REMOVAL OF HEAVY METALS FROM INDUSTRIAL WASTEWATER USING ACTIVATED CARBON FROM COCONUT COIR

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ABSTRAK

Logam berat adalah logam berunsur kimia metalik. Ia mempunyai ketumpatan yang tinggi dan beracun untuk ekosistem dan kehidupan manusia. Sumber-sumber logam berat adalah dari aktiviti perlombongan, bateri asid plumbum, sisa kimia, industri kumbahan dan farmaseutikal. Osmosis terbalik, pemendakan kimia, oksida kimia dan pelunturan udara adalah rawatan konvensional untuk merawat air kumbahan.Pada masa ini, kaedah ini adalah mahal dan sukar dilakukan. Proses penjerapan adalah salah satu kaedah yang boleh digunakan. Ini kerana proses penjerapan lebih mudah dan lebih murah daripada kaedah tersebut. Terdapat banyak jenis sisa pertanian seperti sabut kelapa yang boleh digunakan sebagai penyerap untuk menghilangkan logam berat dari air sisa industri. Sabut kelapa telah dipilih untuk kajian ini untuk mencapai objektif. Tujuan kajian ini adalah untuk mengenal pasti ciri-ciri air kumbahan. Penyerapan atom spektrofotometer telah dijalankan untuk analisis logam berat. Sabut kelapa diperolehi dari industri kelapa, dibasuh dan dikeringkan di bawah cahaya matahari. Kemudian, sabut kelapa direndam dengan 5% hydrogen klorida (HCl) untuk satu malam. Seterusnya, sabut kelapa dikeringkan di bawah cahaya matahari sekali lagi. Selepas kering, sabut kelapa sedia untuk dikeringkan dalam relau selama 20 minit dengan suhu 550 °C. Kemudian, karbon diaktifkan untuk menentukan dos yang optimum dan kesan pH dengan masa yang tetap. Dos karbon aktif yang digunakan ialah 1000 mg, 3000 mg dan 5000 mg manakala untuk pH ialah 2, 6 dan 9. Masa untuk semua ujian adalah selama 2 jam dengan 1 L sampel. Penyerapan atom spektrofotometer dijalankan untuk analisis logam berat. Oleh kerana rawatan yang dijalankan, kepekatan kadmium berkurang selama tempoh dua jam di mana 1000 mg mengingkirkan 60% kadmium, 3000 mg mengingkirkan 55% kadmium dan 5000 mg mengingkirkan 58% kadmium manakala kepekatan plumbum juga mengurang di mana 1000 mg mengingkirkan 52% plumbum, 3000 mg mengingkirkan 56% plumbum dan 5000 mg mengingkirkan 57% plumbum. Keberkesanan pH dengan masa yang berterusan untuk kadmium adalah pada pH 6 manakala plumbum adalah pada pH 2. Rawatan yang berterusan, kepekatan kadmium dan plumbum dapat dikurangkan dari semasa ke semasa yang mampu membuang bahan-bahan berbahaya dari air sisa industri.

ABSTRACT

Heavy metals are metallic chemical elements. It has a high density and toxic towards the ecosystem and human's life. The sources of heavy metals are from mining activities, agricultural activities, lead-acid batteries, chemical waste, sewage and pharmaceutical industries. Reverse osmosis, chemical precipitation, chemical oxidant, and air stripping are the conventional treatment to treat the wastewater. Nowadays, those methods are costly and difficult to conduct. Adsorption process is one of the method that can be used. This is because adsorption process is easier and cheaper than those methods. There are many types of agricultural waste like coconut coir that can be used as the adsorbent to remove the heavy metals from industrial wastewater. Coconut coir has been chosen for this study to achieve the objectives. The aim of this study is to determine the characteristic of the industrial wastewater, to obtain the optimum dosage of the activated carbon from coconut coir and to determine the effect of pH with constant contact time in removing the heavy metals for cadmium and lead. Atomic Adsorption Spectrophotometer (AAS) has been conducted for the analysis of heavy metals. The coconut coir were obtained from the coconut industrial, washed and dried under the sunlight. Then, the coconut coir was soaked in 5% hydrogen chloride (HCl) solution for one night. Next, the coconut coir was dried under the sunlight again. After dried, the coconut coir was ready to dry in the furnace for 20 minutes with 550 °C. Later, the activated carbon from coconut coir was tested for the optimum dosage and effect of pH and contact time. The dosages of activated carbon have been used are 1000 mg, 3000 mg and 5000 mg while for pH are 2, 6 and 9. The contact time for all tests were two hours with sample of 1 L.Test of Atomic Adsorption Spectrophotometer (AAS) is conducted for analysis of heavy metals. As the treatment conducted, the concentration of cadmium was reducing for two hours period where 1000 mg removed 60 % of cadmium 3000 mg removed 55% of cadmium and 5000 mg removed 58 % of cadmium while the concentration of lead also reducing where 1000 mg removed 52 % of lead 3000 mg removed 56 % of lead and 5000 mg removed 57 % of lead. The effective of pH and constant time for cadmium is at pH of 6 while lead is at pH of 2. As the treatment continued, the heavy metals of cadmium and lead can be reduce from time to time of contact time that able to remove the harmful materials from the industrial wastewater.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

%	Percentage
°	Degree

LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solid
EQA	Environmental Quality Act
HCl	Hydrogen Chloride

CHAPTER 1

INTRODUCTION

1.1 Preamble

Wastewater is known as polluted water. It is a dirty water that formed from various of sources. All the dirty water from the school, household, industries, hospital, commercial establishment, storm water, runoff and so on can contribute to wastewater. Wastewater contains many harmful content that can effect human health as it directly pumped into the sea or fresh water bodies without any treatment. Wastewater disposal and human's health has a real relationship (Salgot, Folch, & Unit, 2018). Wastewater form industries can make the surface, ground and sea water polluted. Wastewater from industries discharge a lot of toxic substances whether in organic or inorganic pollutants. Organic industrial wastewater contains organic industrial waste flow which is from the chemical reaction. The inorganic industrial wastewater is discharge from the industries that processing metals. This inorganic wastewater contains many suspended matter. Inorganic wastewater has a high content of organic than domestic water (De Gisi & Notarnicola, 2017). Irrigation and agricultural also contribute to harmful effect of wastewater. This kind of wastewater generate from runoff and storm water that contain high of nutrients.

Treated water in Malaysia is supplied to more than 95% of the population. Water tariffs are among the cheapest in the world where the poor are not denied access. In a day the water is supplied for 24 hours. This wastewater need to be treated before it cause disease to human's life and the environment to supply for the population. There are many agencies responsibilities at different states and federals to treat the wastewater to avoid the effects of heavy metals. Table 1.1 shows the statistic of water supply and wastewater coverage in Malaysia from Academy of Sciences Malaysia 2015.

Table 1.1 Statistic of Water Supply and Wastewater in Malaysia

Year	**2012**				
States	**Number of accounts (all categories)**		**Percentage of population served or connection**		
	Water	**Sewerage**	**Urban**	**Rural**	**Total of State**
Johor	990,783	287,635	100.0	99.5	99.8
Kedah	519,493	120,695	100.0	96.3	98.2
Kelantan	208,187	4,128	57.9	60.8	59.9
Labuan	15,677	5,973	100.0	100.0	100.0
Malacca	258,022	112,847	100.0	100.0	100.0
Negeri Sembilan	365,138	178,954	100.0	99.8	99.9
Penang	533,916	384,138	100.0	99.7	99.9
Pahang	369,741	66,031	98.0	96.0	98.0
Perak	692,865	271,250	100.0	99.2	99.6
Perlis	65,415	6,015	100.0	99.0	99.5
Sabah	262,525		99.8	64.2	82.0
Sarawak*	457,893		99.6	63.5	93.5
Selangor*	1,841,162	1,713,726	100.0	99.5	99.8
Terengganu	252,095	22,664	99.1	92.9	96.0
National average	Total	Total	96.9	90.7	94.7
	6,832,912	3,174,056			

There are many different treatments can be used. Reserve osmosis is the technology with membrane to treat the wastewater. Other than that, air stripping defined as the flow of the air into the contaminated groundwater and the water surface in the above-ground system. Adsorption is known as the attraction of the ions to the surface of the adsorbent. Adsorption is well-known as the cheapest method to treat the wastewater. Therefore, adsorption treatment is needed as the efficient method.

1.2 Problem Statement

Wastewater contains vary of heavy metals that cause harmful to human and pollution to the surrounding. The acceptable level of effluents been discharge have to be obeyed in Malaysia. For treatment of metal-bearing industrial wastewater, a chief concern has also been employed. Industrial wastewater usually produced cadmium as the heavy metals. Cadmium is dangerous to human's health. It is one of the heavy metals that highly toxic even with a minimum concentration. Cadmium is dangerous to human's health. Cadmium is produce from welding activities, agriculture industries and battery industries (Othman, 2012). Cadmium can cause kidney problems to human health. High concentration of fluoride can be found in the surface water or groundwater because of the geochemical reactions which is the disposal of the industrial wastewater. Lead also contain in industrial wastewater. Lead normally discharged from mining, pesticide and the burning of coal from the industries. The effect of lead to human's health are can cause kidney problem, mental disorder in children and liver damage.

The heavy metals have to be treated before it can bring harmful to the environment and human. There are many methods to treat the heavy metals from the industrial wastewater. Some of the methods are by reserve osmosis, chemical precipitation, air stripping or adsorption. The major problem in Malaysia to treat the heavy metals from the industrial wastewater is very expensive by using the technologies. In that way, adsorption is one of the cheapest way to treat it. Adsorption is the efficient treatment for the industrial wastewater because of the minor usage of chemical and biological sludge (Bisht & Agarwal, 2017). Adsorption is cheap, easy to operate and universal nature treatment (Ali, Asim, & Khan, 2012). Adsorption by activated carbon is well-known in this era to treat the wastewater (Prasath, Muthirulan, & Kannan, 2014). Therefore, the major reason was to find out the cheapest way using adsorption method to treat the industrial wastewater.

1.3 Objective

There are three objectives to achieve the aim which are:

1. To determine the characteristic of the industrial wastewater.
2. To obtain the optimum dosage of activated carbon to remove heavy metals.
3. To determine the effect of pH with constant contact time.

1.4 Scope of Study

This study was carried out to study the characteristics of the industrial wastewater, optimum dosage of the activated carbon to remove the heavy metals and the effect of pH with constant contact time. The industrial wastewater samples are obtained from the University Malaysia Pahang Holding at Gebeng, Kuantan. The characteristic of the industrial wastewater can be determined by conducting several experiments for physical characteristics which are the temperature and suspended solid (SS). Besides, the chemical characteristics such as the parameter of pH, biological oxygen demand (BOD), chemical oxygen demand (COD) and metal ions. This study is major on the effectiveness of coconut coir activated carbon to remove heavy metals from the industrial wastewater. The main of the experiments are to measure the optimum dosage and pH in treating the industrial wastewater.

1.5 Significant of Study

Adsorption is one of the treatments that is very suitable to treat the wastewater. This research is to study the advantages of adsorption method. Adsorption of heavy metals using coconut coir activated carbon will not harm the environment as it is an eco environmental. This treatment can help to prevent the surrounding and human health from bad side effects. Besides, adsorption method need a lower cost to conduct it compare to other conventional treatment. Adsorption method by using the local fruit as the adsorbent can show the effectiveness of the local fruit to remove the heavy metals from the industrial wastewater. The procedure of lower cost and treated wastewater will be revealed in the end of this research. This treatment can be practiced or used by any authorities in Malaysia.

CHAPTER 2

LITERATURE REVIEW

2.1 Wastewater

Wastewater is water that has been polluted. The polluted water was caused by the human activities. Wastewater generated from the industrial, domestic, storm water or runoff, commercial wastewater and agricultural activities are the reason of combination of wastewater that can cause pollution. The wastewater was discharge to the lakes, rivers or oceans and groundwater. Untreated wastewater can lead to water pollution. Chemical pollution is one of the dangerous pollution when the concentration of the chemicals were very high. Chemical pollution was the amount of the chemical pollutants that are made by humans or present naturally in the wastewater. Chemical pollutants were generated from the manufacturing industries, disposing of chemicals, household and any chemical industry. Inorganic chemical pollutants were produced from chemicals of mineral origin in. It was not produced by living microorganisms. Chemical pollution was formed from metals and the salts. Groundwater pollution also might occurred because of oil, gasoline or road salts. These products get into the groundwater and cause pollution of groundwater. Some toxic absorbed to the soil because of runoff by the rain. Agricultural activities, construction industries and factories can contribute to the groundwater pollution. Waste from mining activities can generate to these metals and salts. Sulfides and ammonia can cause harm to the human's health. Certain acid been released in the waste water.

Water pollution that come from more than one sources is known as non-point sources pollution meanwhile water pollution discharge only from one source is called as the point sources pollution. The type of wastewater can be determined by the characteristic of the wastewater. Wastewater from the households is called domestic wastewater and municipal or industrial wastewater is discharged from the communities also known as sewage. These type of wastewater can lead to water pollution. Polluted wastewater may contained harmful composition or pathogens that can effect human's health and the environment. Wastewater has to be treated before discharge to the lake or river.

Industrial wastewater and storm water or runoff may discharged to the same sewage or depends on the sewage design. Based on the United Nations Development Programme (UNDP) which is the United Nations' of global development network, almost 90% of the wastewater from the sewage is untreated well before discharged into the body of water. Untreated wastewater cause disturbance to the ecosystem and health. Besides, sewage with untreated wastewater invites the insects to live there and unpleasant smells. Untreated wastewater also can contribute to diarrhoeal diseases because lack of clean water before been reused by the people. A treated water should be done to prevent any harmful disease to humans health and affecting the environment. Hence, a proper treatment have to be apply to the wastewater before been used.

2.1.1 Domestic Wastewater

The definition of domestic wastewater is the wastewater that have discharged from dwellings, business buildings, institutions and sanitary wastewater. The two well-known categories of domestic wastewater are brown wastewater and black wastewater. The sources of brown wastewater commonly wastewater from the residential kitchen, bathroom or laundry activities. The black wastewater can be found in from the sources of urine, toilet paper or faeces. Temperature, colour, odour and solids used to determine the physical characteristics of domestic wastewater. The temperature range of 10 to 21 °C. High temperature of domestic wastewater can lead to the living of the fish species. The anaerobic activities in the wastewater is the main reason wastewater colour turned into dark grey or black color. Anaerobic activities formed sulfide that react with the metals contain in the wastewater. An oil or soapy oil was the fresh domestic sewage. A high concentration of Hydrogen Sulphide (H_2S) can low of appetite for food and vomiting. Solids are the suspended matter in wastewater. Chemical characteristics of domestic wastewater are the reading of wastewater pH, oxygen demand and nutrients. The pH range of domestic wastewater was from 7.0 to 8.0. High pH means the wastewater contains may heavy metals. Oxygen demand indicates the organic load present in the wastewater. Increasing value of oxygen demand is because of the high use of organic nutrients (Na, Na, & Sciences, 2015). Table 2.1 shows the common reading of domestic wastewater.

Table 2.1 Characteristics of Domestic Wastewater

Parameter	Reading
pH	7.0 – 8.0
Dissolved Oxygen (mg/L)	>1.0
Total Suspended Solid (TSS) (mg/L)	100 – 350
Biological Oxygen Demand (BOD) (mg/L)	100 – 300

2.1.2 Industrial Wastewater

Industrial wastewater was produce from the industrial and commercial activities. It is a source to the water pollution and give negative effects for the eco-system and human's health. Coal and steel industry, which is non-metallic minerals industry or metals processing industry can produce suspended matter that eliminated by the sedimentation. The present of chemical flocculation from the iron addition or aluminium salts. Wastewater from metal processing can add the acids and alkaline level and fluoride from the purification of aluminium. Chemical industries wastewater where is pharmaceutical industry increase the concentration of the COD while decrease concentration of BOD. The change in color of the industrial wastewater might have the low or high level of pH. Some industry of brewery produce wastewater that contain high concentration of suspended solids and detergents. High concentration of COD and BOD from the fermentation process by the soluble and insoluble organics. Industrial wastewater can be treated by various method of treatment. One of the low-cost treatment and materials that suitable for industrial wastewater is by adsorption. Figure 2.1 shows the industrial wastewater that contain heavy metals.

Figure 2.1 Industrial Wastewater

2.2 Wastewater Treatment

The removal of the heavy metals in the wastewater is very important. A suitable treatment is required to produce a good treated wastewater. This can avoid any harmful effect to the human and the environment. Nowadays, there are many techniques to treat the wastewater. Precipitation, reverses osmosis or reduction are the method that can be used to treat the wastewater from the heavy metals.

The wastewater need to be treated because the wastewater been reused after treatment process for drinking water to the pollution. Besides, wastewater treatment help to prevent population waste from reaching the water supplies or reduced the floating debris. The natural processes speed up by the water purifies itself.

There are many health risks if the industrial wastewater did not been treated properly. The heavy metals can cause many bad effect to the human health. There are permissible level for each heavy metals. Table 2.2 shows the effect of heavy metals towards human health (Othman, 2012).

Table 2.2 Effect of Heavy Metals towards Human's Health

Heavy Metals	Sources	Effect towards human's health	Allowable level (ppm)
Cadmium	Nuclear fission plant, batteries, fertilizers, pesticides, electroplating, welding	Cancer, bone marrow, gastrointestinal disorder, bronchitis, kidney damage	0.06
Lead	Burning of coal, mining activities, automobile emission, smoking, pesticide, paint	Mental retarded in children, liver, kidney problems, gastrointestinal damage	0.1
Zinc	Plumbing, metal plating, brass manufacture, refineries	Damage of nervous membrane, effect on skin to have corrosion cause of the zinc fumes	15
Manganese	Ferromanganese production, fuel addition , welding	Damage of central nervous system or inhalation problem	0.26
Mercury	Industry of papers, batteries, pesticides	Poisoning of protoplasm, damage of nervous system	0.01

2.3 Adsorption

2.3.1 Adsorption Process

Adsorption is a process which the substances is permeated into a liquid or solid and form a solution. Adsorbent is defined as the gas or liquid particles form to the solid and liquid surface. The action of surface tension generate the pure liquid to decrease its free surface energy by Weber. The surface tension of a liquid is altered if the soluble material is present. Reduction of the work needed to enlarge the surface area that effect the migration of the substance to the surface. The relationship of the reduction is proportional to the concentration of adsorbate to the surface. In most of the wastewater treatment, the adsorption process is result of the several factors. The factors are solute hydrophobicity which means the impurity dislikes the water. The high hydrophobic the substance, the difficult the water to be adsorbed. A hydrophobic substance is more likely to adsorb the water. Adsorption is an efficient treatment to treat the industrial wastewater. It is the low cost treatment than the technologies treatment to remove the toxic metals.

The result of adsorption process is to remove the solutes from the solution and concentration at the surface of the solution. The process of adsorption ends until the content of the solute remaining in the solution equilibrium with the surface. Equilibrium can be achieved by refer to the amount of solute absorbed per unit weight of adsorbent q_e , where as C, the concentration of solute that remain in the solution. The termed of this kind of expression is an adsorption isotherm. There are two well-known equations to describe adsorption isotherms. These two equations are suitable for water and wastewater treatment applications. The Langmuir equation is shown in Equation 2.1:

$$q_e = \frac{QbC}{(1 + bC)} \qquad 2.1$$

b = constant related to the energy or adsorption for net of enthalpy

Q = maximum value of q_e , capacity of ultimate adsorption

C = concentration of substance remaining in the solution

The equation of Freundlich isotherm are as shown in Equation 2.2:

$$q_e = K_F C^{\frac{1}{n}} \qquad 2.2$$

K_F , n = constant, depending on the temperature, adsorbent and substance to be adsorbed

The value of K and 1/n have to be determined from the laboratory evaluation. The carbon dosage need to fixed with variable of time and vary carbon dosage with a constant contact time.

Normally, the Freundlich equation is equal with the Langmuir equation. The concentration, C range is all over the experiment data. Based on Langmuir equation, the equation does not decreasing to the linear adsorption equation at very low concentrations while for Freundlich equation, at the high concentrations, it does equals well to the Langmuir equation, where n must approximate the limit which the surface is fully covered. Those equations are important to show the efficiency of the activated carbon to adsorb the organics from the wastewater. Other that than, those equations also describe the functional of the dependence capacity of the concentration of pollutant.

2.3.2 Adsorbent

There are many agricultural adsorbent can be used such as mangosteen shell, mango peel, coconut coir, papaya or grape waste to remove the heavy metals from the industrial wastewater. Agricultural adsorbent are natural materials with low cost adsorbents as they known as unused resources (Abood, Rajendiran, & Azhari, 2015). It cannot cause harm to the environment because it is environmentally friendly nature. The agricultural waste is been collected and reused to avoid their abundance in nature. Moreover, agricultural waste is easy to find. The agricultural waste need to be modified to be used as a good adsorbent. Table 2.3 shows the comparison of the bioadsorbents (Othman, 2012). It shows different type of bioadsorbents have the different condition of pH, time taken to react towards the heavy metals and concentration taken. Figure 2.2 and 2.3 show the activated carbon from coconut coir and mango peels respectively.

Table 2.3 Comparison of the Bioadsorbents

Biosorbent	**Heavy Metals Removed**	**Parameter**		
		pH	**Time taken (min)**	**Concentration (mg/g)**
Coconut coir	Lead	2	10	26.5
Grape waste	Chromium	4	60	1.91
Mango peel	Lead	5	60	99.05
	Cadmium	5	60	68.92
Papaya wood	Cadmium	5	60	19.88
	Copper	5	60	19.89

Figure 2.2. Activated Carbon from Coconut Coir

Figure 2.3 Activated Carbon from Mango Peels

2.3.3 Type of Adsorbents

There are many types of adsorbents which are activated alumina, silica gel, activated carbon or molecular sieve carbon. Adsorbent usually found from manufactured adsorbents such as activated carbon. A few of adsorbents also occurred naturally like zeolites. All of the adsorbents have their own characteristics. Table 2.4 below shows the types of adsorbents and their applications. Figure 2.4 shows adsorbent from clay and Figure 2.5 shows adsorbent from silica gel.

Table 2.4 Types of Adsorbents and Their Applications

Types of Adsorbents	Applications
Clay	Treat edible oils
Polymers	Water purification
Zeolites	Separate the oxygen and argon
Carbons	Water purification

Figure 2.4 Adsorbent from Clay

Figure 2.5 Adsorbent from Silica Gel

2.4 Activated Carbon

Activated carbon is known as a material has been carbonized. Activated carbon also called as activated charcoal (Tadda, Ahsan, Shitu, & Elsergany, 2016). It function as the adsorbent or decolourizing agent which are very crucial in removing the contaminants from potable water or any polluted wastewater. The chemical formula of carbon is C with chemical weight of 12.01. Carbon has characteristics of insoluble in liquid and for multipurpose solvents. The carbonization of activated carbon required a high temperature. Certain activated carbon were carbonized with mixed of inorganic salts. The additional of inorganic salts can active the gases such as steam or carbon dioxide. Carbonaceous matter treated by phosphoric acid or zinc chloride as the chemical activating agents. Activated carbon made from various types of waste disposal. Commonly, fruit wastes like coconut shells, mango peels, lemon peels or sawdust chosen for carbonized. Carbonized of activated carbon help to increased the surface area of the pores. This gives the high potential for adsorption process. Activated carbon is famous because of the simplicity of its design and operation. It also reduce the pollutants towards the environment and dilute solutions. Activated carbon can come in several forms which are powder, granular or pellet. Figure 2.6 shows activated carbon in powdered form and Figure 2.7 shows activated carbon in granular formed while Figure 2.8 shows activated carbon in pellets size.

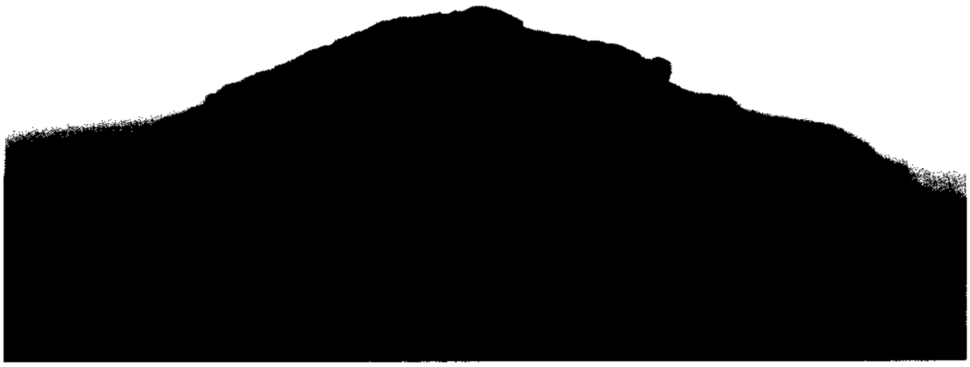

Figure 2.6 Powdered Activated Carbon

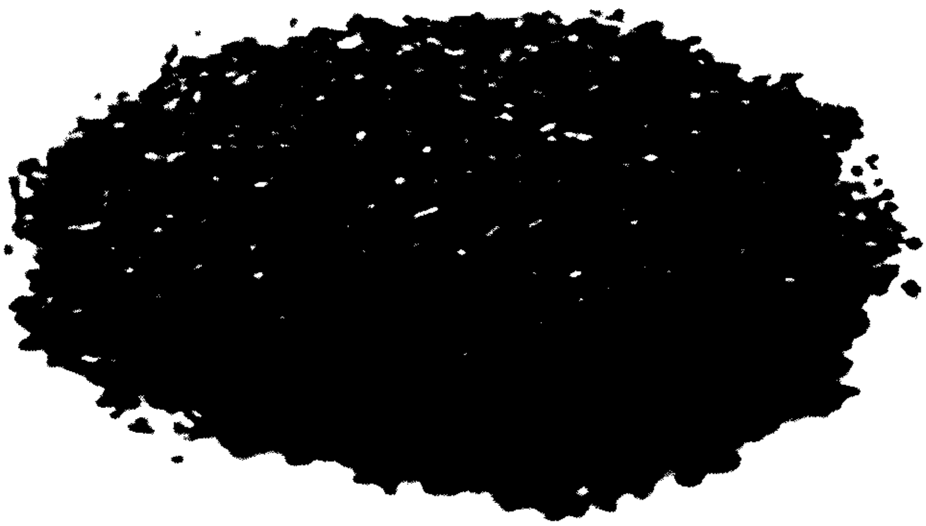

Figure 2.7 Granular Activated Carbon

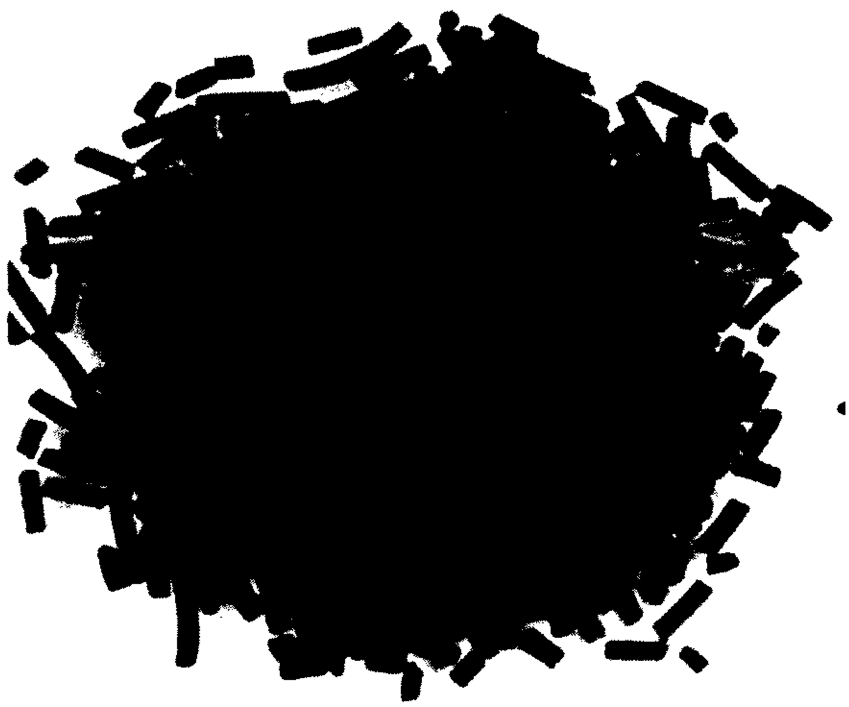

Figure 2.8 Pellets Activated Carbon

2.4.1 Physical Activation Process

There are two steps for physical activated process. The first step is the carbonization of carbonaceous materials. Then, the activation of the resulting char with a high temperatures and the present of CO_2, steam, air which is the mixtures of the all of the gases. These gases act as the oxidizing gases. The using of CO_2 as the activation gas was commonly used because of the simplicity to handle, clean and possesses a minimum reaction rate at a high temperature of 800 °C. This activation process required facilities control. The suitable range of temperature for activated carbon is between 400 °C and 850 °C (Tadda et al., 2016). Sometimes, the activation of carbon also can reach up to 1000 °C while the carbon is activated between temperature of 600°C and 900 °C. This method is application to agricultural biomass residues. These biomass residues are rice husk, rice hull, sawdust and coconut coir pith.

After been carbonized, the activated carbon were crushed into fine powder. The activated carbon were crushed into powder formed because powder has higher surface are per unit mass than the granular carbon (Chiesa, 2018). Thus, this help to increase the adsorption capacity in adsorbing the contaminants from the solution. Then, the activated carbon were sieved using standard of 4 to 16 . The size of the pieces of activated carbon should be approximately 1.0 to 5.0 mm.

2.5 Factor Affecting Activated Carbon Process

2.5.1 Materials

High carbon content, low inorganic content, cheap materials, high density, good volatile content and potential extend of activation are the factors that need to be considered in choosing materials to produce a good activated carbon. Many of the organic substances contain high carbon in it. Table below shows the characteristics of several materials to produce activated carbon. Lignocellulosic material like coconut coir is a precursor for process of activated carbon (Tadda et al., 2016). 45 % of the total materials normally been used. Materials with low inorganic content can give low ash content for the activated carbon production. An average of high volatile content formed with full control process of manufacturing. Nowadays, fruit stones and coconut coir are the good materials for activated carbon. Coconut coir and fruit stones are the main materials for activated carbon because of their hardness, volatile content, high density and content. This help them to prepare GAC production. They are also utilised for micro-porous activated carbon production and applications for variety of usage. Table 2.5 shows the characteristics of materials for activated carbon.

Table 2.5 Characteristics of Materials Used for Activated Carbon

Materials	Soft wood	Hard wood	Lignin	Nutshells	Lignite
Mass of Carbon (%)	40 – 45	40 – 42	35 – 40	40 – 45	55 – 70
Mass of Volatiles (%)	55 – 60	55 – 60	58 – 60	55 – 60	25 – 40
Density (cm^2g^{-1})	0.4 - 0.5	58 – 60	0.3 – 04	1.40	1.0 – 1.35
Mass of Ash (%)	0.3 – 1.1	55 – 60	-	-	5 – 6

2.5.2 Temperature

Temperature is an important parameter to produce an activated carbon. The characteristics of activated carbon produced affected by temperature. The carbonization normally set up to 800 °C for carbon dioxide and the steam mixture. Surface area and production of yield are also affected by temperature. The suitable temperature range for activated temperature is between 200 °C to 1000 °C (Tadda et al., 2016). Volume of volatile substances released was increasing with the increasing of activated temperature at the same time, the reduction of activated carbon yield in the end of the process. In order to produce the best activated carbon, the temperature of activated have to be above than 800 °C. Activation temperature more than 800 °C can increase the fixed carbon and ash content. The removal of volatile matter of the materials might happen during the activation process. This will create more stable carbon an ash-forming minerals. Besides, high temperature can released the volatile matter that can lead to the increasing of the pores and the surface area of the activated carbon.

2.5.3 Time Taken for Activation

Time taken for activation can influence the properties of the activated carbon. The range for activation time were used from 1 to 3 hours (Tadda et al., 2016). These range were appropriate for fruit disposal such as banana peels, coconut coir and palm-fruit bunch. As the activation time increased, the surface area of activated carbon also increased while the yields percentage of the activated carbon was decreased.

2.5.4 Surface Area

Adsorption process is proportional to specific surface area. The increase of the surface area is due to the decrease of the partial size (Prasath et al., 2014). Specific surface area is a portion to the total surface available for adsorption. The external sites of an adsorbent with non - porous, the mechanism of uptake is one of the adsorption. The rate of should be reciprocally with the first power of the diameter. The film transport holds the porous adsorbents. This happened when the external resistance controls the rate.

2.6 Coconut Coir

Cocos nucifera is the scientific name for coconut tree where the coconut is grow. In the past, the coconuts were harvested for their meat and juice. The coconut husk or coir is the waste from the coconut. Coconut coir is considered from the husk to the inner shell of the coconut. There are many types of the coconut coir which are coconut pith and coconut fiber. Coconut coir is an agricultural solid waste. It is the residue in the processing of coconut (M Chaudhuri & Saminal, 2011). Coconut coir has the fastest period to adsorb the heavy metal which is lead from the wastewater. In the condition of acidic pH of 2, the adsorbent can yield lead 26.5 mg/g within 10 minutes. Figure 2.9 shows the coconut coir before been carbonized while Figure shows 2.10 shows the coconut fine.

Figure 2.9 Coconut Coir

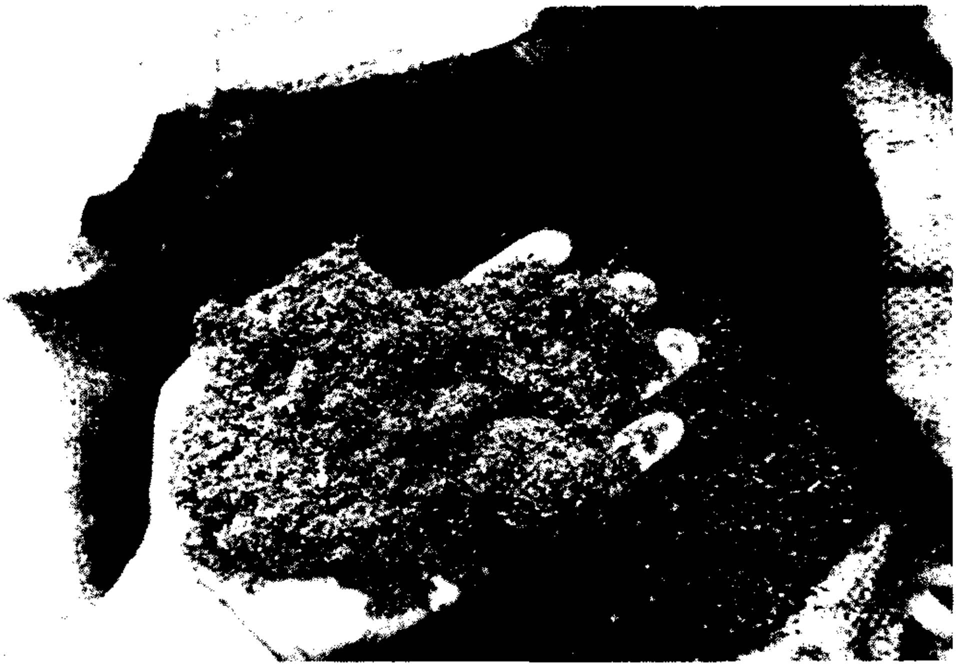

Figure 2.10 Coconut Fine

2.6.1 Effect of Dosage of Activated Carbon

Coconut coir is one of agricultural waste to be used as the adsorbent to remove the heavy metals in industrial wastewater. Coconut coir can adsorb three kind of heavy metals which are copper, nikel and cadmium (Aravind, Chanakya, & Kothuri, 2017). Table 2.6 shows the initial concentration of the heavy metals before treatment.

Table 2.6 Initial Concentration of Copper, Nickel and Cadmium

Heavy Metals	**Cu**	**Ni**	**Cd**
Initial concentration (ppm)	4.971	5.067	0.947

All samples were tested with 90 ml of industrial wastewater. Based on the results obtained in Table 2.7 by Aravind, cadmium, nickel and copper can be removed effectively as the dosage of the activated carbon was increasing. The increase the dosage of activated carbon, the increase the adsorption process. The graph in Figure

2.11 shows the performance of the coconut coir activated carbon in removing the heavy metals.

Table 2.7 Concentration of Copper, Nickel and Cadmium at Different Dosages

Heavy Metals	Concentration of heavy metals (ppm)		
	1 g dosage	3 g dosage	5 g dosage
Cu	0 ppm	0 ppm	0 ppm
Ni	0.003 ppm	0.015 ppm	0.025 ppm
Cd	0.004 ppm	0.010 ppm	0.019 ppm

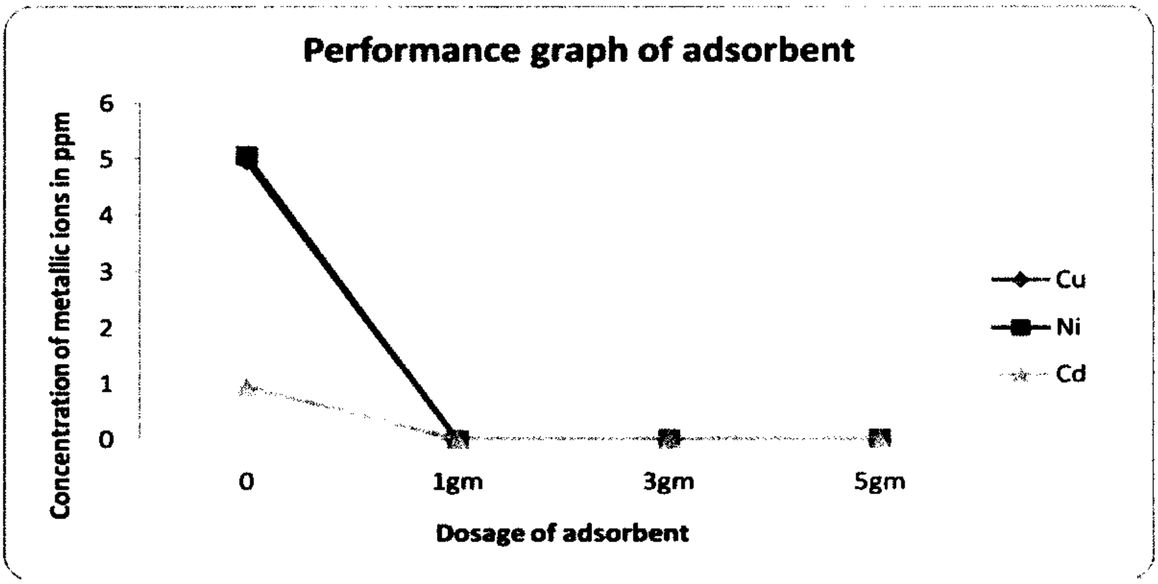

Figure 2.11 Graph Performance of Activated Carbon

Based on the graph in Figure 2.11, dosage of activated carbon is an important parameter. It can affect the activities of adsorption process (Etim, Umoren, & Eduok, 2016). The initial concentration of the heavy metals were decreasing from time to time as the adsorbent dosage was increased. The optimum dosage was determined after the adsorption process has achieved equilibrium. An equilibrium adsorption where the figure shows a constant reading of concentration. The optimum dosage was determined at the first dosage of activated carbon started to show an equilibrium adsorption process. This is because the overlapping of the adsorption sites. That mean the surface area of the absorbent was decreasing and the adsorption site was constant.

Based on results obtained by Chaudhuri & Saminal, 2011, activated carbon from coconut coir also efficient in removing lead. Based on Figure 2.12, the graph shows the percentage of the adsorption has achieved 100 % at the end of the experiment. The dosage of the activated carbon effect the activities of the adsorption in removing lead.

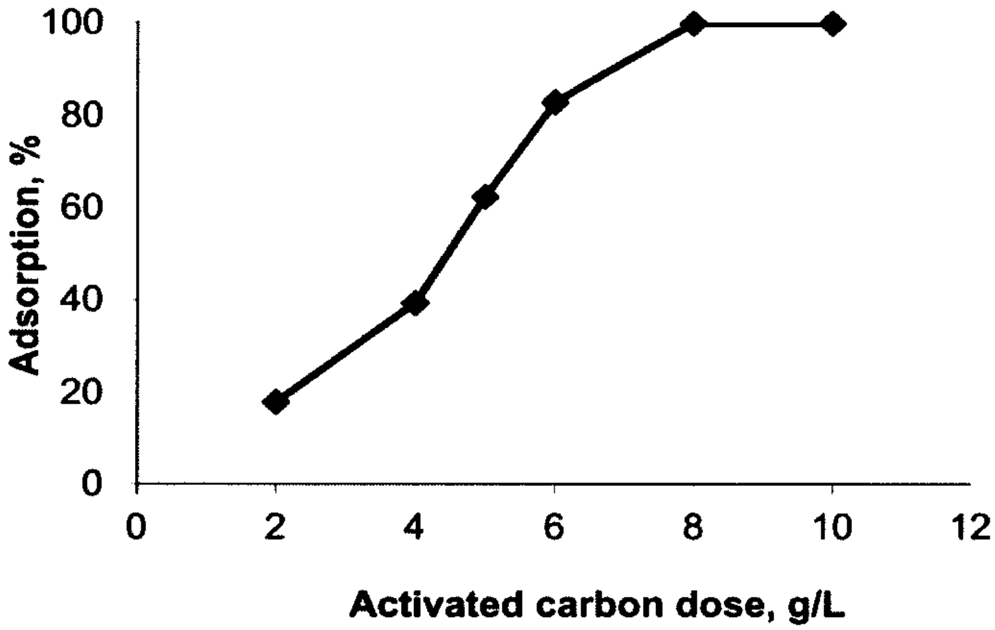

Figure 2.12 Performance of Activated Carbon

2.6.2 Effect of pH of Industrial Wastewater

In adsorption process, the electrostatic changes are control by the pH of the sample (Etim et al., 2016). The charges on the surface of the adsorbent and ionized of the heavy metals can effect the electrostatic changes. The performance of activated carbon from coconut coir with different pH of industrial wastewater conducted by (Thakur & Semil, 2013) is shown in Figure 2.13. Based on the figure, the percentage of adsorption process was increasing until pH of 6. Further increased pH of industrial wastewater, the percentage of adsorption process was decreasing. The maximum percentage in removing cadmium was at pH of 6 with 94 % of removal. pH is one of the important parameter for adsorption of heavy metals from the industrial wastewater. Different heavy metals have their own efficiency pH value to remove the heavy metals. As the pH increase, the adsorption process also increased. Adsorption process was slow at low pH which was acidic state (Malay Chaudhuri, Rahman, Kutty, & Yusop, 2010). The optimum adsorption was achieved for cadmium was at pH of 6. It is almost to the neutral solution.

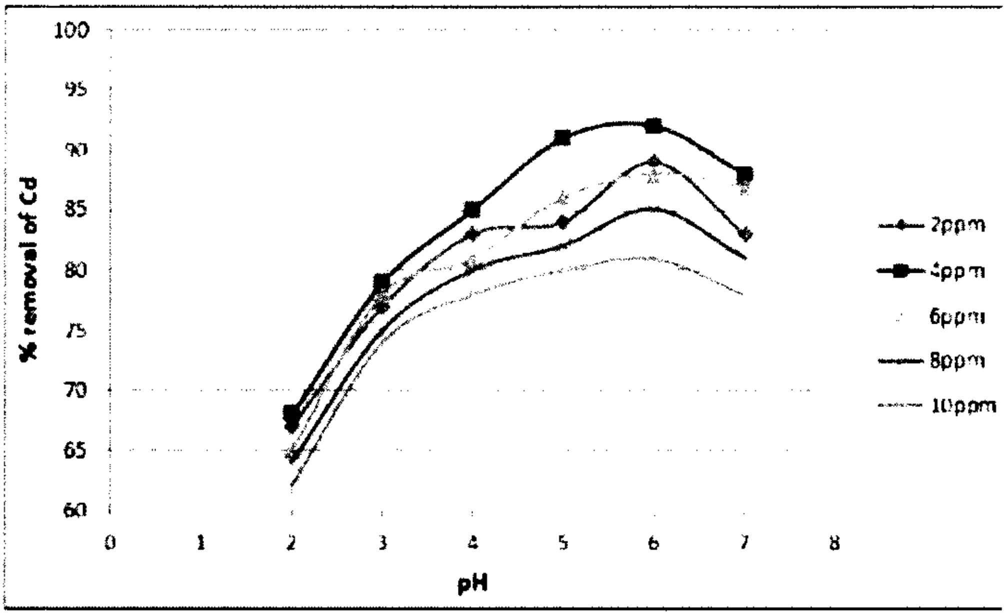

Figure 2.13 Graph Performance of Activated Carbon

Based on the results obtained by Othman, 2012 in Table 2.8, the effective pH to remove lead was at pH 2. The time taken for the adsorption process was 10 minutes. The adsorption capacity was recorded with 26.5 mg/g. That mean, removing lead using activated carbon coconut coir can remove 26.5 mg of lead per 1 gram of adsorbent.

Table 2.8 Efficiency of Activated Carbon

Parameter	**Reading**
pH	2
Time Taken (min)	10
Adsorption capacity (mg/g)	26.5

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents the methodology used to achieve the objectives of the study. Description of the materials and equipments are provided in Section 3.2. The suitable materials and equipments required for each of the experiments were listed. The location the industrial wastewater was collected was stated. The general characteristics of wastewater also discussed in this section. In order to determine the highest reading of parameter, the reading for Biological Oxygen Demand (BOD) and Total Suspended Solid (TSS) calculated using formula given in Equation 3.1 and Equation 3.2 respectively :

$$\text{BOD}_t = \frac{(DO_i - DO_t)}{P} \quad (3.1)$$

Where:

BODt = biochemical oxygen demand, $\frac{mg}{L}$

DOi = initial DO of the diluted wastewater sample about 15 minutes after preparation, $\frac{mg}{L}$

DOt = final DO of the diluted wastewater sample after incubation for t days, $\frac{mg}{L}$

P = dilution factor

$$Total\ Suspended\ Solid, \frac{mg}{L} = \frac{(A - B\ \times 100)}{C} \quad 3.2$$

Where:

A = weight of filter and dish + residue in mg

B = weight of filter in mg

C = volume of sample filtered in mL

Chemicals and reagents that selected have to be correct. Analytical method were discussed in Section 3.3. Analytical methods are to discuss the experiments that should be conducted. This subtopic was to identify the suitable experiments for the research to achieve the objectives. Last but not least, Section 3.4 was the procedures on the experiments. A set of procedures of particular experiment that should be held was explained in this section. The procedure of the experiments was explained in details to avoid any mistake or spoiled experiment while conducting it. Therefore, methodology has to be described carefully. A good quality of methodology is required for references.

Figure 3.1 illustrates the study framework of the whole experimental work of the study. The flowchart is important to make sure the progress was in a good flow to avoid many missing steps. First of all, the details on the activated carbon and industrial wastewater have to be studied. The introduction of the coconut coir as the activated carbon adsorption. The proper preparation of the coconut coir and industrial wastewater was done. The coconut coir and industrial wastewater has been analyzed by conducting the experiment and the performance was collected. Result and analysis was obtained depends on the data collected. The heavy metals in the wastewater was also identified. Conclusion and any comment was discussed in to improve the treatment. The percentage of removal efficiency to remove the heavy metals was calculated again using the formula as shown in Equation3.3 and the amount of the heavy metals adsorbed per gram of the activated carbon (q_e) were calculated using Equation 3.4. Lastly, the thesis report was written.

$$Removal\ efficiency = \frac{c_i - c_e}{c_i} \times 100 \quad 3.3$$

Where:

Ci = concentration of the heavy metal in the influent

Cc = concentration of the heavy metal in the effluent

$$q_e = \frac{V}{M} (C_e - C_o) \qquad 3.4$$

Where:

C_e = initial concentration of the heavy metal ($\frac{mg}{L}$)

C_o = equilibrium concentration of the heavy metal ($\frac{mg}{L}$)

V = volume of sample (L)

M = mass of the activated carbon (mg)

The equation used to calculate the value of $R_L$as shown in Equation 3.5 below :

$$R_L = \frac{1}{1 + b\, C_O} \qquad 3.5$$

Where:

b = equilibrium adsorption constant

C_O = the initial concentration of the heavy metals

R_L .> 1 (unfavourable)

1 < R_L< 1 (favourable)

R_L = 0 (irreversible)

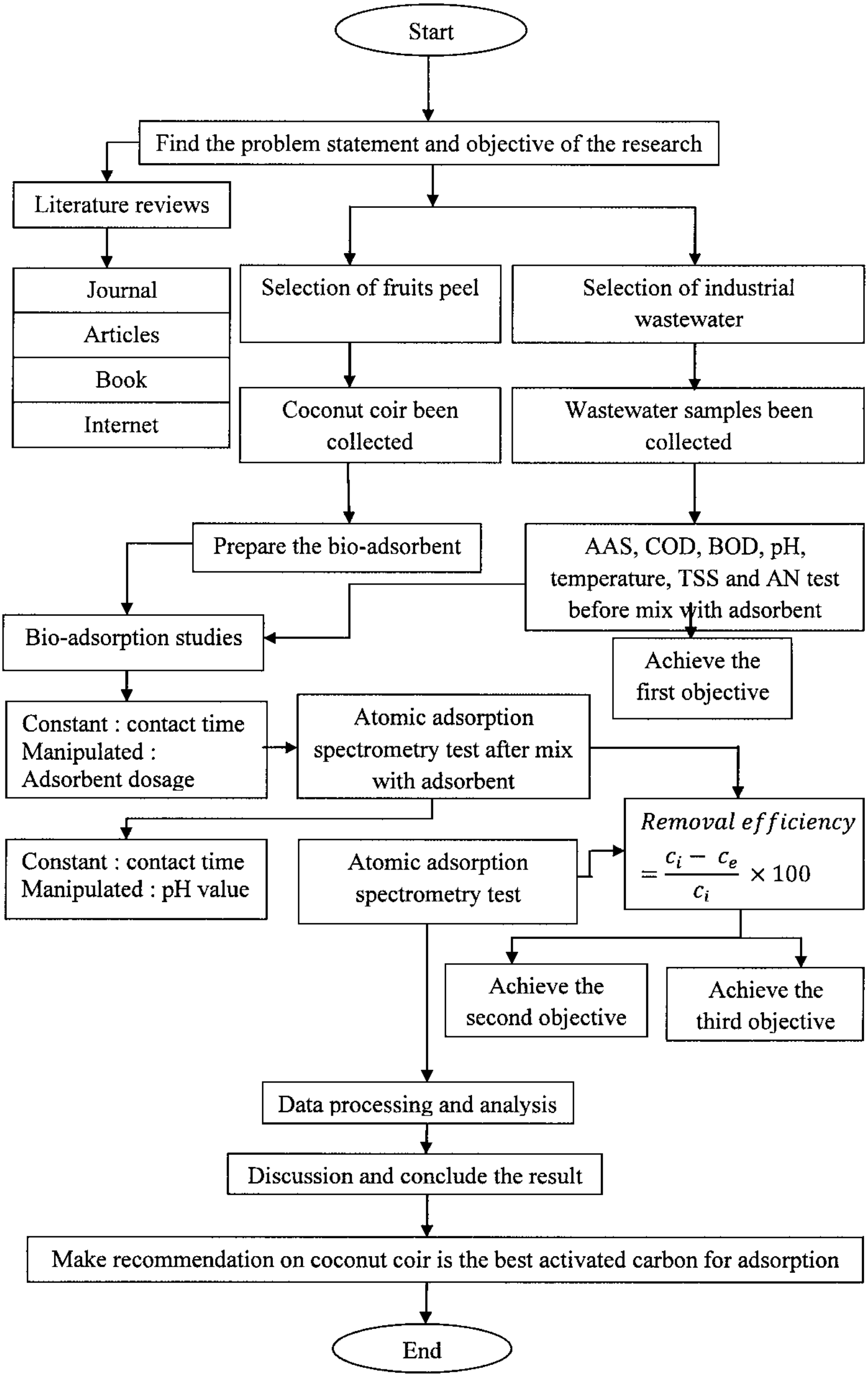

Figure 3.1 Research Framework of the Experiment Work of the Study

3.2 Materials and Equipments

3.2.1 Wastewater Composition

Municipal wastewater contain 99% of water with relatively a few concentrations of suspended, dissolved organic or inorganic solids and pathogens. In this study, industrial wastewater was collected for the experiments. The location of the sample taken was from University Malaysia Pahang Holding in Gebeng, Kuantan, Pahang. This area is link via the East Coast Expressway to the West Coast of Peninsular Malaysia. There is a petrochemical cluster located at this place. It is strategic place for various of multinational corporations of industrial companies. The various of the industrial companies make this location is suitable for the sample of industrial wastewater. Figure 3.2 shows the sample of industrial wastewater.

Figure 3.2 Sample of Industrial Wastewater

3.2.2 Adsorbent

The coconut coir was collected from the industrial. Then, the coconut coir was washed with distilled water and dried under the sunlight. Next, the coconut coir was soaked with 5% of hydrogen chloride (HCl) for one night. Figure 3.3 shows the coconut coir was soaked with hydrogen chloride (HCl). The coconut coir was dried under the sunlight again as shown in Figure 3.4. The coconut coir was ready for carbonized as shown in Figure 3.5. The carbonized of the coconut coir was using furnace with 550°C for 20 minutes. Lastly, the coconut coir was taken and powdered into particles as shown in Figure 3.6. The activated carbon was stored in an tight container.

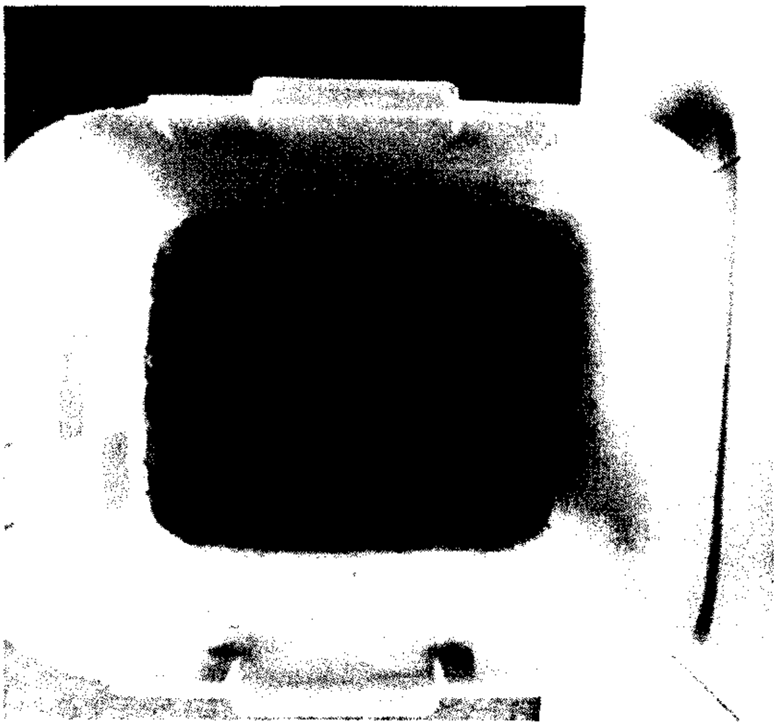

Figure 3.3 Coconut Coir Soaked with Hydrogen Chloride (HCl)

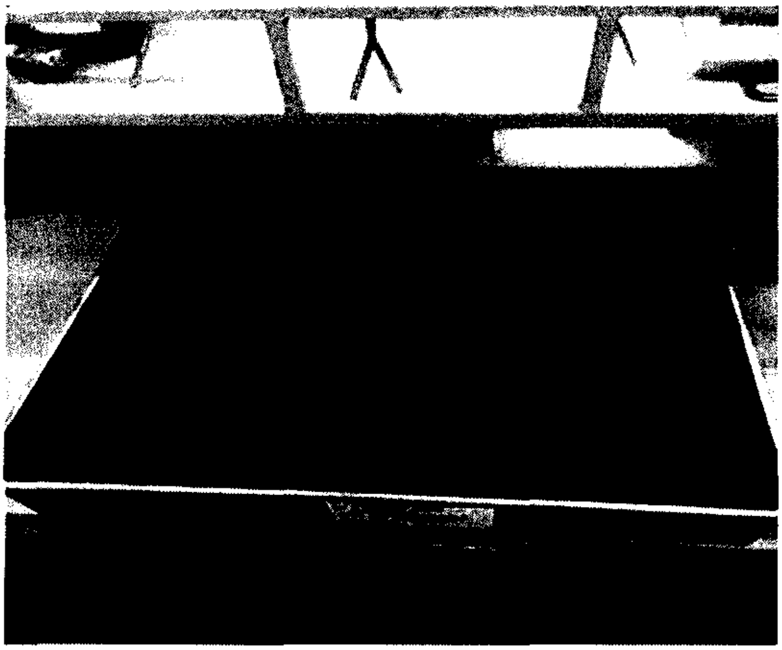

Figure 3.4 Dried Coconut Coir

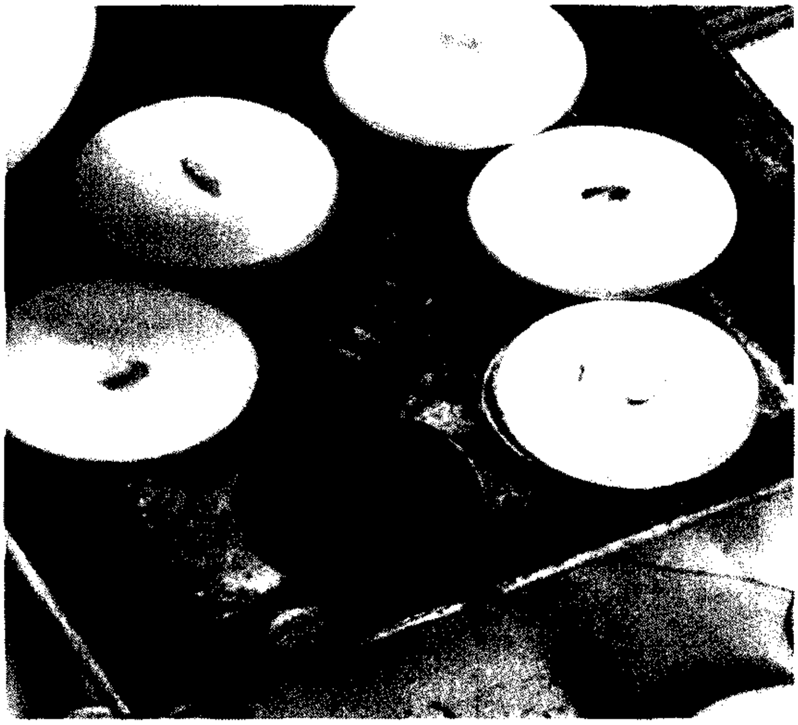

Figure 3.5 Coconut Coir Ready for Carbonized

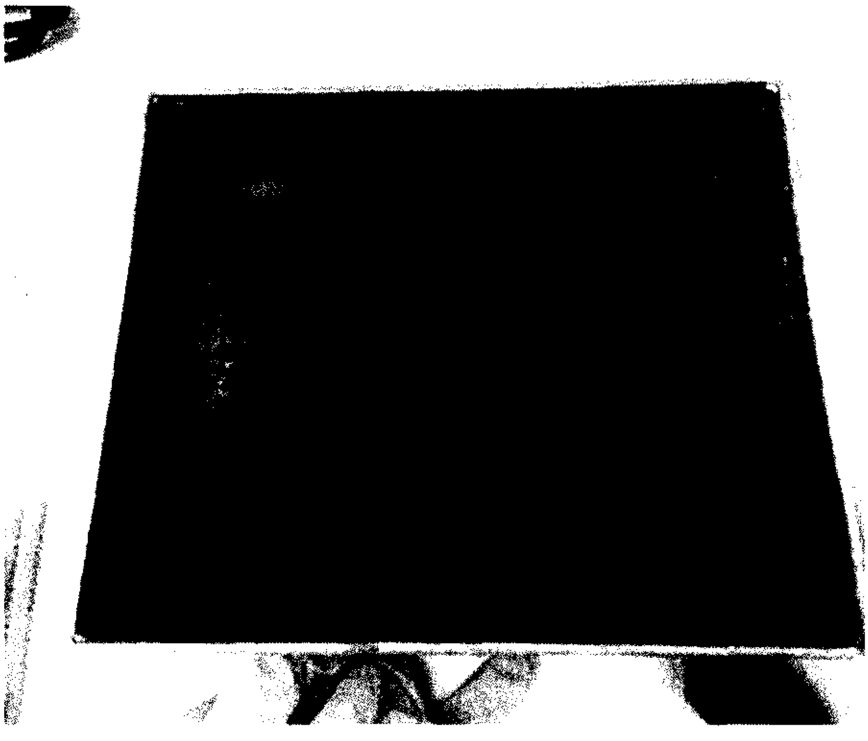

Figure 3.6 Activated Carbon

3.2.3 Chemical and Reagents

There were seven parameters need to be done for the industrial wastewater which are pH, temperature, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Suspended Solid (TSS), Ammoniacal Nitrogen (AN) and heavy metals. The experiments were carried out at the environmental laboratory in the Faculty of Civil Engineering and Earth Resources. Figure 3.7 shows the preparation of HCl and Figure 3.8 shows the apparatus required for the preparation of HCl. The apparatus were beaker 500 ml and 1000 ml, dropper, measuring cylinder 100 ml and conical flask.

Figure 3.7 Preparation of Hydrogen Chloride (HCl)

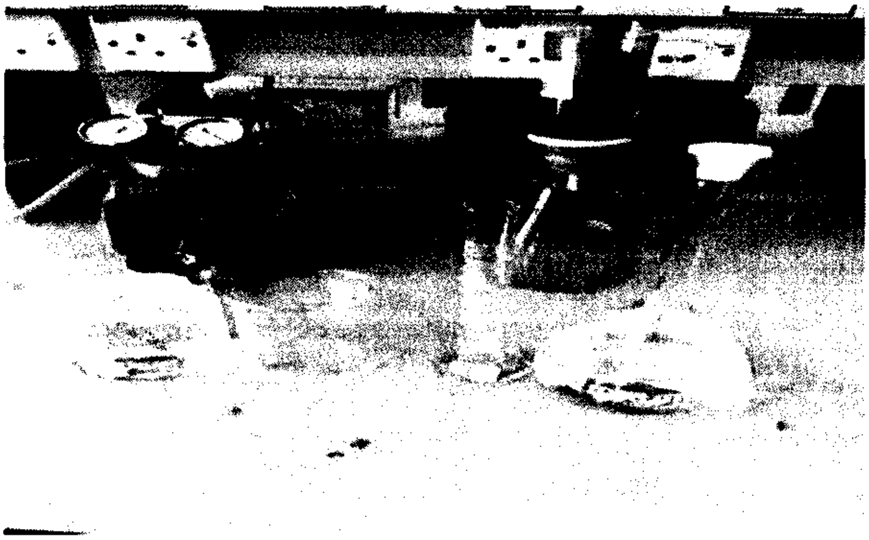

Figure 3.8 Apparatus for Chemical Preparation

3.2.4 Equipments

Table 3.1 shows the list of equipments used for each of experiment.

Table 3.1 List of Equipments used in the Experiments

Equipments	Brand	Application
pH meter	SevenCompact	pH reading
Thermometer	Brannan	Temperature
BOD incubator Dissolved Oxygen Meter	Shel Lab YSI 5100	BOD
COD Reactor Colorimeter	HANNA Instruments DR 3900	COD
Drying oven Analytical balance	Memmert Sartorius	TSS
UV – VIS Spectrophotometer	DR 5000	Ammonia Nitrate
Atomic Adsorption Spectrophotometer	Perkin Elmer AAnalyst 400	AAS

Figure 3.9 shows spectrophotometer to measure the concentration of ammonia nitrate in the industrial wastewater. This is for ammonia nitrate application. Figure 3.10 shows the Atomic Absorption Spectrometer (AAS) to measure the concentration of the heavy metals present in the industrial wastewater before and after the treatment. Figure 3.11 shows the pH meter to read the pH of the industrial wastewater. Figure 3.12 shows the photo of analytical balance to weight the residue, filter paper and the dish for total suspended solid experiment. Lastly, dissolved oxygen meter is shows in the Figure 3.13 for BOD test.

Figure 3.9 Spectrophotometer

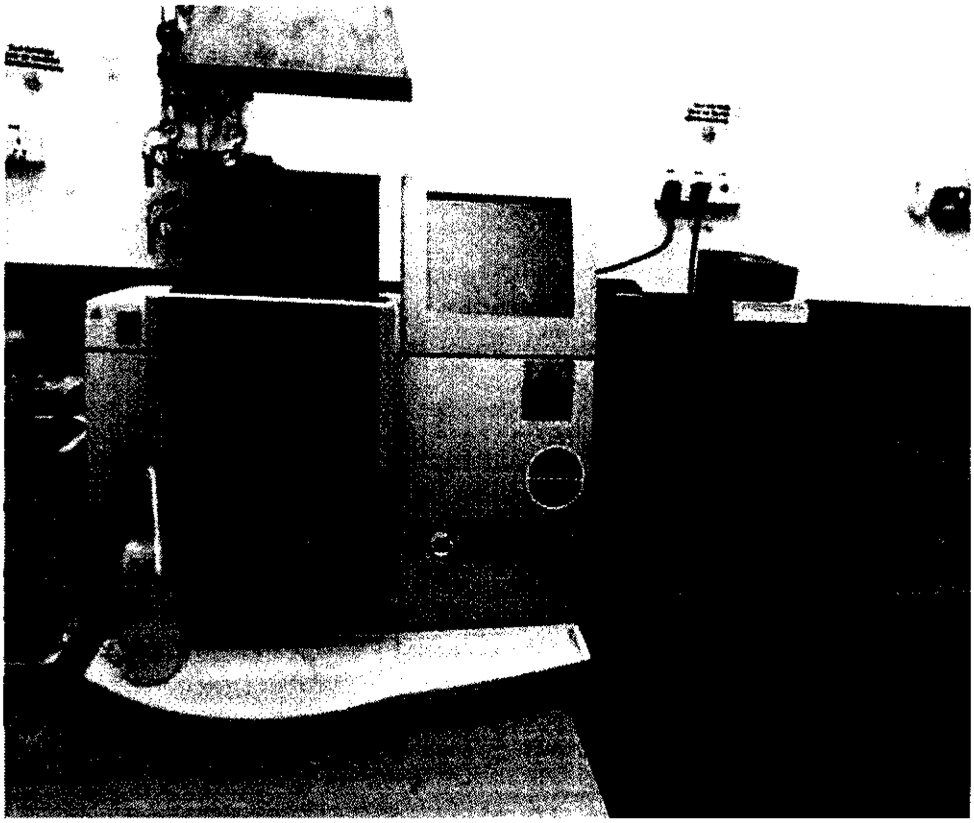

Figure 3.10 Atomic Adsorption Spectrometer (AAS)

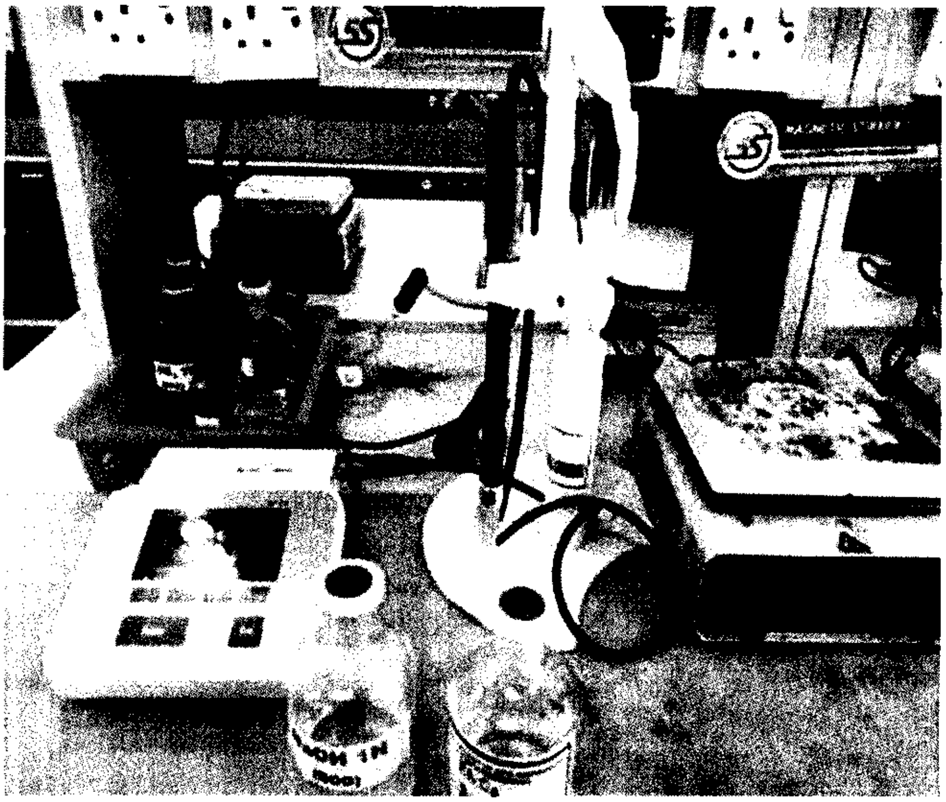

Figure 3.11 pH Meter

Figure 3.12 Analytical Balance

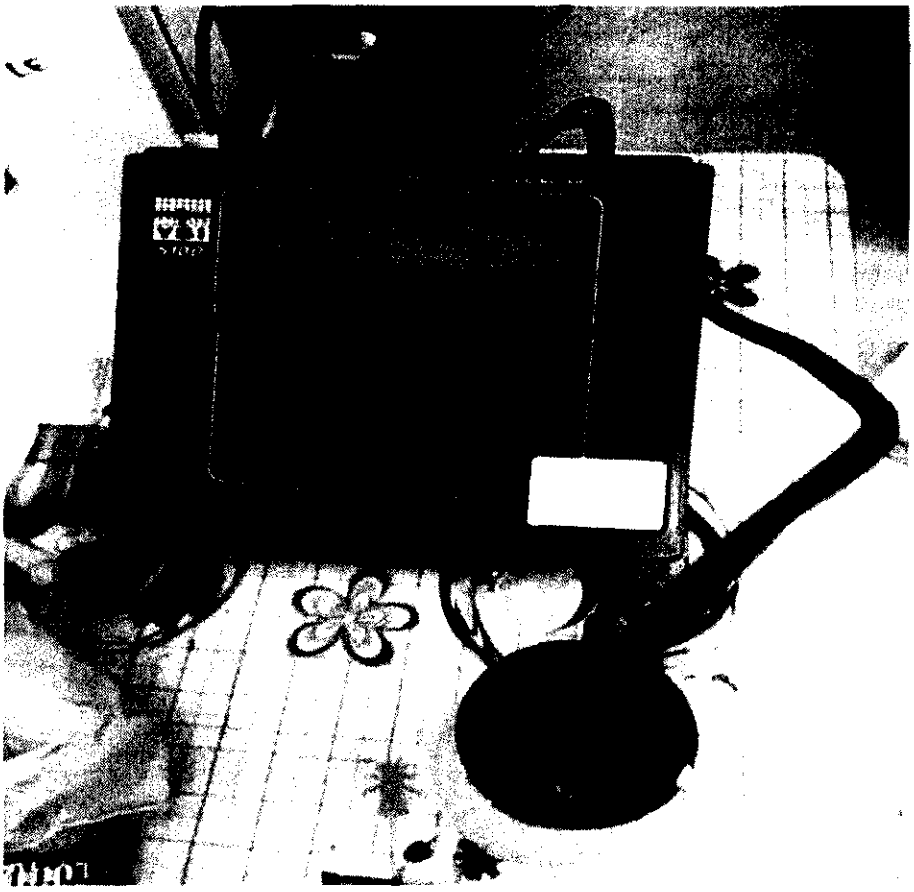

Figure 3.13 Dissolved Oxygen Meter

3.3 Analytical Method

pH, temperature, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Suspended Solid (TSS), Ammoniacal Nitrogen (AN) and heavy metals are the experiments that have been carried out. The experiments will be carried out at the environmental laboratory in the Faculty of Civil Engineering and Earth Resources.

3.4 Experiment Procedures

The sample of industrial wastewater was collected from the industrial sewerage from University Malaysia Pahang Holding at Gebeng, Kuantan, Pahang. Atomic Absorption Spectrometer (AAS) was used to determine the initial concentration of the heavy metals which were cadmium and lead. The sample of 1 Liter industrial wastewater was taken and adsorbent was added with 1000 mg, 3000 mg and 5000 mg in each beakers. Another three samples the pH value were adjusted to pH 2, 6 and 9. The solution was mixed using Excella E1 Platform Shaker for 20 minutes as Figure 3.14. Then, the samples were left for 2 hours to allow adsorption process to happen as shown in Figure 3.15. The samples were filtered with What man filter paper number45. 100 ml from each samples was taken for atomic adsorption spectrophotometer to determine the concentration of heavy metals cadmium and lead after treatment. The temperature was maintained 25 °C throughout the experiment.

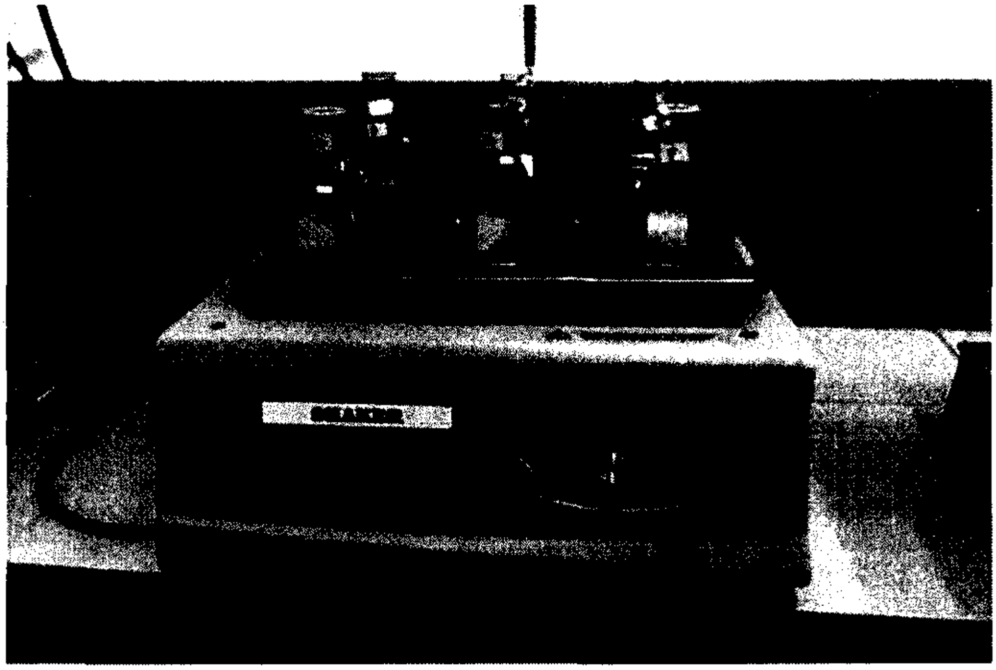

Figure 3.14 Samples Mixed using Shaker

Figure 3.15 Samples Left for Adsorption Process

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter provides the details of the results and discussions on the removal of heavy metal from industrial wastewater using activated carbon of coconut coir. In Section 4.2 the characteristics of wastewater was determined after several experiments were conducted. A table was shown in this section. Table 4.1 shows the reading of the parameters. All the parameters were collected carefully to ensure a valid data.

Section 4.3 discussed about the determination of the optimum dosage of the activated carbon. This section has provided the table to show the concentration of cadmium and lead before and after treatment. In order to show the effectiveness of the activated carbon, a graph of removal efficiency against dosage of activated carbon was plotted for the performance of activated carbon. The amount of the heavy metals adsorbed per gram of the activated carbon (q_e) were calculated and graphs to show the performance of activated dosage was plotted in this section.

Section 4.4 discussed about the effect of pH on the performance of coconut coir. In this section, the tables were shown to see the concentration each of the heavy metals before and after treatment with different pH of wastewater. Graphs for the performance of activated carbon were plotted to determine the effective pH to remove each of the heavy metals. In every sections, the reasons of the results obtained were explained in details.

Section 4.5 discussed about the Langmuir isotherm. This section proved the activated carbon from coconut coir was fitted the Langmuir isotherm.

4.2 Characteristics of Wastewater

Table 4.1 Characteristics of Industrial Wastewater

Parameters	Reading	EQA 1974	
		Std A	Std B
pH	4.49	6.0-9.0	40
Temperature (°C)	28.6	40	40
Biological Oxygen Demand (BOD) (mg/L)	6.36	20	50
Chemical Oxygen Demand (COD) (mg/L)	499	50	100
Total Suspended Solids (TSS) (mg/L)	0.015	50	100
Ammoniacal Nitrogen (mg/L NH_3-N)	0.160	-	25
Heavy Metals			
Cadmium (mg/L)	0.457	0.01	0.02
Lead (mg/L)	0.312	0.10	0.50

Based on Table 4.1, the reading for cadmium and lead were very high were 0.457 mg/L and 0.312 mg/L respectively. The quality of the industrial wastewater was low. Wastewater with high content of heavy metals is dangerous for the eco-system and human's life. The reading for other parameters were not meeting the standard of EQA 1974. Standard A was wastewater that discharged from upstream and Standard B was from downstream. A good quality of industrial wastewater, the reading of cadmium should be 0.02 mg/L while for lead is 0.5 mg/L based on the standard published by EQA 1974. There were many development of residential located at Gebeng. The domestic wastewater also flow to the river and increase the reading of the parameters. Besides, the wastewater from the restaurants can contribute to the river pollution. The reading of the Chemical Oxygen Demand (COD) was high with reading of 499 mg/L. The present of chemical in the wastewater is high. A quality wastewater supposed to have 100 mg/L and below of COD. An efficient treatment for the wastewater is required at the river in Gebeng to avoid the negative impacts to the communities and environment.

4.3 Determination of Optimum Dosage

The type of heavy metals have been tested were cadmium and lead. There were three different dosages of activated carbon to test the performance of the activated carbon of coconut coir on the removal of the heavy metals which were 1000 mg, 3000 mg and 5000 mg respectively. The heavy metals have been removed from the sample of 1 Liter of industrial wastewater even with minimum dosage 1000 mg of activated carbon. The result shows a constant concentration of cadmium, after added adsorbent more than 1000 mg. All the tests was tested with constant time contact which is 2 hours. Table 4.2 shows the concentration of cadmium after tested with different dosages of activated carbon from coconut coir. Figure 4.1 and Figure 4.2 show the graph performance of the activated carbon with different dosages of adsorbent.

Table 4.2 Concentration of Cadmium

	Initial Concentration	**Dosage of Activated Carbon**		
		1000 mg	**3000 mg**	**5000 mg**
Concentration of Cadmium (mg/L)	0.457	0.183	0.206	0.190

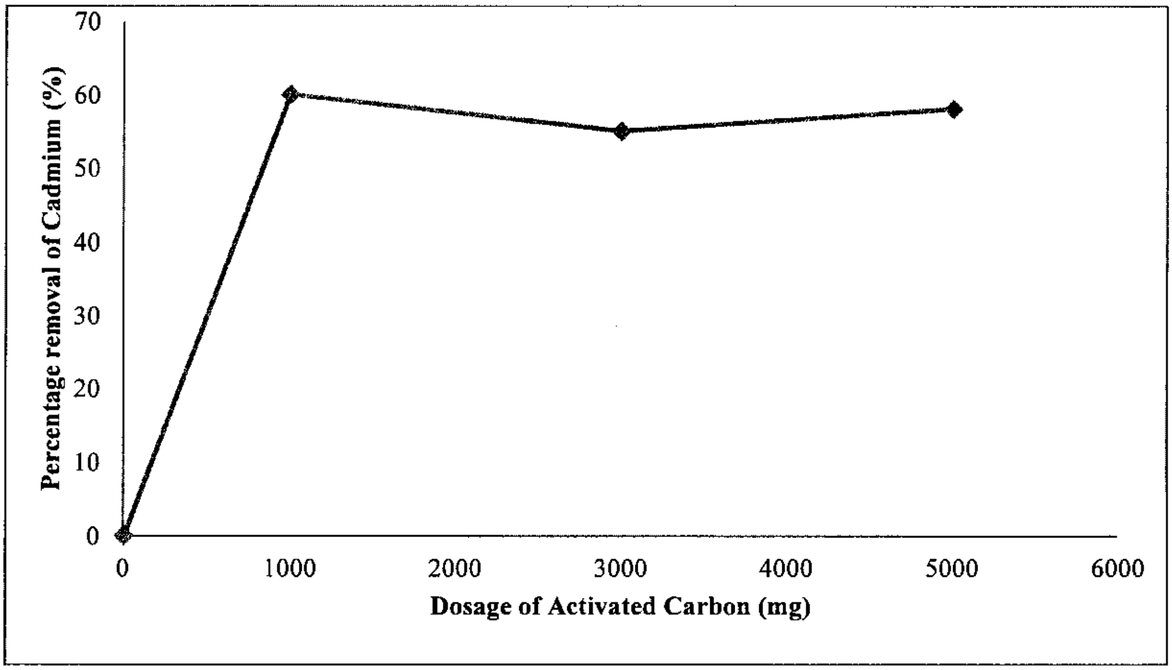

Figure 4.1 Removal Efficiency of Cadmium by Activated Carbon

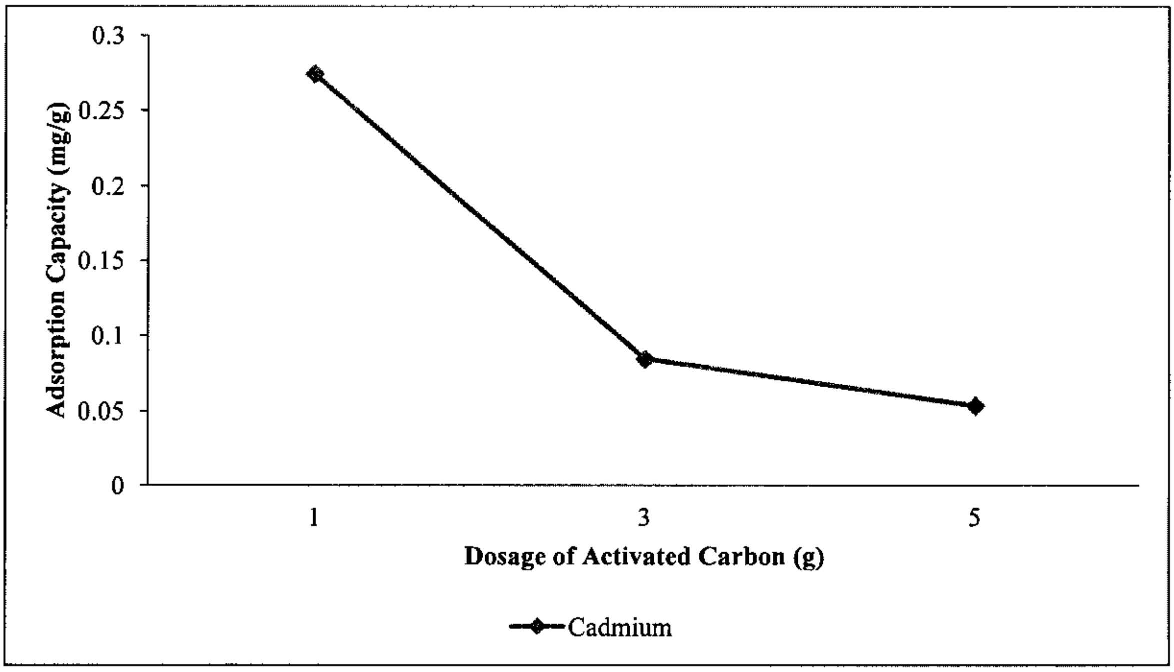

Figure 4.2 Adsorption Capacity Performance of Activated Carbon

Based on Figure 4.1, activated carbon from coconut coir is an effective adsorbent to remove the heavy metals from the industrial wastewater. The initial concentration of cadmium before added the adsorbent was 0.457 mg/L. The efficiency removal of cadmium for 1000 mg of the adsorbent was 60%. The concentration of cadmium reduced to 0.183 mg/L from the initial concentration. The treatment continue for 3000 mg of adsorbent. The percentage of the removal of cadmium was 55% from the initial concentration. For 5000 mg, the concentration of cadmium decreased to 0.190 mg/L with efficiency of 58%. The further increase of adsorbent create no increase in adsorption process. The adsorption capacity was determined by the dosages of the activated carbon. From Figure 4.2, the adsorption capacity of the activated carbon decreased with increasing dosages of activated carbon. That mean the adsorption process has achieved the equilibrium where the adsorption sites was overlapping. This was because of the particles in the adsorbent was overcrowding.

Table 4.3 shows the concentration of lead from the initial reading of concentration until the treatment process. Figure 4.3 shows the graph for performance of the activated carbon from coconut coir with different dosage.

Table 4.3 Concentration of Lead

	Initial Concentration	**Dosage of Activated Carbon**		
		1000 mg	**3000 mg**	**5000 mg**
Concentration of Lead (mg/L)	0.312	0.150	0.137	0.135

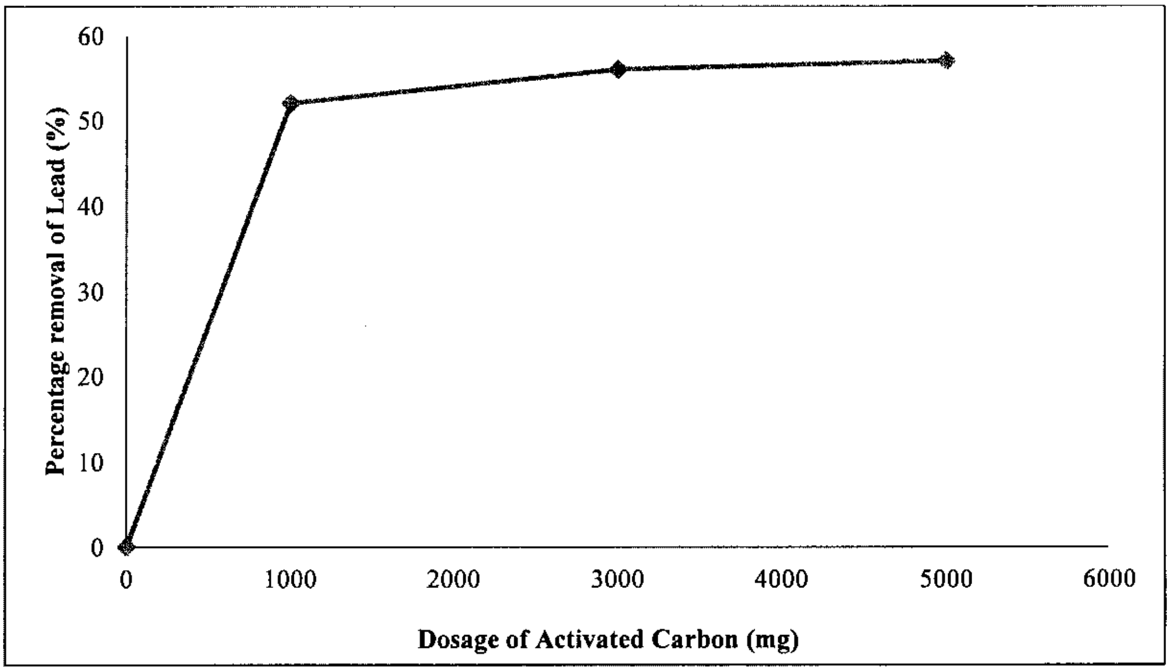

Figure 4.3 Removal Efficiency of lead by Activated Carbon

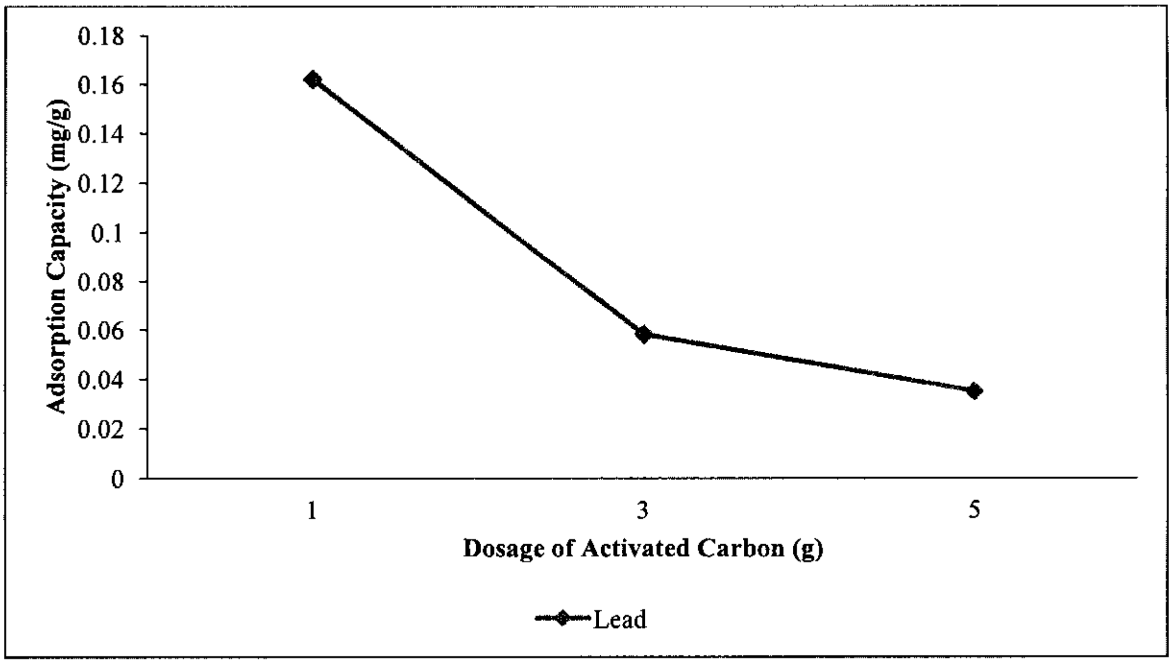

Figure 4.4 Adsorption Capacity Performance of Activated Carbon

Figure 4.3 shows the performance for coconut coir activated carbon in removing lead. Based on the graph, the performance of the activated carbon was efficiently removed the heavy metal of lead. This is because the removal efficiency of the lead been removed was increasing from time to time. The removal of lead was effective even using the minimum dosage of adsorbent. 1000 mg of adsorbent has effectively removed 52% of lead which was the initial reading of lead concentration was 0.312

mg/L. The treatment was tested with 3000 mg of adsorbent. The result shows the efficiency of 3000 mg of adsorbent can remove 56% of lead from the wastewater. The concentration of lead was decreased to 0.137 mg/L. As the treatment continued with 5000 mg of activated carbon, the concentration of lead was reducing constantly where it can remove 57% of lead. Figure 4.4 shows the capacity was decreased as the dosages of the activated carbon was increased. Same trend as in removing cadmium, the adsorption process remain constant after achieved the equilibrium adsorption. The surface of the activated carbon was decreased as further adsorption process.

4.4 Effect of pH on the Performance of Coconut Coir

The experiment was conducted with three different pH which were 2, 6 and 9. A constant time of 2 hours to allow the adsorption process with 1 Liter of industrial wastewater sample were tested. pH need to be controlled in adsorption of heavy metals. The test was conducted with 1000 mg of adsorbent. Based on the result, the removal each of the heavy metal has different value of pH for the adsorption process. The optimum adsorption process for cadmium was at pH of 6. At pH of 2, the result shows the optimum removal of lead from the wastewater. This was because the low concentration of lead present in the sample than cadmium. Different type of heavy metals need special condition to treat from the wastewater. Table 4.4 shows the concentration cadmium before and after treated with different pH values.

Table 4.4 Concentration of Cadmium

	Initial Concentration	**pH of wastewater**		
		2	**6**	**9**
Concentration of Cadmium(mg/L)	0.457	0.239	0.115	0.135

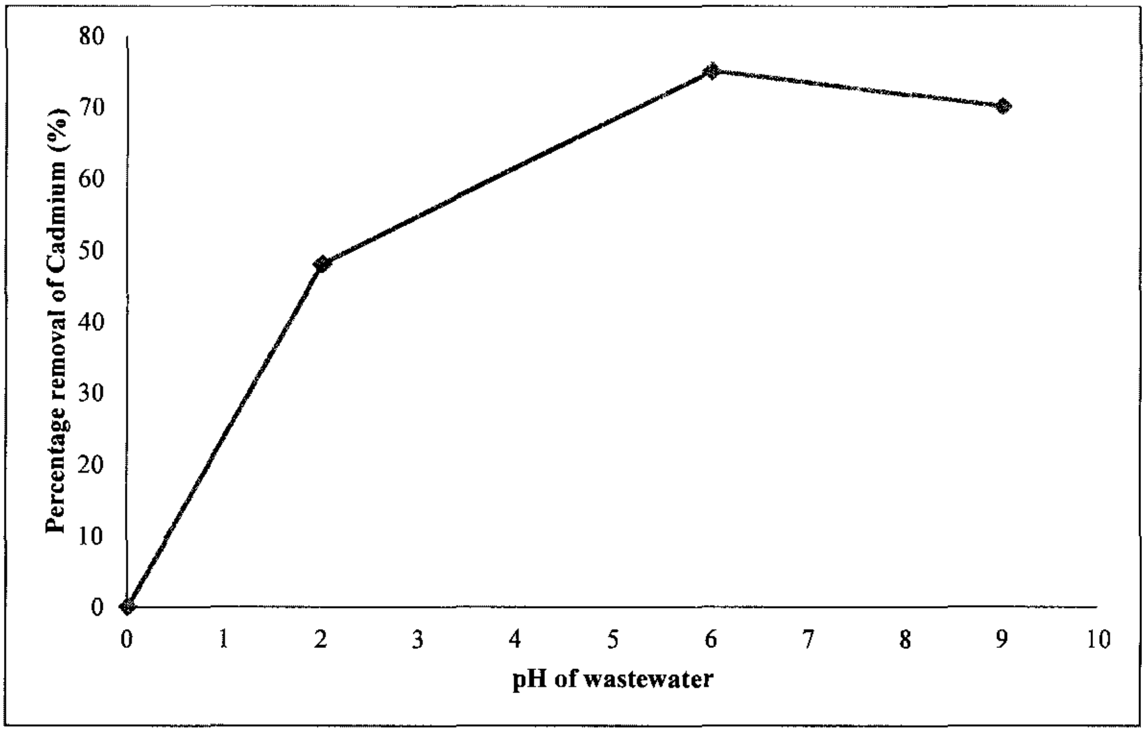

Figure 4.5 Removal Efficiency of Cadmium by Activated Carbon

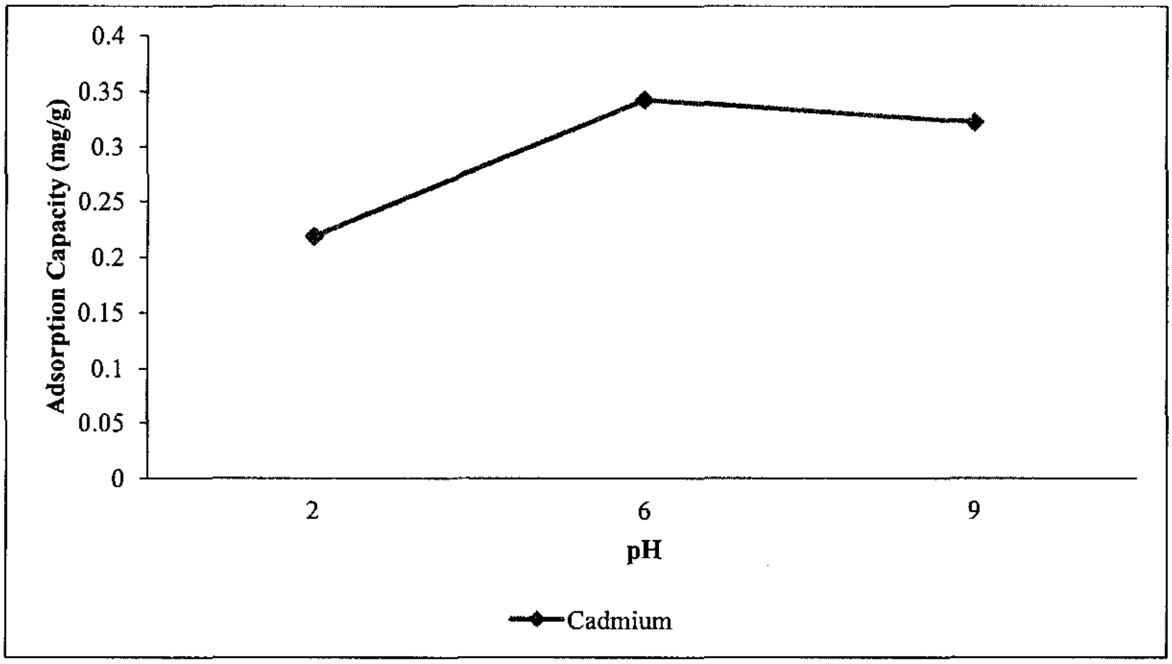

Figure 4.6 Adsorption Capacity Performance of Activated Carbon

Based on Figure 4.5, the performance of the activated carbon from coconut coir is efficient at pH 6. This result shows the activated carbon was effectively removed cadmium from the wastewater. At pH 2, the percentage removal of cadmium was 48%. When the pH of wastewater was increased to pH of 6, the percentage of cadmium also increasing to 74% from the initial concentration. This show the removal of cadmium was effective at pH 6. At pH 9, the removal of cadmium start to decrease. The percentage of cadmium was 70%. The initial concentration of cadmium present in the wastewater was 0.457 mg/L. At pH of 6, the concentration dropped to 0.115 mg/L, which was the highest percentage of cadmium removal. This is because pH is dependent. The binding of ions in the metal occurred due to the surface of the functional groups. Adsorption process was low at acidic condition. As the pH was increasing, the adsorption process also will increase. The optimum pH was at 6 because the adsorption sites released H^+ lead to exchanged of ion and complex mechanisms was formed. Adsorption process is slow at acidic and alkaline because the metal precipitate as hydroxides. From Figure 4.6, the adsorption capacity was efficient in adsorbing cadmium. This is because the adsorption capacity increased from 0.218 mg/g to 0.342 mg/g. The adsorption capacity for cadmium was low in acidic condition and increasing with increased of pH. The ability of the adsorption can determine from the graph in Figure 4.6 as the adsorption capacity increasing even in different pH of industrial wastewater.

Table 4.5 shows the concentration of lead from the initial reading of concentration until the treatment process. Figure 4.7 shows the performance of the activated carbon from coconut coir with different pH of wastewater while Figure 4.8 shows the graph for performance of activated carbon with different pH of industrial wastewater.

Table 4.5 Concentration of Lead

	Initial Concentration	**pH of wastewater**		
		2	**6**	**9**
Concentration of Lead (mg/L)	0.312	0.094	0.110	0.137

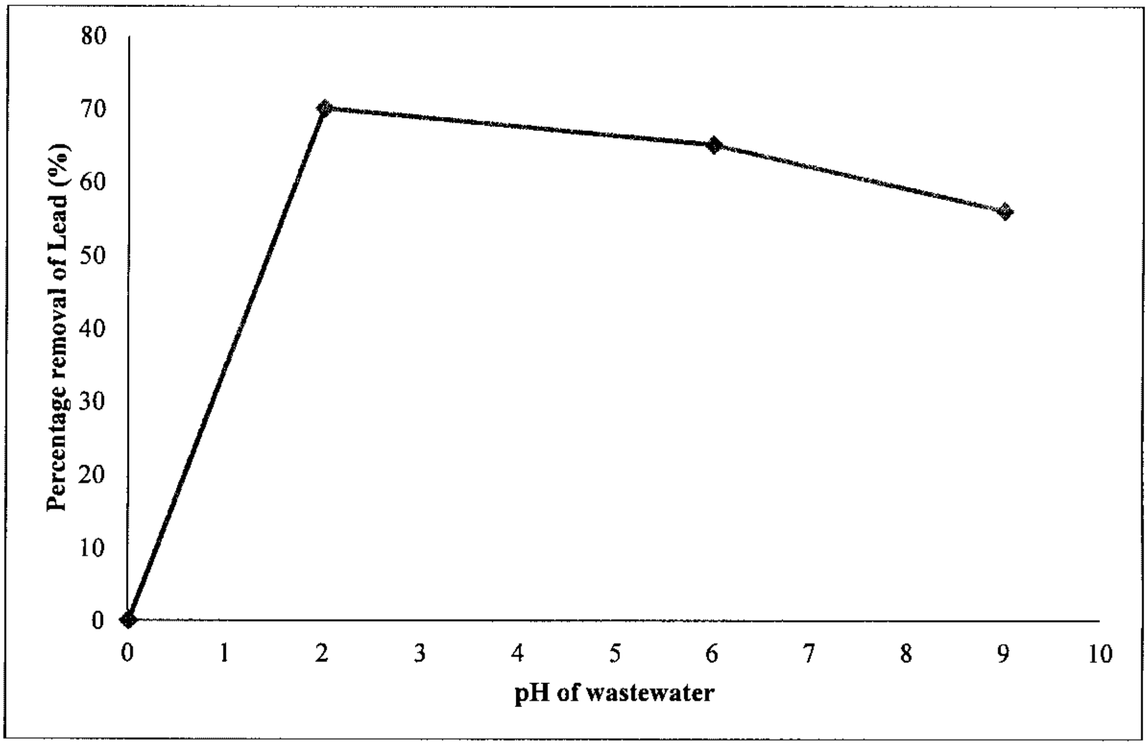

Figure 4.7 Removal Efficiency of Lead by Activated Carbon

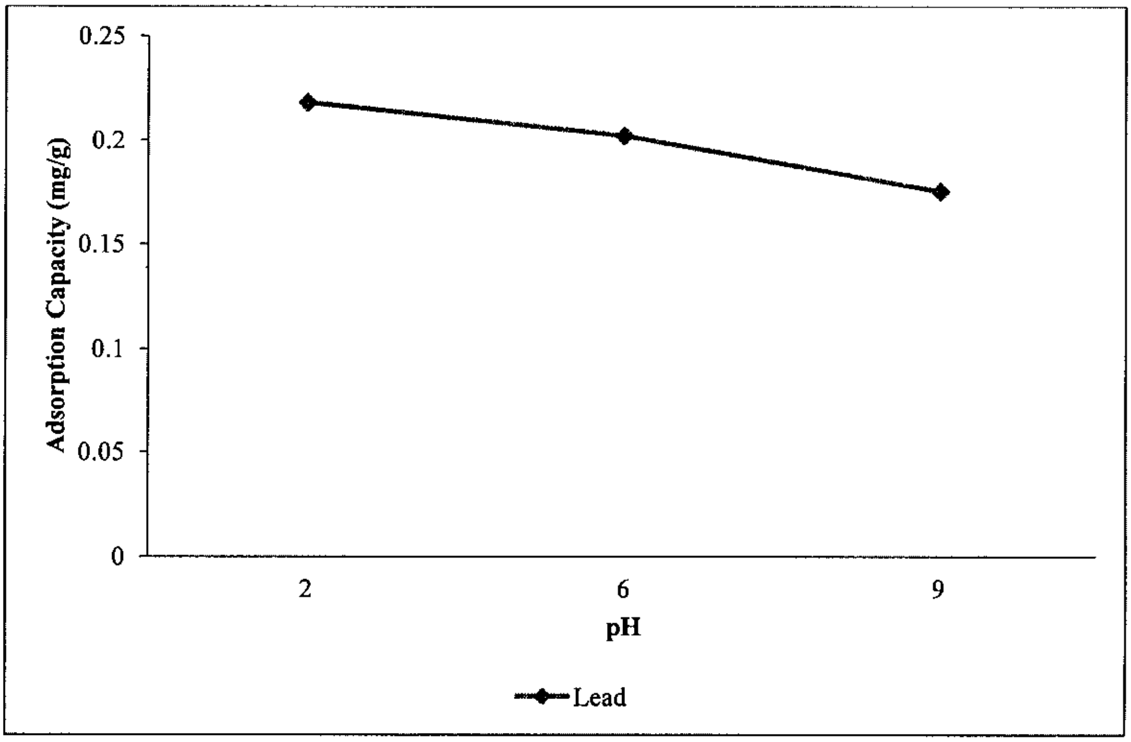

Figure 4.8 Adsorption Capacity Performance of Activated Carbon

Figure 4.7 shows the performance of activated carbon from coconut coir with different pH. The highest percentage removal of lead was 70% which at pH of 2. At pH 6, the percentage removal of lead was 65% where as at pH of 9 the removal was 56%.

At a low pH of wastewater, lead can be removed because the concentration of lead present in the wastewater was low than other heavy metals. The optimum pH to remove lead from wastewater was at acidic condition. From the results, the higher the pH, the higher the percentage of metal ions removed. This was because the surface of the adsorbent was deprotonated and negatively charge. Hence, the attraction among the positive ions occurred. Based on Figure 4.8, the adsorption capacity was higher which was able to absorb 0.218 mg/g lead from the wastewater. This is because lead was effectively removed in acidic condition at pH 2. As the pH increased, the adsorption capacity was decreased because all the lead was effectively removed.

4.5 Langmuir Isotherm

Figure 4.9 shows the Langmuir isotherm performance by activated carbon from coconut coir while Table 4.6 shows the results obtained for the Langmuir isotherm parameters.

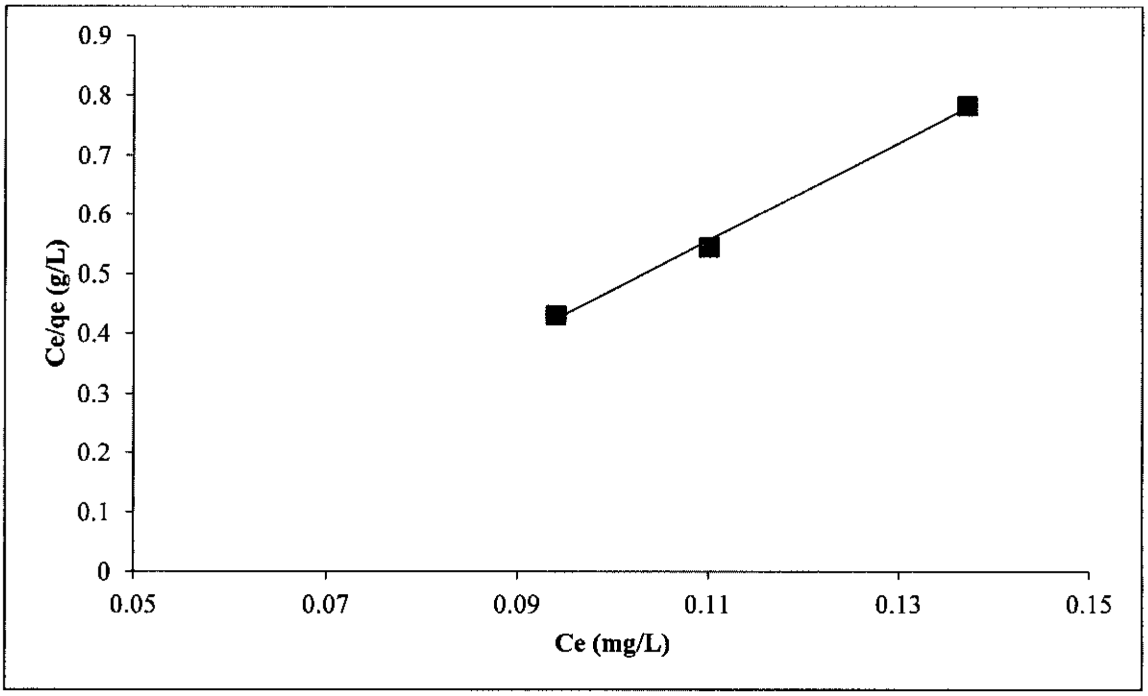

Figure 4.9 Performance of Activated Carbon using Langmuir Isotherm

The results obtained from Figure 4.9 and Table 4.6 showed that the linear equation of the Langmuir isotherm was $y = 9.795x + 0.05$. The values were obtained from the graph in Figure 4.9. From the results, the data were valid and fitted in Langmuir model. The value calculated was the proves the Langmuir adsorption was favourable. This is because the $R_L$value which was 0.611 was between the range.

Table 4.6 Langmuir Isotherm for Lead Adsorption by Activated Carbon

Q_o	b	R_L
9.795	2.042	0.611

CHAPTER 5

CONCLUSION

5.1 Introduction

In the present study, the performance of coconut coir in removing heavy metals from industrial wastewater was explored. From this study, the objectives were achieved. The following conclusions are drawn from the results obtained from the study :

1. The results of characteristics wastewater was shown the reading for parameter of heavy metals were very high at the initial. Before treatment, the reading for cadmium and lead were 0.457 mg/L and 0.312 mg/L respectively. This industrial wastewater need to be treated before the heavy metals bring harm to the human's life and eco-system.

2. Based on the results, objective two was achieved by obtaining the optimum dosage of 1000 mg activated carbon to remove the heavy metals from industrial wastewater. A minimum dosage of 1000 mg can effectively remove the heavy metals with average maximum adsorption capacity of 0.249 mg/g.

3. The effective to remove cadmium with 2 hours of contact time was at pH 6 while lead was at pH of 2. The adsorption capacity recorded from cadmium and lead was 0.342 mg/g and 0.218 mg/g respectively.

As a conclusion, coconut coir can be used to treat the industrial wastewater. Nowadays, there are various kind of conventional method to treat the wastewater which are expensive and difficult to conduct. From this study, the results and discussion have shown that coconut coir gives many advantages in treating the wastewater. It was the cheapest method to be used. The efficiency to remove the heavy metals from the industrial wastewater was effectively removed. Coconut coir is a good adsorbent to carry the adsorption process.

5.2 Recommendation

Recommendations for further studies are as follows:

1. Further studies on other parameter of activated carbon from coconut coir such as the size of the adsorbent.

2. The equipments in the laboratory must be maintained to keep the equipments in a good condition for the best result of the experiments.

3. The wastewater collected from the source must be preserved to maintain the characteristics of the wastewater for next experiments.

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APPENDIX A
TEMPLATE OF DATA COLLECTION

OBJECTIVE 1

Volume of industrial wastewater : 1 Liter   Contact time : 2 hours

Temperature : 28.6 °C

Parameters	**Reading**
pH	
Temperature (°C)	
Biological Oxygen Demand (BOD) (mg/L)	
Chemical Oxygen Demand (COD) (mg/L)	
Total Suspended Solids (TSS) (mg/L)	
Ammoniacal Nitrogen (mg/L NH_3-N)	
Heavy Metals Cadmium (mg/L) Lead (mg/L)	

OBJECTIVE 2

Volume of industrial wastewater : 1 Liter pH: 2

Temperature : 28.6 °C Contact time : 2 hours

	Initial Concentration	Dosage of Activated Carbon		
		1000 mg	3000 mg	5000 mg
Concentration of Cadmium (mg/L)				
Concentration of Lead (mg/L)				

OBJECTIVE 3

Volume of industrial wastewater : 1 Liter Contact time : 2 hours

Temperature : 28.6 °C

	Initial Concentration	pH of wastewater		
		2	6	9
Concentration of Cadmium (mg/L)				
Concentration of Lead (mg/L)				