time and the present of sodium chloride. Carbon electrode will be used for both cathode and anode in this study. Carbon electrode will be a constant parameter for the type of electrode throughout this study. The ranges of voltages applied were 3V, 6V and 9V with the range of treatment time were 10 minutes, 20 minutes, 30 minutes and 40 minutes. The used of carbon electrode is due to the cheaper cost, has a high chemical stability during contact with both aqueous and organic electrolytes (Sirisomboonchai et al., 2018) and its efficiency in removing pollutant. These study were focused on removal of colour, turbidity, COD, total suspended solids.