EFFECTIVENESS OF COAGULATION/FLOCCULATION PROCESS FOR THE REMOVAL OF CHEMICAL OXYGEN DEMAND (COD), COLOR AND SUSPENDED SOLID IN INDUSTRIAL WASTEWATER TREATMENT

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By

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I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

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This study is for creating a better environment to the society. Thank you.

ABSTRAK

Kehadiran air kumbahan lateks di dalam alam sekitar memberi negatif kepada kualiti air dengan menyebabkan banyak permasalahan seperti warna, bau dan sebagainya. Selain itu, ia boleh mendatangkan kesan buruk kepada masyarakat dan penduduk hidupan liar kerana air adalah salah satu sumber yang penting sebahagian daripada kehidupan. Oleh itu, penting untuk merawat air kumbahan sebelum melepaskan air permukaan. Proses pengentalan dan pemberbukuan telah dijalankan untuk memaksimumkan penyingkiran COD, pepejal terampai dan warna dengan menggunakan aluminium dan ferik klorida sebagai bahan pengental. Parameter lain juga termasuk dalam kajian ini seperti kekeruhan, BOD dan UV254mm untuk pengumpulan data yang lebih banyak. Untuk sampel air sisa purata, pengentalan proses dengan menggunakan alum dan pH 6 menunjukkan peratusan tertinggi penyingkiran warna dan pepejal terampai dengan 96.35% dan 99.45% pada dos optimum 80 mg / L. Walau bagaimanapun, untuk penyingkiran COD menunjukkan sedikit peratusan penyingkiran, iaitu 33.05%. Pengentalan dengan menggunakan ferik klorida berserta pH 6.0 menunjukkan penyingkiran warna yang paling tinggi dan pepejal terampai dengan 99.25% dan 99.5% pada dos optimum 300 mg / L. Walau bagaimanapun, penyingkiran COD hanya 37.75%. Ia boleh menyatakan bahawa, proses pengentalan / pemberbukuan tidak memperbaiki penyingkiran COD dalam air sisa. Oleh itu, ia memerlukan lebih banyak rawatan. Untuk kajian ini, dapat disimpulkan bahawa penggunaan ferik klorida adalah lebih baik dalam penyingkiran warna dan pepejal terampai berbanding alum.

ABSTRACT

The presence of latex wastewater in the environment gave negatives impact on the water quality by causing many such a problems such as colour, odour and etc. Other than that, it can bring harmful effect to society and wild life population because water is one of essential part of life. Therefore, it is important to treat wastewater before releasing into the surface water. For this study, coagulation and flocculation process had been conduct to maximize the removal of COD, suspended solid and colour using aluminium and ferric chloride as coagulant. Other parameters are also included in this study such as turbidity, BOD and UV_{254mm} for more data collection. For average sample of wastewater, coagulation using alum with pH 6 showed the highest percentage of removal of colour and suspended solid with 96.35% and 99.45% at optimum dose of 80 mg/L. However, for COD removal show little percentage a removal, which is 33.05 %. Coagulation using ferric chloride with pH 6.0 showed the highest removal of colour and suspended solid with 99.25% and 99.5% at optimum dose of 300 mg/L. However, the COD removal only 37.75%. It can be state that, coagulation / flocculation did not improve the removal of COD in wastewater. Thus, it requires more treatment. For this study, it can be conclude that the use of ferric chloride was better in removing colour and suspended solid compared to alum.

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LIST OF ABBREVIATIONS

Alum	Aluminium Sulphate
$FeCl_3$	Ferric Chloride
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand

NOMENCLATURES

Fe	Ferric
Ca	Calcium
Mg	Magnesium
Se	Selenium
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Introduction

In many part of the world, economic, social and political problems have arisen following rapid industrial development and urbanization, resulting in adverse effects on the quality of life. Malaysia is one of the developing country that facing the same problem. The uses of larger resources such as forestry, freshwater and marine resources for space suitable for further development. Thus, it gives opportunity for a better livelihood in industrialized, economically booming urban areas. However, those rapid development of industrialized placed put very high pressure to surrounding environment especially at these locations waterbodies such as rivers, lakes, and coastal waters. Preventing pollution from industrial wastewater activities is important to ensure the sustainability of the environment.

Industrial wastewater are effluents that results from human activities, which are associated with raw material processing and manufacturing. Example of industrial wastewaters include those from chemical, pharmaceutical, electrochemical, electronics, petrochemicals and food processing industries. It should be noted the location of industries in urban areas where building congestion is already a problem. Water pollution occurs when potential pollutants in wastewater reach certain amounts causing harmful to the receiving waterbody. Appropriate management of industrial wastewater treatment is a matter of priority. In 2015, Malaysia government has spent a total of RM 2.55 billion on environmental protection and the highest contributor for the environmental protection expenditure (EPE) is industrial sector at RM 1.88 billion.

Even though, nature has ability to cope with small amounts of wastewater and pollution but it would affect if billions of gallons of wastewater did not undergo treatment before releasing it back into the environment. The objectives of treating the wastewater is to reduce the pollutant to a level nature can handle. If the wastewater is not properly treated, it gives negatively impact to environment and human health. The impact of industrial wastewater discharge on the environment and society can be tragic at times. This also include harm to living creatures in water, wildlife populations, oxygen depletion, beach closures and other restrictions.

1.2 Problem Statement

Industrial wastewater are one of the main pollution that contributes to the pollutant of the environment. Industrial wastewater that exist such as textile industry, landfill leakage, latex industry etc. In order to study the treatment of wastewater that produced by those industries a collaboration was carried out with Teleflex Medical Sdn Bhd that produced latex wastewater. Latex wastewater characteristic are very high in total suspended solid (TSS), high organic matter and nitrogen containing pollutants, high acidity and strong smell (Pendashteh et al., 2017). Sample of wastewater are took at influent stage of treatment and coagulation/flocculation process for treatment.

Thickening material used in coagulation/flocculation treatment process are aluminium sulphate (alum) and ferric chloride ($FeCl_3$).The effectiveness between both coagulants are compared for better removal. Other than that, ferric chloride ($FeCl_3$) is the coagulant that use in treatment plan. The result from both of coagulants were compared to make some improvement in treating latex industrial wastewater.

Apparently, no major studies have been done to clarify the treatment of latex industrial wastewater by using aluminium sulphate (alum) and ferric chloride (FeCl) in coagulation / flocculation process. Therefore, this study was carried out to analyse the efficiency of alum and ferric chloride in clarifying the wastewater in differential condition. At the end of study, the optimum pH, dosage and mixing time were determined by achieving the best performances of alum and ferric chloride.

1.3 Objectives of study

In order to find the best solution to solve the problem stated in the problem statements, the following objectives are set up to be guideline and reference during the study. The objectives are listed as follows:

1. To determine optimum dose of alum and ferric chloride for removal of chemical oxygen demand (COD), suspended solid (SS) and colour from latex industrial wastewater.

2. To determine the suitable pH by using optimum dose of alum or ferric chloride to remove chemical oxygen demand (COD), suspended solid (SS) and colour.

3. To determine the removal of chemical oxygen demand (COD), suspended solid and colour by coagulation/flocculation process.

1.4 Scope of Work

The scope of work performed in this study consists as followed:

1. The study was done using latex industrial wastewater that were collected from Teleflex Medical Sdn Bhd which is located at Kemunting, Taiping.
2. Coagulation/ flocculation process were conducted by Jar Test using alum and ferric chloride with pH control at pH 5 , pH 6 and pH 6.5. The coagulant dose (mg/L) were varied for alum and ferric chloride at 80, 100, 125, 150, 200, 300 and 100, 150, 200, 250, 300, 350 respectively.

3. To determine the optimum dosage and pH for chemical oxygen demand (COD), suspended solid (SS) and colour removals based on highest removal.

1.5 Dissertation Outline

The thesis has been categorized into specific chapters for better viewing and understanding of the study. This dissertation consists of five chapters.

Chapter 1: Introduction – this chapter gives an overview of the thesis, followed by the problem statement to identify, and understand why this research was carried out and its relevance to current times followed by the objectives of this research in order to set the desired target of work and finally the justification of this research.

Chapter 2: Literature review – This chapter will discuss the previous research findings which are related to this study.

Chapter 3: Methodology – Explanation of research methodology that have been used in the research by running the experiment at environment laboratory.

Chapter 4: Results and discussion – Present results, analyses and discussion from the experiment.

Chapter 5: Conclusion – This chapter contains the conclusion and recommendation of study.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter review the definition and history of industrial wastewater, coagulation process, types of coagulants and water quality parameter. Industrial wastewater generates estimated volume of 2.97 billion cubic per meters per year based on report census 2010, Department of Statics Malaysia. However, this statics were from 8 years ago and the volume of wastewater could be doubled from the number now due to growth of industrial in Malaysia. In the wastewater, some of the common parameters that should be observed are turbidity, colour, pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD) and suspended solid. The quality of the effluent wastewater should be controlled by having low turbidity, suspended solid and colour without any unpleasant odour. To accomplish a standard effluent quality of wastewater there are several treatment technologies can be used, which includes coagulation/flocculation.

2.2 Introduction

Industrial wastewater can be define as water that has been used as part of making a commercial product. It differs from domestic wastewater or municipal wastewater that also called as sewage. This type of wastewater contain pollutants that are present in colloidal form. In such cases the colloidal suspension may contain organic materials, metal oxides, insoluble toxic compounds, stable emulsion and material producing turbidity (Prakash et al., 2014). Industrial wastewater is by-product of industrial or commercial activities. For a given water and wastewater, such material may comprise suspended, dissolve organic and inorganic matter, as well as several biological organisms, such as bacteria, algae or viruses (Renault et al., 2009). Whether any kind of product we produce, water is required for nearly every step production across a multitude of different industries. Nguyen Trung Viet (1999) stated latex processing amount to 30-35 m^3/ton. A large quantity of water is used in latex processing treatment plant for washing, dilution of the latex and further processing step. The resulting wastewater must be carefully managed. Other than that, the composition of industrial wastewater are varied depends on the type of industry and materials processed. It can be that some of that wastewater can be originally very strong, easily biodegradable, largely inorganic or potentially inhibitory.This material has to be removed, as it causes deterioration of water quality by reducing the clarity (Renault et al., 2009).

The main concern of discharging latex wastewater contains substantial amounts of biodegradable organic compound and offensive smell. To comply with environmental protection laws, a treatment for certain things in wastewater must be removed. This includes organic matter, inorganics such as sodium, potassium, calcium, magnesium , copper, lead, nickel and zinc,pathogens and nutrients. Without proper treatment, the discharge of wastewater to the environment may cause serious and prolong consequences. Therefore, suitable technologies must be used for treating this wastewater (Mohammadi et al., 2013).

2.3 Coagulation and flocculation

Coagulation and flocculation describe the chemical process of contact and adhesion whereby the particles of a dispersion (colloids) form larger-size cluster (flocs or flakes) allowing them to be more easily removed from water (e.g. by settling). The coagulation-flocculation processes facilitate the removal of suspended and colloidal particles. Coagulation/ flocculation is a frequently applied proess in the primary purification of industrial wastewater (and in some cases in secondary and tertiary treatment) (Renault et al., 2009).It may be used as pre treatment prior to biological treatment in order to enhance biodegradability of the wastewater during the biological treatment (Amuda and Amoo, 2007). It is used in the first stage of solids-liquids separation: settling, flotation or filtration. This is one of the universal treatment physical-chemical methods that relatively simple technique which is used in water and wastewater(Ghafari et al., 2009). Coagulation or flocculation process was conducted for the treatment of industrial wastewater to achieve maximum removal of COD, TP and TSS.(Abu Hassan et al., 2009). All these works showed that the coagulation/flocculation process involved several mechanisms such as charge neutralization, precipitative coagulation, bridging, electrostatic patch and aggregation phenomenon (Renault et al., 2009). Coagulation usually completes in a very short period of time (e.g. about 10s), whereas flocculation occurs usually over a period of 20 to 45 min.

The advantage of physical chemical treatment reduce suspended solid, colloidal matters and non-settable matter. Coagulation and flocculation process was conducted to achieve maximum removal of turbidity, chemical oxygen demand and suspended solid (Ghafari et al., 2010). Other than that , it can be supported by Amuda et al., (2006) stated that coagulation/flocculation process have been found to be cost effective, easy to operate and energy saving treatment alternatives. The efficiency of coagulation/ flocculation strongly affects the overall treatment performance; hence, the increase of the efficiency of coagulation stage seems to be a key factor for the improvement of the overall treatment efficiency (Renault et al., 2009). However, based by Amokrane et al., (1997) reported that the percentage of COD removal efficiency obtained via coagulation process were generally 50-60%.

The most important operational parameters of coagulation arethe type of coagulant, its concentration, and pH. The increase incoagulant dosage and pH control are common options for enhancingthe removal of organics, but the disadvantages are the increase incorrosion tendency of water, treatment cost, and treatmentcomplexity (Carlson et al., 2000). Based on Ghafari et al., (2010) there are parameters that need to be optimized in this process which are coagulant dose, pH, speeds and times of rapids also slow mixing. The main variables in optimizing the process are dosage of coagulant and pH. However, other variable parameter also important such as duration and speed of mixing. Optimization of these variable were carried out "changing one factor at one time' method, which means single factor is verified while other factors are kept constant at specific set condition of time. (Amuda et al., 2006) investigated the effect of coagulant dose, polyelectrolyte dose, pH of solution and addition of polyelectrolyte as coagulant aid and found to be important parameters for effective treatment of beverage industrial wastewater.

2.3.1 Optimum coagulant dose

Coagulant dosages vary in a wide range aiming at maximum removal efficiency of pollutants (Watanabe et al., 1993).In order to determine the range of coagulant dosage, preliminary study need to be conducted. From a jar test experiment were carried out by Ghafari et al (2010), the result revealed 9.4 g/l for alum. While based on Amuda and Amoo, (2007) results that removals of COD, TP and TSS increased substantially as the dosage of ferric chloride increases. The removal efficiency increases rapidly with the use of 300 mg/L dose of ferric chloride. Furthermore, the high concentration (>300 mg/L) of coagulant the removal of COD and TP increased slowly until it become constant at coagulant above (>500 mg/L). At this point it is important to note that optimum dose of ferric chloride that enhanced maximum removal of COD, TP and TSS was 300 mg/L.

2.3.2 Optimum pH

Coagulation pH as a factor that influences coagulation is important because addition of metallic cation automatically lowers pH, which may cause further eduction in the removals of contaminants (Amuda and Amoo, 2007). In the past, Ph values of 6.6-7.6 were considered suitable for all anaerobic bacteria with an optimum Ph range between 7.0-7 by Nguyen Trun Viet (1990). It can be supported by (Renault et al., 2009) statement that decresing the pH from alkaline levels to near neutral levels have strong positive effects on the reduction of turbidity, suspended solid (SS) and chemical oxygen demand (COD). The optimum initial pH was also determined in two stages by firstly identifying a narrow range and then conducting jar test applying pH values within the narrow range to attain optimum value. Experiments accomplished using the previously achieved optimum dose. The optimum pH for alum was 7 (Ghafari et al., 2010). It was observed that optimum pH 9 enhanced substantial removal of the contaminants with optimum dose at 300 mg/L. By increasing, the pH above 9 markedly deteriorated the quality of wastewater. (Amuda and Amoo, 2007)

2.3.3 Optimum time and speed for rapid mixing

Based on experimented speed of rapid mixing were in the range of 80 to 300 rpm. (Ghafari et al., 2010).The “changing one factor at a time” procedure is not accurate method for optimizing speed and time of mixing. Therefore, interaction between speed and time should be logically undertaken through a survey of their concurrent variations.

The rapid mix stage helped to disperse the coagulant (Prakash et al., 2014).The optimum condition apply in my study are 1 min duration and 130 rpm for alum and ferric chloride.

2.3.4 Optimum time and speed for slow mixing

Range of variations of speed and time for slowing are adopted to find the best result. This slower mixing speed helped promote floc formation by enhancing particle collisions which led to larger flocs (Prakash et al., 2014) Based on (Ghafari et al., 2010) they used 10 -50 rpm and 10-30 min. The optimum condition apply in my studies are 30 min duration and speed 35 rpm for alum and ferric chloride.

2.4 Types of coagulant

The commonly used metal coagulant are those based on aluminium and those iron based. The aluminium coagulants are aluminium sulphate, aluminium chloride and sodium aluminate. While, ferric sulphate and ferric chloride iron based coagulants. It can be supported by Stechemesser H and Dobios B (2005) ; Bartby J (2007) stated that the most common additives are aluminium sulphate (generally known as alum), ferric chloride and ferric sulphate. The addition of these cations results in colloidal destabilization, as they specifically interact with and neutralises the negatively charged colloidal (Renault et al., 2009). This statement can be supported by Renault et al., (2009) that aluminium and iron slats gives cationic hydrolysis products that are strongly adsorbed on negative particles and give effective destabilisation. The coagulants effectiveness based on their ability to form multi charged poly nuclear complexes with enhanced adsorptions characteristic. It can be control by adjusting pH of the system. Among these coagulants, iron salts are more efficient than aluminium ones (Amokrane et al., 1997).

When metal coagulants are added to wastewater, a reaction of metal ions (Al and Fe) hydrolyse rapidly and forming a series of metal hydrolysis species. The effective of the hydrolysis species are determine by efficiency of rapid mixing, the optimum pH and the coagulant dosage for treatment. Ghafari et al.,(2010) stated that iron slats are generally more efficient than aluminium ones in coagulation/flocculation process. The application of simple metal coagulants (conventional) is widespread, especially due to the relatively low cost and the simpler application route. However, they exhibit several disadvantages, such as the need for the pH adjustment before or after treatment, the sensitivity to temperature changes, the need for the higher dosages because the charge neutralization is not usually sufficient, the sensitivity to sample specific characteristic and composition, as well as the excessive sludge production (Renault et al., 2009).

2.4.1 Aluminium based Coagulant

Aluminium based coagulant such as alum ($Al_2(SO_4)_3$) and aluminium chloride ($AlCl_3$) are the most commonly used coagulant. Early as 1500 BC, Egyptians were reported using aluminium sulphate (alum) in water treatment to cause suspended particles to settle.

The advantages of using alum are that it is stable, easy to handle and readily soluble. In addition, alum salts are better in turbidity removal and can be more effective in low doses compared to ferric salts. In addition, by using aluminium salts the colour removal efficiency is high. Other than that , the performance of alum is no longer needs to be proved and its appreciated for its low cost, ease of use and availability (Renault et al., 2009). However, it produce abundant sludge that is difficult to dehydrate. In addition, the use of alum is source of concern and the debate about its possible toxicity is still open. Since high aluminium concentrations in water may have human health implications, environmentally friendly coagulants will present an interesting alternative for the purification of wastewater (Bartby J., 2007). The disadvantages are relatively high coagulant residuals in treated water for certain cases, possible Alzheimer's diseases and high alkalinity consumption.

2.4.2 Ferric based coagulants

Ferric salts that are commonly used in coagulation are ferric chloride (FeCl) and ferric sulphate ($Fe_2(SO_4)_3$) has been reported by (Budd et al., 2004). Ferric salts hydrolysis are similar with aluminium salts when added to water but from a different hydrolysis product. It has been reported that optimum pH for ferric based coagulation is between pH 4.5 to pH 6 (Budd et al., 2004). Other than that, iron salts compared with aluminium salts are more efficient at lower dosage, have heavier flocks, coagulate at a wider pH range, and pose less health risk in overdose (Maranon et al., 2008; li et al., 2010; Liu et al., 2012; Umar et al., 2016). The efficiency of coagulation with ferric chloride is influenced by the pH, with suggested optimal range between product 4.5 and 6.0 (Yan et al.,2008; Matilainen et al., 2010)

The advantages of using ferric chloride in wastewater treatment plan because it helps to make water clean and etc. Other than that, ferric chloride does not produce dangerous fumes, is odourless and even though is corrosive but it not absorbed through skin. The disadvantage of ferric chloride is it needs greater chemical addition in order for stabilize and corrosion control when results produce a low buffering capacity. To summaries, ferric chloride is a chemical that effectively use in coagulation/flocculation process.

2.5 Advantages of Coagulant and Flocculation

There are many advantages using coagulation and flocculation method in treating wastewater. Firstly, there are many research that had been done in various types of industrial wastewater and a lot improvement have been done. Besides, it easy to operate relatively simple design and low energy consumption had been done successfully employed in different types of industries (AlMubaddal et al., 2009). (Mat et al., 2013)This method can be used as a pre-treatment, post treatment or even as main treatment of wastewater due to versatility of the treatment process (Torres et al., 2009)

2.6 Summary of literature

Industrial wastewater is one of pollutant that need to be treat before discharging to the environment. Thus, it need a suitable treatment for removal of those parameters such as COD , suspended solid, colour and etc. Coagulation / flocculation process by jar test is conducted. A series of jar test with different dosage, pH and coagulant are chosen to find the optimum condition. A constant time for rapid mixing and slow mixing is determine based on literature review. For rapid mixing, the mixing was 150 rpm for 60 s. For slow mixing, the mixing was 35 rpm for 35 minutes. Let it settle for 30 minutes. Ferric chloride chloride is found to be better in removing those pollutants in wastewater than alum. Thus, this study is important as it proven whether alum or ferric chloride is better in removal of pollutants. All condition must followed the acceptable conditions for discharge of industrial effluent or mixed effluent of Standard B.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter explains the experiment work that have been carried out. The optimum coagulant dose and optimum pH were determined, as well as the equipment involved were briefly discuss. The experimental procedures were also explains.

This study focused on latex industrial wastewater that produced by Teleflex Medical Sdn Bhd that located in Kemunting, Taiping. The method of treatment using coagulation/ flocculation process by using jar test conducted. Besides, the comparison made between the types of coagulants (Alum and Ferric Chloride) under varied coagulant dose, with pH control and without pH control for all samples. The comparison is made in order to see the effectiveness of the coagulant in removing chemical oxygen demand (COD), suspended solid (SS) and colour.

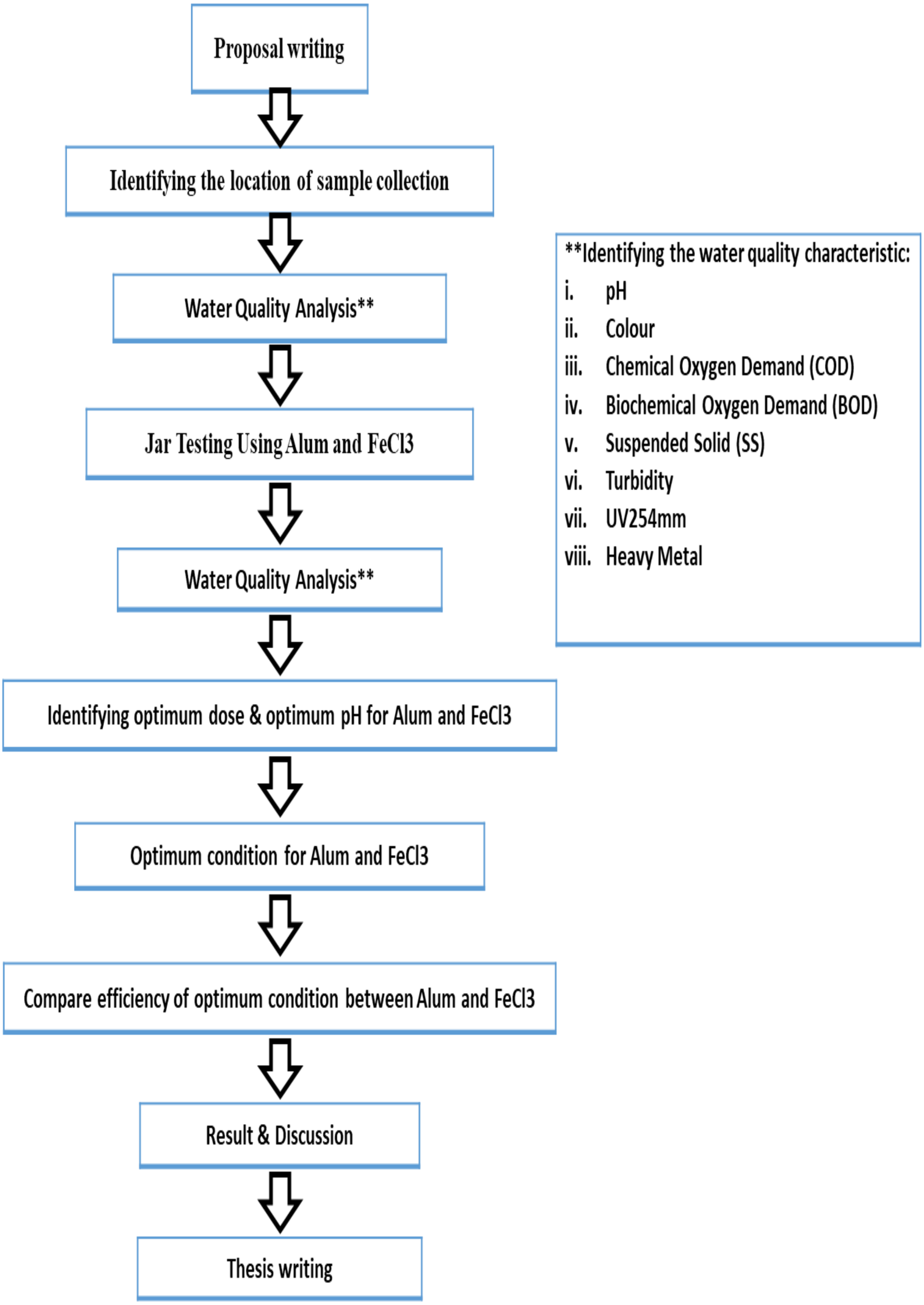
3.2 Wastewater sample collection

The wastewater sample were collected from Teleflex Medical Sdn Bhd that is located in Kemunting, Taiping. This company is a company that produces medical parts for anaesthesia, respiratory, urology and related sets. The production of the wastewater is varies due to request of order from customer. When the order from customer is highly in demand, thus the production of wastewater were more polluted and vice verse. For this study, the wastewater sample collected for two times only in two weeks. The location of sample collected in the treatment plant is the first influent stage of treatment. By using a bucket to collect the sample and pour into sample bottles and keep in cold storage in environment laboratory at 4° C. The location were shown in Figure 3.1 and Figure 3.2

Figure 3.1 : Location of Teleflex Medical Sdn Bhd

Figure 3.2: Influent stage of treatment plant.

3.3 Flowchart of study



3.4 Chemical reagents and equipment

In this study, two coagulants were applied to the sample, which are aluminium sulphate (Alum) and Ferric Chloride (FeCl). A series of jar test was conducted.

3.5 Jar Test (Coagulation and flocculation)

For alum reagents , a series of jar test conducted as stated below :

No of exp	1	2	3	4	5	6
Jar Test 1 Dose (mg/L)	pH 6 80	pH 6 100	pH 6 125	pH 6 150	pH 6 200	pH 6 300

No of exp	1	2	3	4	5	6
Jar Test 2 Dose (mg/L)	pH 6.5 80	pH 6.5 100	pH 6.5 125	pH 6.5 150	pH 6.5 200	pH 6.5 300

For ferric chloride reagents, a series of jar test conducted as stated below :

No of exp	1	2	3	4	5	6
Jar Test 1 Dose (mg/L)	pH 5.0 100	pH 5.0 150	pH 5.0 200	pH 5.0 250	pH 5.0 300	pH 5.0 350

No of exp	1	2	3	4	5	6
Jar Test 2 Dose (mg/L)	pH 6.0 100	pH 6.0 150	pH 6.0 200	pH 6.0 250	pH 6.0 300	pH 6.0 350

3.5.1 Preparation Aluminium Sulphate (Alum) reagents

Concentration of 10000 mg/L was prepared for alum coagulant. 10 g of aluminium sulphate ($Al_2(SO_4)_3.16H_2O$) were added to 1000 ml of distilled water. The solution was then mixed properly. The amount of alum for certain dosage were determined using equation below :

MaVa = MsVs

Where: Ma = Concentration of Alum (1000 mg/L)

Va = Volume of Alum required

Ms = Concentration of Alum for certain dosage

Vs = Volume of sample for jar test

3.5.2 Preparation Ferric Chloride (FeCl) reagents

Concentration of 10000 mg/L was prepared for ferric chloride coagulant. 25 ml of concentrated ferric chloride were added to 1000 ml of distilled water. The solution was mixed properly. The amount of ferric chloride for certain dosage was determined by using equation below:

MaVa = MsVs

Where: Ma = Concentration of Ferric Chloride (1000 mg/L)

Va = Volume of Ferric Chloride required

Ms = Concentration of Ferric Chloride for certain dosage

Vs = Volume of sample for jar test

3.5.3 Jar Test

A coagulation is a process to destabilize the colloids by adding chemicals that neutralizes the negative charges. The chemicals are knows as a coagulants. Coagulations is basically a chemical process. Flocculation is a process of agglomeration of destabilized particles into larger size particles knowns as flocs which then can be effectively removed by sedimentation or flotation.

A conventional jar test apparatus had been carry out in the experiments to coagulate sample of latex wastewater by using aluminium sulphate and ferric chloride. The objectives of jar test to determine the optimum and enhanced dosage of alum and ferric chloride. Firstly, six 1000 ml beakers were filled with 700 ml of raw wastewater samples. After that, pH was adjusted wastewater by adding NaOH or H_2SO_4 until achieved the final value of pH. Alum solution with 80 mg/L concentration was added to the beakers corresponding to doses 100, 125, 150, 200 and 300 mg/L. For ferric chloride solution with 100 mg/L concentration was added to the beakers corresponding to doses 150, 200, 250, 300 and 350 mg/L. The test was conducted with rapid mixing at 150 rpm for a minute, followed by slow mixing (flocculation) at 35 rpm for 30 minutes and finally 20 minutes for flocs to settle. Finally, the supernatant was taken to check the parameter after completion of jar test. All test were performed at room temperature. Figure 3.3 shows the jar test had been carried out in laboratory.

Figure 3.3 : Jar test

3.6 Water Quality Analysis

A few parameters were selected to be observed for all water samples which were pH, turbidity, true and apparent colour, dissolved oxygen, chemical oxygen demand, biological oxygen demand, suspended solid and heavy metals.

3.6.1 pH

It is very important to determine the pH value of sample collected before undergoing any test. pH values for each sample was determined using pH meter (Mettler Toledo).

Firstly, pH meter was calibrated using buffer solution of pH 4, pH 7, pH 10 before it could be used to determine the pH value of sample because to minimize the error in reading and to ensure the instrument measurement in range. After finish calibrating the pH meter , rinse the electrode using distilled water. Then the electrode was immersed into the sample. The readings were took three time to get an average value.

The standard method was adopted from Standard Method 4500-HB, ASTM Method D1293-95 and USEPA method 150.1.

3.6.2 Turbidity

Turbidity measure the clarity of the water on how much the material suspended in water decreases the passage of light through the water. It provides an indicator of contamination and is critical measurement for monitoring the characteristics and a quality within the sample's sources or process.

Turbidity of sample was determined using portable turbidity meter TB400. The wastewater sample of 10 ml was placed inside sample cell. Before pouring the sample, the sample cell had been washed using distilled water to avoid contaminants. Clean the external surface of sample cell was cleaned by using a provided cloth before placing the sample cell inside turbidity meter to avoid contaminants. Finally, insert the turbidity sample cell into turbidity meter and record the value. The equipment as shown in Figure 3.4

Figure 3.4 : Portable Turbidity Meter

3.6.3 Colour

The colour in water might be due to the presence of natural meyallic ions (iron and manganese), humus, weeds, industrial waste and etc. The removal of colour in wastewater for general applications. Colour can be divided into two categories which is true colour and apparent colour. The term apparent colour includes colour due to substances in solution and due to suspended matter. Apparent colour was determined on the raw sample without filtration while true colour are sample that have been filtered using 0.45 micrometre membrane (Figure 3.5).

The colour test was carry out using a portable spectrophotometer DR 2800 in the laboratory. Fill 10 ml of sample in sample cell. The external surface of glass cell was cleaned using tissue paper to avoid any contaminates before placing it inside the spectrophotometer. The sample cell insert into cell holder spectrophotometer and record the value.

The method was adapted by Platinum-Cobalt Standard Method that equivalent to NCASI method 253 using 455 nm. The equipment is shown in Figure 3.6

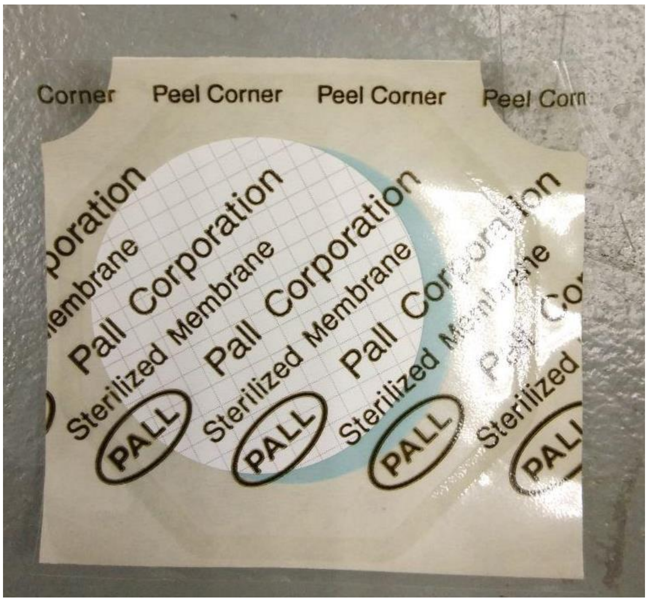


Figure 3.5 : 0.45 micrometer filter paper.

Figure 3.6 : Apparatus to Filter for True Colour Test.

3.6.4 Dissolved Oxygen

Dissolved oxygen (DO) refers to a measure of how much oxygen was dissolve in the water. It is an important parameter in the assessment of water quality because it influence on the organism living within a body of water. It can be determined using Winkler method.

Firstly, pour the sample slowly into the BOD bottle until it was full. Make sure no formation of bubble because it can additional amount of dissolved oxygen in the sample.

3.6.5 Chemical Oxygen Demand

Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. The test method uses a strong a chemical oxidant in an acid solution and heat in order to oxidize organic carbon CO_2 and H_2O. COD test result can be used to estimates the BOD result of given sample. This test can be completed much quicker than BOD.

Firstly, prepare the reagents for COD test, which are potassium dichromate ($K_2Cr_2O_7$) and sulphuric acid (H_2SO_4). Pour 1.5 ml of potassium dichromate followed by 3.5 ml sulphuric acid and lastly 2 ml sample into the vial test tube. Then, shake the vial test tube for properly mix the solution. Put the vial test tube into COD reactors for 2 hours at 110° Celsius. After finished heating, the sample was eft to cool down to room temperature. The external vial test tube was cleaned using a cloth or tissue paper to avoid dust. Then, the vial was placed inside the cell holder of DR2800 spectrophotometer and record the value of COD sample.

The standard method was referred to in this research is closed reflux method (Colorimetric method). This standard method was adapted form DR2800 spectrophotometer for COD test.The equipment shown in Figure 3.7

Figure 3.7 : COD reactor.