STUDY OF THE INFLUENCE OF THE OPERATIONAL PARAMETERS ON THE REMOVAL OF COD, BOD AND COLOUR OF AN INDUSTRIAL WASTEWATER TREATMENT PLANT

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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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ABSTRAK

Kajian ini mengkaji pengaruh parameter operasi untuk loji rawatan air sisa industri. Pengeluaran perindustrian seperti syarikat peranti perubatan mencipta kuantiti yang banyak dan jenis air sisa yang mengakibatkan pencemaran alam sekitar yang serius. Air buangan lateks adalah salah satu air sisa industri yang dihasilkan dari produk pembuatan yang berasal dari bahan pemprosesan lateks. pH air buangan lateks adalah kira-kira 3.88 dan ia berada dalam keadaan berasid. COD, BOD dan Warna air buangan lateks masing-masing adalah 1093mg/L, 48.8mg/L dan 1751PtCO. Terdapat beberapa proses rawatan untuk merawat air kumbahan industri dan secara amnya dibahagikan kepada tiga tahap rawatan iaitu rawatan fizikal, kimia dan biologi. Dalam kajian ini, lima tempat terpilih dalam loji rawatan air sisa lateks dimonitor dan kecekapan penyingkiran telah dibandingkan antara rawatan fizikal, kimia dan biologi. Rawatan fizikal, kimia dan biologi loji rawatan terpilih adalah perangkap getah, pembekuan dan pemberbukuan dan rawatan biologi menggunakan Mikroorganisma Berkesan. Kecekapan penyingkiran purata COD, BOD, Warna dan TSS untuk rawatan biologi masing-masing adalah 79%, 39%, 74% dan 78%. Kemudian, rawatan kimia menggunakan kaedah pembekuan dan pemberbukiran dan ferric chloride sebagai koagulan boleh dikeluarkan 56% COD dan 28% BOD dalam air buangan lateks. Semasa proses rawatan pembekuan dan pemberbukuan, 53% TSS dan 38% Warna telah dikeluarkan. Rawatan yang paling berkesan ialah rawatan biologi menggunakan (EM). Hasilnya juga memperlihatkan parameter kajian efluen yang dirawat berikut pelepasan standard B untuk efluen perindustrian.

ABSTRACT

The research attempts to study the influence operational parameters for industrial wastewater treatment plant. Industrial production such as medical device company create large quantities and varieties of wastewater that are causing serious environmental pollution. Latex wastewater is one of the industrial wastewater generated from manufacturing product that originated from latex processing material. The pH of latex wastewater is about 3.88 and it was in acidic condition. The COD, BOD and Color of latex wastewater were 1093mg/L, 48.8mg/L and 1751PtCO respectively. There are several treatment processes to treat industrial wastewater and it generally divided into three stages of treatment which is physical, chemical and biological treatment. In this study, five selected points in the latex wastewater treatment plant was monitored and the removal efficiencies was compared between physical, chemical and biological treatment. Physical, chemical and biological treatment of the selected treatment plant was rubber trap, coagulation and flocculation and biological treatment using Effective Microorganism. The average removal efficiency of COD, BOD, Colour and TSS for biological treatment are 79%,39%,74% and 78% respectively. Then, chemical treatment using coagulation and flocculation method and ferric chloride as coagulant able removed 56% of COD and 28% of BOD in latex wastewater. During coagulation and flocculation treatment processes, 53% of TSS and 38% of Colour have removed. The most efficient treatment is biological treatment using (EM). The result also shows the studied parameter of treated effluent follows the standard B discharge for industrial effluent.

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LIST OF ABBREVIATIONS

COD	Chemical Oxygen Demand
BOD	Biochemical Oxygen Demand
TSS	Total Suspended Solid
DO	Dissolved Oxygen
HRT	Hydraulic Retention Time
DOE	Department of Environment
EM	Effective Microorganism
UASB	Up-flow Anaerobic Sludge Blanket
MBR	Membrane Bioreactor
DAF	Dissolve Air Flotation
AOPs	Advance Oxidation Processes

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Industrial wastewater is one of the major cause of the water pollution in the environment. A huge amount of industrial wastewater directly discharged to the environment such as lakes, rivers and coastal areas caused a serious problem to the ecosystem and human's life (Han-chang, 2002). The compositions of industrial wastewater very varied depends on the type of industry and material processed such as rubber manufacturing industry, dairy product processing and fertilizer industry. Some of these wastewaters easily biodegradable, have high organic concentration or largely inorganic. This means the wastewaters have high concentration of TSS, BOD5 and COD (Ng, 2006). The wastewater produced from different kind of industries usually contains suspended solids, dissolved solids, inorganic and organic particles, metal and impurities.(Lee *et al.*, 2014).

Treating wastewater generated from industrial activities is essential for water resource conservation and avoidance of environmental effect. Wastewater treatments are complex system which require a complex set of concurrent physiochemical and biological processes (Bayo *et al.*, 2006). The treatments processes very difficult and require many operational stages and some of those energy-intensive also need the use of several chemical reagent. Hence, a various of industrial and manufacturing process produce an enormous amount of spent solutions to treat wastewater in order to remove chemical and biological hazardous compound (Ferella, 2018).

The treatments processes consist of physical, chemical and biological treatment. There are several treatment technologies to treat the wastewater generated by industry activities such as coagulation and flocculation, dissolve air flotation, advance oxidation processes. Hence, the high variability of wastewater treatment process, it is important to monitor the performance of industrial wastewater treatment plant in order to guarantee the concentration limit provided by the standard discharge regulations and compare the efficiency of different treatment stages.

An industrial rubber processing manufacturer was selected to study about the treatment processes of wastewater generated. Latex wastewater is commonly generated from this industry activities and the production process material originated from latex discharged large amount of wastewater containing high concentration of organic compounds (Nguyen and Luong, 2012). The main sources of latex wastewater are normally from the latex serum, uncoagulated latex and washings from various processing stage. A set of treatment processes was designed to treat latex wastewater generated from the cleaning of latex containers and the treatments technologies in wastewater treatment plant are combination of physical, chemical and biological treatment. The treatment of latex wastewater was monitored to determine the efficiency of wastewater treatment plant.

1.2 Problem Statements

Industrial production such as medical device company create a large quantities and varieties of wastewater that are causing serious environmental pollution. Increasing global population and industrial development have caused an increase in the amount of wastewater requiring treatment. Discharging industrial wastewater directly to a water body can cause direct damage to wildlife and aquatic plants (Xu *et al*., 2011a). Industrial development and innovation create a variety of industrial sewage and lack of sewage treatment equipment. This caused serious environmental protection imbalance, improper sewage treatment or directly discharge to the environment. Then, the operating cost of wastewater treatment plant required the following components such as electricity, labour and chemical cost(Long *et al.*, 2018). Wastewater treatment consumes a lot of energy and it is often the main operation cost of wastewater treatment(Li *et al*., 2017). Latex wastewater contains both organic and inorganic matter such as ammonia, formic acid ,sodium metabisulphite and sodium sulphite and heavy metal such as Zn, Fe and Cu that originated from natural latex rubber and from chemical used in rubber processing phase(Kantachote *et al*., 2005). Then, latex wastewater also heavily polluted which are suspended solids, high organic matter and nitrogen-containing pollutants, acidity and smelly(Nguyen and Luong, 2012). Furthermore, latex wastewater also contains a little amount of uncoagulated latex and significant amount of proteins, sugars, carotenoids and organic and inorganic salts which originated from latex itself. These constituents are excellent substrates for the proliferation of microorganism generating high biochemical oxygen demand (BOD) and bad odour and the most important is cause serious impact on the environment(Abraham *et al*., 2009).

Recently, there are several approaches to treat latex wastewater. Advantages and disadvantages of the treatment methods rely on simplicity, flexibility and effectiveness of the operation, cost, technical problems and maintenance (Mohammadi *et al.*, 2010). On the other hand, type of chemical used, suspended material concentration, composition or dosage are significant parameter to achieve high performance of wastewater treatment process(Abraham *et al*., 2009). Hence, it is very necessary to explore the operational parameters of wastewater treatment processes to seek for some possible pathways to save energy and lower the cost while the water pollution also can be control. In this study, an industrial wastewater treatment plant of Teleflex Medical Sdn Bhd was monitored. Teleflex Medical Sdn Bhd located at Kamunting, Perak and it is a medical instruments manufacturer such as anaesthesia, respiratory, urology and related sets products. Wastewater produced from this industry is latex wastewater which come from the cleaning of latex containers.

1.3 Objectives

In order to examine the best solution to solve the problems discussed in the problem statements, this research is expected to achieve following objectives:

1. To identify the influence of the operational parameters for industrial wastewater treatment plant.
2. To determine the removal of Biochemical Oxygen Demand(BOD), Chemical Oxygen Demand(COD) and Colour for every stage of treatment process.
3. To compare the removal of Biochemical Oxygen Demand(BOD), Chemical Oxygen Demand(COD) and Colour of different types of treatment processes.

1.4 Scope of research

To achieve the above objectives, the scopes of study as follows:

a) The study was focused on the current Wastewater Treatment Plant own by Teleflex Medical Sdn Bhd in Kamunting, Perak.
b) The assessment of wastewater characteristics was conducted only at five points of treatment stages of Wastewater Treatment Plant which are wastewater collection pit, rubber trap, primary clarifier, Nano aeration tank and treated effluent.
c) Based on the data collection, statistical analysis was developed using Microsoft Excel and the result obtained was discussed

1.5 Advantages of the Research

The advantages of the research are listed as below:

1. To monitor the performance of COD, BOD and Colour removal of industrial wastewater treatment plant.
2. Improve the quality of treated effluent of industrial wastewater and help to control water pollution.
3. To optimize the design and the treatment process which more significant to the current wastewater characteristic.
4. Minimize the operational, energy consumption and maintenance cost.
5. Gives an exposure about wastewater treatment process in actual wastewater and treatment condition.

1.6 Thesis Structure

The thesis has been categorized into several chapter accordingly during the research is carried out. Firstly, chapter 1 give an overview on the back ground of the research study, problem statement, objective, scope of research and benefits of the research study. Then, chapter 2 explained about the literature review or previous finding related to this study. Chapter 3 discussed the research methodology that have been used during the research project. This chapter is based on the experiment that was carried out for data collection during the research project. Chapter 4 present result, analysis and discussion from the experiment that have been done of the research study and it will relate to the targeted objective. Finally, Chapter 5 contains the conclusions and recommendations of the researched study.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Nowadays, wastewater generated from the most industries need to treat before discharge to the environment and the treatment are required by law. However, the selection of wastewater treatment technologies is difficult and involves an appropriate decision maker. The selection of the best combination of technologies to treat industrial effluent is a complex process in which require some information must be taken as consideration such as previous experience, expertise and human-kind reasoning (Castillo *et al.*, 2017). The huge of variety of industrial and manufacturing processes produced numerous wastewater treatment method in order to remove biological and chemical hazardous compound which by product of the industrial activities. The treatment process is very difficult and require many stage because the wastewater generated might be have a great amount of different chemical compound like metal, acids, bases, salt, volatile organic compounds (VOCs) and microorganism as result of Waste Solution Treatment Plant (WSTPs) are composed of several stage of treatment processes (Ferella, 2018). Therefore, because of the high variability of wastewater generated and wastewater treatment solutions, it is important to monitor continuously the performance of wastewater treatment plant in order to guarantee the treated effluent comply to the standard and the treatment methods are compatible to the current wastewater characteristics.

2.1.1 Physical and Chemical Characteristic

Wastewater characteristic was examined based on physical, chemical and biological characteristic. However, physical and chemical characteristic have been considered in this study. The physical characteristic that had measures are pH, Suspended Solid and Colour. 'pH' is a numerical representation of acidic or basic nature of solution(Anotai et al., 2007). Suspended solid refers to particles which remains in suspensions in water either due to the motion of the water or because the density of the particles is lighter or equal to the water. Then, colour in the wastewater is due to the dissolve particle for true colour and colloidal particle for apparent colour. The chemical characteristics of wastewater are COD, BOD, Organic Matter and Heavy Metal. Chemical oxygen demand (COD) is defined as the amount of specific oxidant that react with the sample under controlled conditions. Chemical oxygen demand (COD) is used to determine the quantity of pollution in the latex wastewater. The higher value of chemical oxygen demand indicates the higher organic pollution in the water sample. COD test is determined because takes less time than Biological oxygen Demand test. COD is recommended for latex wastewater because has toxicity and organic matter cannot be determined by biological oxygen demand (Mohammadi et al., 2010). BOD is the amount of oxygen required by bacteria to stabilize organic matter under aerobic conditions. The BOD test involves the determination of oxygen uptake by bacteria under standard conditions (5 days incubation at 20 °C). Usually, COD and BOD are conventional method that represented an organic matter in the wastewater. Because testing COD and BOD is complicated, time-consuming and real-time monitoring of these organic matter is often not feasible. Therefore, UV 254 nm test as practical way to measure organic matter in the latex wastewater sample because it contains high organic compound (Mohammadi et al., 2010)

2.1.2 Latex Wastewater Characteristic

The natural rubber industry in the South-East Asia region, especially in Malaysia, Thailand and Indonesia is concentrated because more than 60% worldwide of rubber production comes from these three countries. Then, Malaysia is one of the largest rubber producer in the world whereby the rubber industry is significant to the economy and social. Rubber trees produces a rubber latex that can used as raw material for three intermediates of the rubber product. First, technically specified rubber (TSR) as raw material to make high viscosity product such as belts. Ribbed smoked sheets(RSS) which are used as a raw material for making industrial rubber parts and vehicle tires. Rubber latex in form of concentrated latex is used as a raw material for making dipped products such as medical glove (Tanikawa, 2012).

In a natural rubber processing factory, large volume of water, chemical and other utilities are consumed and produced enormous amounts of wastewater containing a high concentration of nitrogen (especially, ammonia), organic matter and sulfate. Discharge of wastewater generated from latex processing industry directly to waterways resulted in water pollution and the human health also might be affected (Mohammadi *et al.*, 2010). Wastewater produced from the natural latex processing is heavily polluted which the wastewater contains high suspended solids (the remaining latex), nitrogen containing pollutant (N-organic, N-NH_3), high organic matter, acidity and smelly. Anotai *et al*. (2007) was discovered acidic latex wastewater contains high average zinc and acetic content which are 816mg/L and 20,862mg COD/L respectively and it was treated by a series of chemical and biological treatment processes without any addition of acid and base to pH adjustment .The typical characteristic of wastewater generated from the latex processing industries as shown in Table 2.1(Nguyen and Luong, 2012).

Table 2. 1: Characteristics of influent and effluent of the concentrated latex processing factories in South East region.

No	Items		Factories in Southeastern region, Vietnam		QCVN 01:2008/BTNMT	
	Name	Units	Influent	Effluent	A	B
1	pH	-	8.74	7.64	6 - 9	6 - 9
2	COD	mg/L	18807	234	50	250
3	BOD	mg/L	9536	91	30	50
4	TSS	mg/L	1147	98	50	100
5	T-N	mg/L	781	80	15	60
6	NH_3	mg/L	481	38	5	40

Note: QCVN 01:2008/BTNMT: Quy chuẩn Việt Nam về nước thải công nghiệp chế biến cao su thiên nhiên (National technical regulation on the effluent of natural rubber processing industry)

Table 2. 2: Characteristics of raw Standard Malaysian Rubber process wastewater.

Parameters	Units	SMR values (this study)	SMR concentration[b]
pH	-	7.35	7.5
COD	mg/L	1850	2960
BOD_5	mg/L	890	1380
Suspended Solids (SS)	mg/L	270	310
Total Nitrogen (TN)	mg/L	248	Not specified
Ammoniacal nitrogen (AN)	mg/L	49	57

[b] Source: Vijayaraghavan *et al*. (2008).

Table 2.2 shows another characteristic of raw Standard Malaysian Rubber wastewater obtained from the Chip Hong Rubber Sdn. Bhd., Johor Malaysia. Wastewater generated has high COD, BOD5 and Suspended Solid (Rosman *et al.*, 2013). Therefore, wastewater that discharge directly into the environment without appropriate treatment will cause a serious impact to the ecological balance. The wastewater of processing fresh latex is the most polluted source compared to the processing of block rubber and miscellaneous rubber because wastewater generated from the concentrated latex processing from fresh latex is highly concentrated with uncoagulated rubber particles and organic matter. The characteristics of late wastewater become highly acidic and highly sulphated when the process the processing of skim latex. However, the wastewater of rubber block processing from the miscellaneous rubber is the less polluted because it mainly from the washing and soaking process of miscellaneous rubber(Nguyen and Luong, 2012).

2.2 **Wastewater Treatment**

There are several processes have been used for latex wastewater treatment in Malaysia. These methods have advantages and disadvantages depends on simplicity, flexibility, and effectiveness of the operation, cost, technical problems and maintenance. Therefore, an economical and removal efficiency technologies for the treatment of latex wastewater are required. Initially, conventional treatment options have been used for rubber wastewater treatment but biological treatment such as aerobic, anaerobic and facultative pond become popular since these methods more effective for organic reduction and inexpensive(Mohammadi *et al.,* 2010). The wastewater treatment processes consist of physical, chemical and biological treatment and the treatment can be either individually or combined physical, chemical and biological method.

Nguyen and Luong, (2012) discussed there are many technologies that can be applied for treatment of latex wastewater generated by factories. However, several limitations still exist on the treatment technologies. For examples, the technologies such as UASB, activated sludge, Oxidation ditch are not able to remove completely the Nitrogen-containing pollutant in wastewater while conventional decantation process cannot cater the wastewater that highly concentrated with uncoagulated rubber particles. Besides, the biological treatment had difficulties on the maintenance of microorganism community which they usually die because of the high organic load in the latex wastewater.

Generally, most of the factories used physical treatment like rubber trap as a pretreatment unit to recover the uncoagulated latex and other solid particles from the wastewater before discharge to the secondary treatment units. The conventional rubber trap has less removal efficiency compare to chemical and biological treatment.

2.2.1 Biological Method

Biological method is one of the extensively used method to treat latex wastewater by removing dissolved and colloidal organics by activated sludge process. This system changes the contaminants such as dissolved and colloidal organic material to a biological sludge which can be remove during sedimentation process. Usually, activated sludge process is implemented at secondary treatment after the primary settling basin. The removal of suspended solid using activated sludge process were low which is from 78% to 87% removal. Insufficient of oxygen concentration cause bulking and rising sludge problems. Therefore, an appropriate oxygen control system recommended to ensure sufficient oxygen is provided to assist the treated effluent compliance with the effluent standard (Mohammadi *et al.*, 2010).

2.2.1.1. Aerobic and anaerobic treatment

The conventional methods of biological treatment are either aerobic or anaerobic processes can be applied to remove organic matter in the wastewater. Anaerobic process has high removal efficiency and produced large amount of biogas in lower operating cost. Some countries such as Malaysia, Thailand and Sri Lanka are usually applied the aerobic and anaerobic processes to treat wastewater generated from natural rubber latex processing (Mohammadi *et al.*, 2010). Aerobic is the biological reaction in the presence of oxygen while an anaerobic means in the absence of oxygen. The types of bacteria or microorganism that are involved in the degradation of organic matter in a given wastewater and the operating conditions of the bio reactor directly relate to the anaerobic and aerobic conditions.

Conventional activated sludge process in the most common and oldest biotreatment used in industrial wastewater. The suspended impurities removal in the activated sludge process based on the biological treatment system comprising aeration tank followed by secondary clarifier. The aeration tank is to maintain the specific concentration of biomass (measured as mixed liquor suspended solids(MLSS) or mixed liquor volatile suspended solid (MLVSS) with a sufficient dissolved oxygen (DO) (typically 2mg/L) to biodegrade the soluble organic matter. Then, cyclic activated sludge or sequence batch reactor (SBR) is another technology that offer several operational and performance advantages over the conventional activated sludge process (Arun, 2011). Aerobic granular sludge (AGS) technology is one of alternative option in biological treatment which high capability to withstand extensive organic and inorganic loads and demonstrated to have high potential to treat various types of wastewaters. Sequence Batch Reactor (SBR) is used to develop aerobic granules with intermittent aerobic-anaerobic mode with 8 cycles in 24 hours. As result, the technology offers rapid settling for solid liquid separation in wastewater treatment (Saad *et al.*, 2018).Bakare *et al*. (2017) was discovered that sequence batch reactor operated under continuous low aeration scheme in the reactor enhance microbial activity degrading organic materials and the performance was better compared to the reactor operated under cyclic aeration scheme.

2.2.1.2. Pond Technology

This technology is widely used for treatment of latex wastewater from primary rubber industry. Almost all palm oil and rubber factories in Malaysia have installed pond as a primary wastewater treatment (Usa, 2007). Before entering the pond system, there is a latex trap and a neutralization stage as a pretreatment step. This technology can remove over 95% Biological Oxygen Demand (BOD) when properly designed and BOD levels of 50-100 mg/L can be achieved by this method (Lonholdt and Andersen, 2005).

Pond system require low cost and it is more economical. Biological pond very effective at removing disease-causing organisms (pathogens) from wastewater. The treated effluent suitable for irrigation purpose. However, this process requires large installation area and generate strong smell because the treatment in open space. The implementation of pond system might cause pollution to the groundwater if the pond does not carefully cover by waterproofing material. This process only suitable for less polluted wastewater such as wastewater from the miscellaneous rubber processing. Due to strong smell, it should not be applied near to the residential area. Lastly, the application biological pond are not effective on the removal of heavy metal and the open space of pond provide a breeding area for mosquitoes and other insects.(Nguyen and Luong, 2012). Table 2.3 shows the various rubber treatment system and their efficiency.

Table 2. 3: Rubber treatment system and their efficiency

Treatment	**Description**	**COD removal efficiency (%)**	**BOD removal efficiency (%)**	**SS removal efficiency (%)**	**Reference**
Aerobic filter	Packed with aquarium media with dimension of 30 cm * 100 cm; OLR = 11.8 gCOD/L/day and HRT= 10 days	92	-	-	Anotai *et al*. (2007)
Up-flow anaerobic sludge blanket (UASB).	Steel cylinder shape with dimension of 600 m^3 * 250m^3, consist of a wastewater distributor, a lid for scraping sludge, dry rubber content and a gas -solids separator.	80			Taechapatarakul (2008)
Biological method incorporated with sulphate reduction system (purple non-sulphur photosynthetic bacteria	Optimum growth in latex wastewater with 0.50% ammonium sulphate and 1mg/L nicotinic acid in a pure culture and or a mixed culture	90	90	-	Kantachote *et al*. (2005)
Ozonation followed by batch activated sludge process.	Ozone dosage = 66.44 mg O_3/L O_2 of; pH= 9.0 and contact time = 30 min	92	96	-	Rungruang and Babel (2008)
Combined physical, chemical and biological method (gas injection technique).	-	67	77	-	(Yusoff *et al.*,2004)

2.2.1.3. Effective Microorganism (EM) and Photosynthetic Bacteria

The use of effective microorganism reduces the volume of sewage sludge and has been suggested in wastewater treatment plant, or on-site wastewater treatment system such as septic tank and industrial effluent. EM is a mixer of various groups of naturally useful living in the environment, not pathogenic, anaerobic microorganism such as phototrophic, lactic bacteria and yeast. From the research studied by (Priya *et al.*, 2015), the maximum removal of COD and TSS were 88% and 80% respectively in Hybrid Up flow Anaerobic Sludge Blanket (HUASB) reactor in the presence of (EM) with OLR of 9kg.COD/m3/day while HUASB reactor in the absence of (EM) only remove 76% of COD and 68% of TSS. Photosynthetic bacteria (PSB) have been used to treat heavy metal, dye wastewater, olive milk wastewater and latex wastewater because the common wastewater treatment method such as activated sludge process generates large amount of hazardous sludge. The soybean wastewater COD decreased by 95.7% after 168 hours treatment by PSB called as Z08 without extra light and oxygen provision(Lu *et al.*, 2010). Namsivayam *et al*., (2011) had found that a reduction of all test parameters under all tested incubation period in treated domestic sewage. Total dissolved solid had been reduced from 21060 mg/L to 1012, 940 and 901 mg/L. Then, the pH also reduced from 9.0 to 8.4, 7.4 and 7.1. The COD was decrease from 164 to 141,112 and 109 mg/L and the BOD was reduced from 2.8 to 2.1, 1.5 and 0.9 at respective incubation time.

2.2.2 Physical and Chemical Treatment Methods

Generally Physical treatment is preliminary step in almost all the processing industries. Rubber trap is one of the physical treatment to recover un coagulated latex and other solid particles from the wastewater before proceeding to the secondary treatment. However, the removal of this conventional rubber trap is lower. Therefore, the flotation technique has been researched to improve the treatment efficiency of conventional rubber trap in the latex industry. The result implied that the pH adjustment the mixed wastewater from concentrated latex and skim rubber process lines gave to be 4.5 and it promoted the highest coagulation efficiency. The removal of SS, turbidity, COD and BOD were 98%, 99%, 80% and 81% respectively. As conclusion, air flotation could promote a higher treatment efficiency and rubber recovery from the rubber trap. Therefore, the method can be an alternative solution in latex wastewater management(Nguyen and Luong, 2012).

2.2.2.1. Coagulation and Flocculation

Coagulation and flocculation is one of the most widely used solid liquid separation process for the removal of suspended solid, dissolved solid, colloid and organic matter in industrial wastewater. After addition of coagulant and flocculant, dispersed particles are aggregated or agglomerated together to form large particles called as flocs which settle down and cause clarification of the system. Coagulant is mainly induced by inorganic metal salts, such as ferric chloride, $FeCl_3$ and aluminium sulphate, $Al_2(SO_4)_3$. In some cases, metal salts can be used in wastewater treatment without assistance of flocculant(Lee *et al*., 2014).

Coagulation-flocculation is a treatment method that used cationic inorganic metal salts as coagulants and long chain non-ionic or anionic polymer act as flocculants. Most of suspended solid particle in the wastewater carry negative charge in aqueous medium. By addition of inorganic coagulant, metal salt will hydrolyse rapidly in the wastewater to form cationic species, which are absorbed the negative charged colloidal particles, resulting the formation of flocs. However, the coagulation processes not always perfect because only small flocs are formed give a problem at sedimentation process. Therefore, the uses of an anionic or non-ionic polymeric flocculant to bring together the slow settling micro -flocs formed by the coagulant to form larger and denser flocs ,thereby facilitating their removal in subsequent, sedimentation, flotation and filtering stage(Lee *et al*., 2014).

2.2.2.2. Electrolysis, electrocoagulation and electro flotation

The biological method used for latex wastewater required long hydraulic retention time and high shock load capacity. Therefore, electrochemical method is more appropriate method because its cost, easy to control, short retention time and high efficiency of removal. This method was developed based on in-situ hypochlorous acid (HOCL) generation. The HOCL act as oxidizing agent to destroy the organic compound in the latex wastewater. Then, the optimum operating condition were found at initial pH 4.5, three percent of sodium chloride and the current density 74,5mA/cm^2. After 90 min electrolysis, the pH become 7.3 and removed 98% COD and 97% BOD. The electrochemical treatment requires shorter hydraulic retention time compared to the conventional biological treatment and the other aerobic oxidation method (Nguyen and Luong, 2012).

Nguyen and Luong, (2012) also mentioned in their research study another advantage of electrochemical treatment is the use of solar energy for electrolysis, which help for rural areas in order to reduce running cost of the treatment processes. Ni'am *et al.*,(2007)have found that COD removal efficiency is high as 72.28% and 96.74% of the turbidity removal with current density of 5.62 mA cm^{-2} using electrocoagulation technique.

2.2.3 Advance treatment Technologies

2.2.3.1. Advance oxidation processes (AOPs)

Advance oxidation processes (AOPs) is the treatment that utilize the very strong oxidizing power of hydroxyl radicals to oxidize organic compounds to the preferred end product of carbon dioxide and water. This advance treatment has many benefits in wastewater treatment because they can be applied for overall organic content reduction. Specific pollution destruction, sludge treatment, odour and colour reduction (John and James, 2009). The ozonation method can eliminate odours, reduce oxygen demand matter, increase the dissolve oxygen and reduce the suspended solids. The Fenton process is one of the advance oxidation processes (AOPs) that gives both economic advantages and effectiveness in contaminant reduction for degradation of organics (Ferella, 2018).

2.2.3.2. Membrane Technology

The biological process such as aerated lagoons, facultative lagoons and oxidation ditch requires large land area, high energy consumption, long period of treatment. The technology of membrane bioreactor (MBR) can overcome of these problems. This technology only requires small space area, high ability of disinfection and high loading rate capability, high removal of solid and organic compound. Nik *et al*. (2010) shows that the optimum flux of process was obtained at 0.009 m^3/m^2xh and at this flux rate, the process could be continuously operated more than one month without chemical cleaning of membranes. The of the removal of COD 96.99% at the initial concentration of 3500 mg/L and BOD 96.78%.

2.2.4 Combined treatment

The combine of physical, chemical and biological treatment is the most effective treatment of rubber wastewater in Thailand and Malaysia. Combined physical and chemical treatment method system followed by two stage biological method was used to remove fibre and suspended solid in Malaysia. The treatment involved fibre screening, dissolve air floatation(DAF), an aeration basin, a secondary clarifier and a sludge dewatering system. The treated effluent is consistent with the DOE standard A. (Mohammadi *et al.*, 2010). The combination of treatment process such as decantation, stabilization, dissolve air flotation (DAF), coagulation and flocculation bring high removal efficiency of suspended solid was 70% but the cost of combination processes become higher. Removal of remaining latex in the wastewater play an important role in whole wastewater treatment system because it can reduce pollution load and the congestion of follow up treatment. Therefore, an appropriate treatment for economy and efficiency of removal of remaining latex should be take into consideration(Nguyen and Luong, 2012).

The combination of chemical and biological processes is an efficient method in wastewater treatment. The coagulation and flocculation using iron chloride and chimec 5161 able to remove 92% of COD, 97% of colour and 44.5% of BOD. Then, the combination of chemical and biological treatment generate a clear effluent the removal of COD and BOD were 96% and 92.5% respectively (Aboulhassan *et al.*, 2014).

2.3 Summary of Literature Review

Latex wastewater is highly polluted and contained high amount of organic matter, suspended solids and in acidic condition latex wastewater have average amount heavy metals (zinc). There are several treatment methods to treat latex wastewater and the method have advantages and disadvantages depends on the simplicity, flexibility, effectiveness and cost. The most common treatment methods are physical, chemical and biological treatment. However biological method in one of the extensively used method and biological treatment can be either aerobic and anaerobic conditions. The treatment in aerobic condition is widely used because latex wastewater highly in organic matter that easily degrade by bacteria and microorganism. The uses of effective microorganism (EM) is suggested in the wastewater treatment plant to reduce the volume of sludge and the presence of EM increase the removal efficiencies of COD and TSS. Lastly, combined treatment is most effective treatment to treat latex wastewater and it started with physical followed by chemical and biological treatment.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explained on the site selection, wastewater sampling, data collection and the experiment that was carried out to achieve the research study. An industrial wastewater treatment plant in the Teleflex Medical Sdn Bhd, Kamunting, Perak was selected. Most of the Teleflex Medical Sdn Bhd products originated from latex processing material such as endotracheal tubes, cardio-thoracic drainage and balloon catheters. Therefore, wastewater generated is latex wastewater which coming from the cleaning activities where latex containers washed at specific cleaning area.

For this study, it is focused on the performance of wastewater treatment plant. Five selected points was determined in the treatment plant which are wastewater collection pit, rubber trap, primary clarifier, Nano aeration tank and Effluent. Rubber trap represented as physical treatment in the wastewater treatment plant and primary clarifier is the mechanism to separate clear supernatant after chemical treatment which is coagulation and flocculation processes. Lastly, Nano aeration tank as biological treatment stage where oxygen was provided to promote biological reaction between wastewater and dosed effective microorganism (EM). The overall current treatment processes of wastewater treatment plant in Teleflex Medical Sdn Bhd shown in Figure 3.3 and the flow of work of this research summarized in Figure 3.1

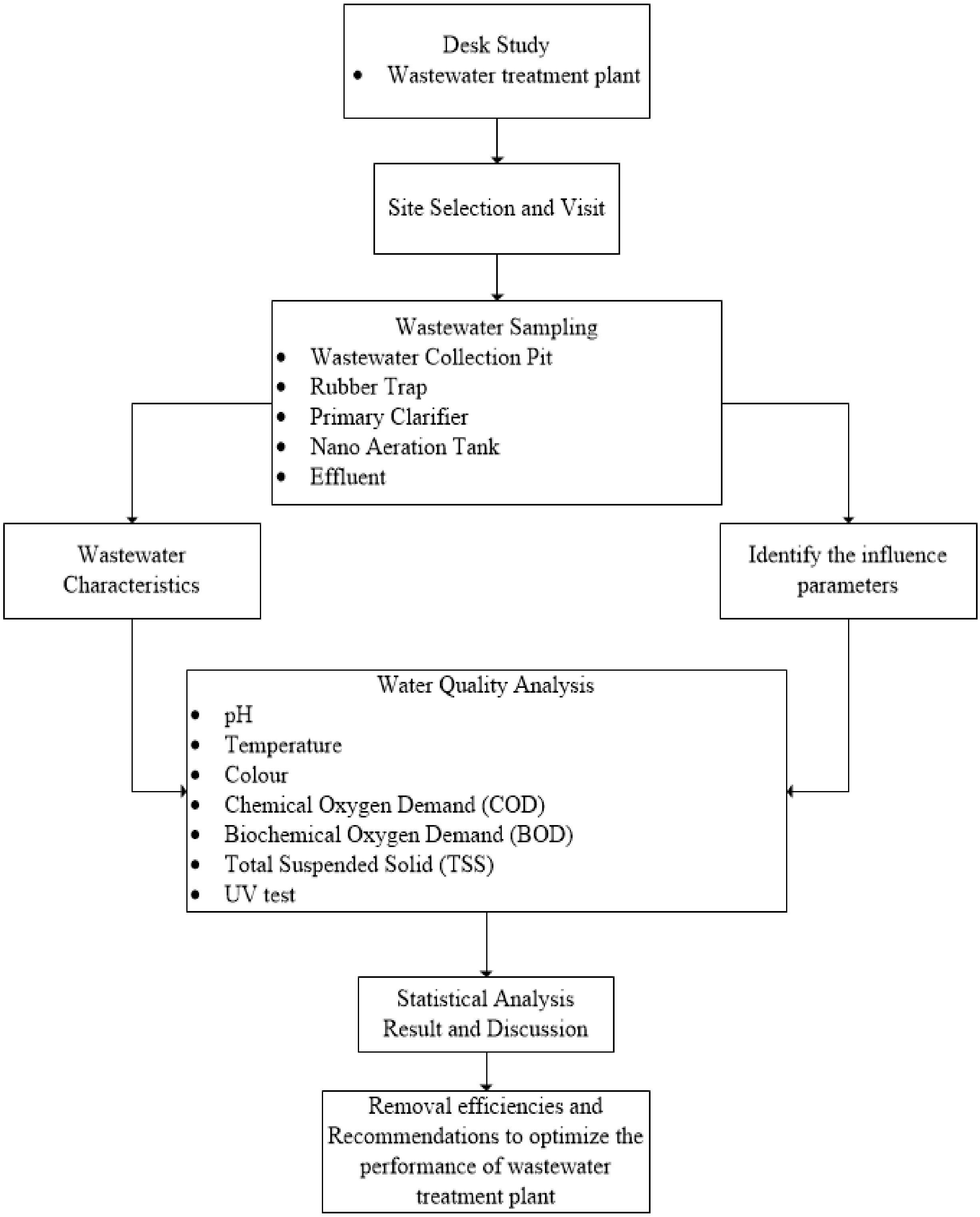

Figure 3. 1: Flow chart of the research