THE EFFECTIVENESS OF ACTIVATED CARBON FROM COCONUT SHELL AS WASTEWATER POLLUTANT REMOVAL

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A thesis submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Civil Engineering

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NOVEMBER 2010

ABSTRACT

Nowadays, water quality has become the popular issue as best quality water is needed for their daily lives. There are many types of treatment to improve water quality and one of them is by using activated carbon. The purpose of this study is to identify the effectiveness of activated carbon from coconut shell as wastewater pollutant removal. The needs to identify the most effective and suitable characteristics of activated carbon are important because it defines the best alternative and at the same its efficiency in wastewater treatment. To identify the effectiveness of activated carbon, the wastewater samples were checked for influent and effluent wastewater. Samples were taken from drainage systems near Kolej Kediaman 3 before the domestic wastewater was discharged to the near river. The wastewater samples then were treated using activated carbon with different size (granular, powdered) and quantity (50g, 100g, and 200g). After analyzing the water quality based on seven parameters, all of samples (G50, G100, G200, P50, P100, and P200) showed the improvement in removing wastewater pollutant due to its removal efficiency. Among of the six samples, powdered activated carbon of 200g (P200) gave the most effective results compared to other samples due to its highest removal efficiency. From the result obtained, it showed that activated carbon have potentials to be used as a filter medium in removing wastewater pollutant. This study had also lead to many recommendations in order to improve the potential of activated carbon as a wastewater pollutant removal.

ABSTRAK

Kebelakangan ini, kualiti air telah menjadi isu yang hangat kerana kualiti air yang baik diperlukan untuk kegunaan seharian. Tujuan dari kajian ini adalah untuk mengenalpasti keberkesanan karbon teraktif dari tempurung kelapa sebagai penyingkiran sisa pencemaran. Terdapat banyak jenis rawatan untuk meningkatkan kualiti air dan salah satu daripadanya menggunakan karbon teraktif. Tujuan kajian ini adalah untuk mengenal pasti keberkesanan karbon teraktif daripada kulit kelapa sebagai penyingkir pencemaran. Keperluan untuk mengetahui ciri-ciri karbon teraktif yang paling berkesan dan sesuai sangat penting kerana ia menerangkan alternatif yang terbaik dan juga keberkesanannya dalam rawatan air buangan. Untuk mengenalpasti keberkesanan karbon teraktif, sampel air sisa diperiksa sebelum dan selepas air sisa dirawat. Sampel diambil dari sistem longkang berhampiran Kolej Kediaman 3 sebelum air sisa domestik mengalir ke sungai berhampiran. Sampel air sisa kemudian dirawat menggunakan karbon teraktif yang pelbagai saiz (butiran, serbuk) dan kuantiti 50g, 100g, dan 200g). Setelah kualiti air dianalisa menggunakan tujuh parameter, kesemua sample (G50, G100, G200, P50, P100, dan P200) telah menunjukkan peningkatan dalam menyingkirkan pencemaran air sisa berdasarkan kecekapan penyisihan. Diantara enam sampel, karbon teraktif serbuk sebanyak 200g (P200) memberikan keputusan yang paling efektif berbanding sampel-sampel yang lain berdasarkan kecekapan penyisihan tertinggi. Daripada keputusan yang diperoleh, dapat ditunjukkan bahawa karbon aktif berpotensi untuk digunakan sebagai media penapis dalam menghilangkan sisa pencemaran air. Penyelidikan ini juga memberi banyak cadangan dalam usaha meningkatkan potensi karbon teraktif sebagai penyingkiran sisa pencemaran.

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AC	Activated Carbon
COD	Chemical Oxygen Demand
BOD	Biochemical Oxygen Demand
TSS	Total Suspended Solid
AN	Ammonia Nitrogen
EQA 1974	Environmental Quality Act 1974
UMP	Universiti Malaysia Pahang
KK3	Kolej Kediaman 3
G50	Granular Activated Carbon of 50 gram
G100	Granular Activated Carbon of 100 gram
G200	Granular Activated Carbon of 200 gram
P50	Powdered Activated Carbon of 50 gram
P100	Powdered Activated Carbon of 100 gram
P200	Powdered Activated Carbon of 200 gram
NTU	Nephelometric Turbidity Units
Mg/L	Miligram per Litre

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CHAPTER 1

INTRODUCTION

1.1 General

Water is a common chemical substance that is essential to all known forms of life. Availability of water for cleansing is directly to control or elimination of disease. While the world's population tripled in the 20^{th} century, the use of renewable water resources has grown six-fold. Within the next fifty years, the world population will increase by another 40 to 50%. This population growth, coupled with industrialization and urbanization will result in an increasing demand for water and will have serious consequences on the environment (World Water Council, 2008).

Water covers about two-thirds of the earth's surface. But most is too salty for use. Only 2.5% of the world's water is not salty, and two-thirds of that is locked up in the icecaps and glaciers (Wikipedia, 2010).

Water pollution is a major problem in global context. It has been suggested that it is the leading worldwide cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily. An estimated 700 million Indians have no access to a proper toilet, and 1,000 Indian children die of diarrhea sickness every day. Some 90% of China cities suffer from some degree of water pollution, and nearly 500 million people lack access to safe drinking water. In addition to the acute problems of water developing countries, industrialized countries continue to struggle with pollution problems as well. In the most recent national report on water quality in the United States, 45% of assessed stream miles, 47% of assessed lake acres, and 32% of assessed bay and estuarine square miles were classified as polluted (Wikipedia, 2010).

Activated carbons can be produced from virtually any type of carbonaceous materials such as coconut shell, palm shell, nut shell, olive stones, oil-palm stones, agricultural wastes, and many others. The preparation of activated carbon generally involves two steps: carbonization of the raw material in the absence of oxygen and activation of the carbonized products with water and/or CO_2. Volatile matters are released in the carbonization step, and the remaining solid carbon structure is generally called as char. In the following activation step, char reacts with activating agents to form activated carbon (AC) with improved pore structure and surface properties. However, well-tailored activated carbon for specific application and having a specific surface area of 500 m^2 g^{-1} or larger cannot be easily obtained by simply carbonizing the carbonaceous materials or biomass above, and because of its ready availability and stability in production, much has been done on coal for the industrial production of activated carbon (Zhang et al, 2007).

Nowadays, water quality has become the popular issue in this worldwide. A lot of people need the best quality of water for their daily lives. Therefore, it needs treatment to make it safe for human and all living things in this world. There are many types of treatment that can improve water quality. One of the treatments is using activated carbon as a wastewater pollutant removal. Activated carbon comes from many types like saw dust, rice husk, wood, coconut shell and other but, this study will focusing more on activated carbon from coconut shell.

1.2 Problem Statement

Water pollution is a major problem in the global context. It has been suggested that it is the leading worldwide cause of death and diseases. One way to reduce water pollution is by using activated carbon for wastewater treatment.

There are many types or characteristics of activated carbon used in previous study. The needs to identify the most effective and suitable characteristics of activated carbon is important because it can produce the best result and at the same time give the best effectiveness of wastewater treatment.

1.3 Objectives

The main objectives of this study are:

1. To produce activated carbon from coconut shell.
2. To determine the effectiveness of activated carbon using coconut shell as wastewater pollutant removal.
3. To choose the most suitable and effective characteristics of activated carbon from coconut shell as wastewater pollutant removal.

1.4 Scope of Study

Scope of study can be listed as follows:-

i. Water samples were taken from effluent domestic wastewater near Café KK3.

ii. The water samples were analyzed in Environmental Laboratory FKASA at Universiti Malaysia Pahang to determine their characteristic based on the water quality parameters; Biochemical Oxygen Demand, Chemical Oxygen

Demand, pH, Total Suspended Solid, Turbidity, Oil and Grease, and Ammonia Nitrogen.

iii. The activated carbon is produce using coconut shell by activation process.

iv. The water samples are treated using activated carbon to identify their effectiveness and performances.

1.5 Location of study

The location of study at Kolej Kediaman 3, Universiti Malaysia Pahang (UMP), Gambang, Pahang Darul Makmur. Water samples were taken at effluent of open drainage system KK3. The water samples then treated through a filtration system by using water filter. The location of study is shown in Figure 1.1 and Figure 1.2.

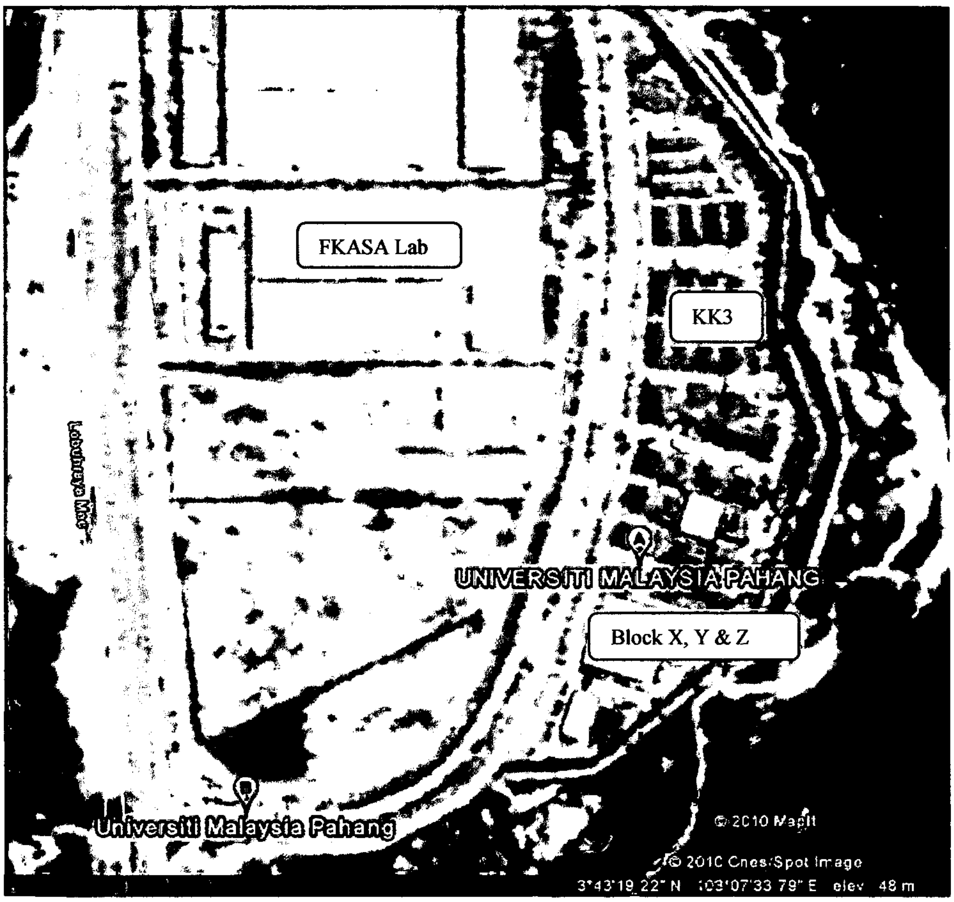

Figure 1.1: Universiti Malaysia Pahang Map

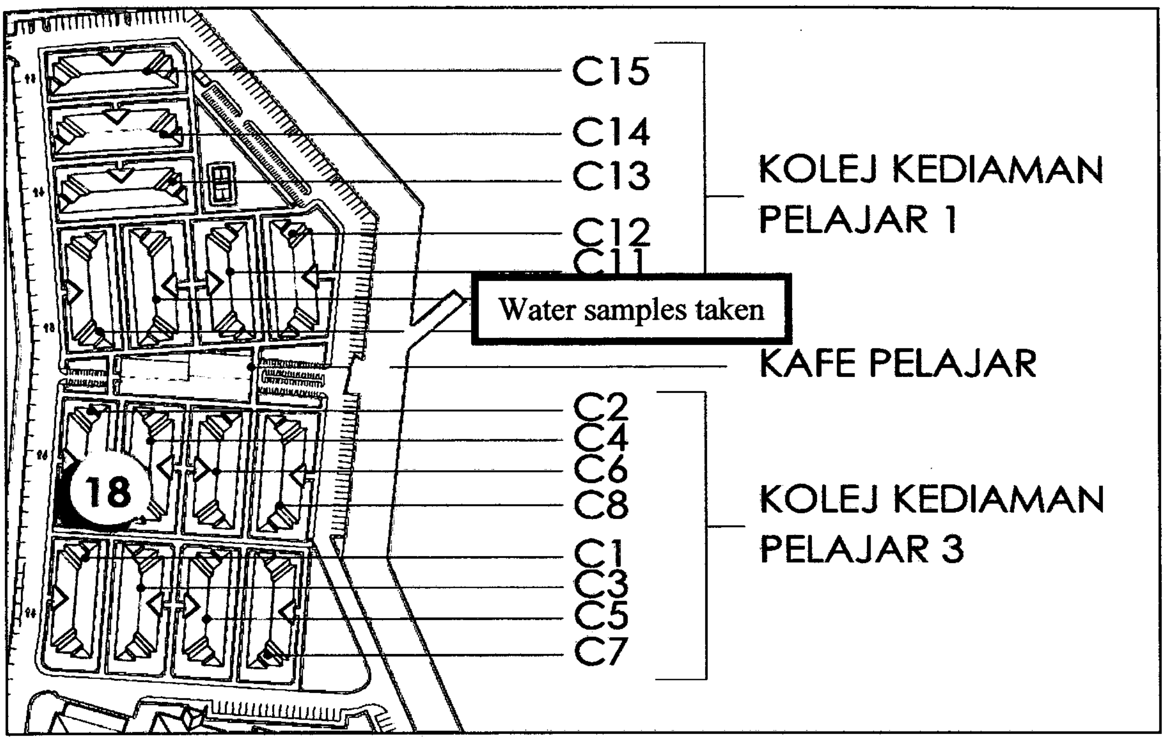

Figure 1.2: Location of study area

1.6 Significant of Study

One of the used of activated carbon using coconut shell is to remove wastewater pollutant. It is beneficial to our industry because it can improve water quality. When water quality is improved, it is safe for living things especially human being use the water to drinks, bath, and so on. Other than that, there is a lot application of activated carbon using coconut shell such as used in gas purification, gold purification, metal extraction, water purification, medicine, sewage treatment, air filters in gas masks and filter masks, filters in compressed air and many other applications. But in this study, it is focus in wastewater samples taken from effluent of domestic wastewater near Cafe KK3 (Kolej Kediaman 3), University Malaysia Pahang (UMP) as a sample to remove wastewater pollutant. To choose the most suitable and effective characteristics of activated carbon from coconut shell as wastewater pollutant removal, the size of activated carbon has to be prioritized. The size of activated carbon like Granular Activated Carbon (minimum 0.297 mm) and Powdered Activated Carbon (0.177 mm and below) was included in this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review explains all the information and relevant data regarding this research and briefly discussed and supported with all articles reviews extracted from journals, references book, thesis, e-book, internet articles and other relevant sources.

2.2 Water Pollution

Water pollution is a major problem in the global context. It has been suggested that it is the leading worldwide cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily. An estimated 700 million Indians have no access to a proper toilet, and 1,000 Indian children die of diarrhea sickness every day. Some 90% of China's cities suffer from some degree of water pollution, and nearly 500 million people lack access to safe drinking water. In addition to the acute problems of water pollution in developing countries, industrialized countries continue to struggle with pollution problems as well. In the most recent national report on water quality in the United States, 45 percent of assessed stream miles, 47 percent of assessed lake acres, and 32 percent of assessed bay and estuarine square miles were classified as polluted (Wikipedia, 2010).

2.2.1 Types of Pollution

Surface water and groundwater have often been studied and managed as separate resources, although they are interrelated. Sources of surface water pollution are generally grouped into two categories based on their origin (Wikipedia, 2010).

2.2.1.1 Point source pollution

Point source pollution refers to contaminants that enter a waterway through a discrete conveyance, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain. The U.S. Clean Water Act (CWA) defines point source for regulatory enforcement purposes. The CWA definition of point source was amended in 1987 to include municipal storm sewer systems, as well as industrial storm water, such as from construction sites (Wikipedia, 2010).

2.2.1.2 Non-point source pollution

Non-point source pollution refers to diffuse contamination that does not originate from a single discrete source. NPS pollution is often accumulative effect of small amounts of contaminants gathered from a large area. The leaching out of nitrogen compounds from agricultural land which has been fertilized is a typical example. Nutrient runoff in storm water from "sheet flow" over an agricultural field or a forest is also cited as examples of NPS pollution (Wikipedia, 2010).

2.2.2 Causes of Pollution

Many causes of pollution including sewage and fertilizers contain nutrients such as nitrates and phosphates. In excess levels, nutrients over stimulate the growth of aquatic plants and algae. Excessive growth of these types of organisms consequently clogs our waterways, use up dissolved oxygen as they decompose, and block light to deeper waters. This, in turn, proves very harmful to aquatic organisms as it affects the respiration ability or fish and other invertebrates that reside in water (Krantz and Kifferstein, 1997).

Pollution is also caused when silt and other suspended solids, such as soil, wash off plowed fields, construction and logging sites, urban areas, and eroded river banks when it rains. Under natural conditions, lakes, rivers, and other water bodies undergo Eutrophication, an aging process that slowly fills in the water body with sediment and organic matter. When these sediments enter various bodies of water, fish respiration becomes impaired, plant productivity and water depth become reduced, and aquatic organisms and their environments become suffocated. Pollution in the form of organic material enters waterways in many different forms as sewage, as leaves and grass clippings, or as runoff from livestock feedlots and pastures. When natural bacteria and protozoan in the water break down this organic material, they begin to use up the oxygen dissolved in the water. Many types of fish and bottom-dwelling animals cannot survive when levels of dissolved oxygen drop below two to five parts per million. When this occurs, it kills aquatic organisms in large numbers which leads to disruptions in the food chain (Krantz and Kifferstein, 1997).

2.2.3 Classifying Water Pollution

The major sources of water pollution can be classified as municipal, industrial, and agricultural. Municipal water pollution consists of waste water from homes and commercial establishments. For many years, the main goal of treating municipal wastewater was simply to reduce its content of suspended solids, oxygen-demanding materials, dissolved inorganic compounds, and harmful bacteria. In recent years, however, more stress has been placed on improving means of disposal of the solid residues from the municipal treatment processes. The basic methods of treating municipal wastewater fall into three stages: primary treatment, including grit removal, screening, grinding, and sedimentation; secondary treatment, which entails oxidation of dissolved organic matter by means of using biologically active sludge, which is then filtered off; and tertiary treatment, in which advanced biological methods of nitrogen removal and chemical and physical methods such as granular filtration and activated carbon absorption are employed. The handling and disposal of solid residues can account for 25 to 50 percent of the capital and operational costs of a treatment plant. The characteristics of industrial waste waters can differ considerably both within and among industries. The impact of industrial discharges depends not only on their collective characteristics, such as biochemical oxygen demand and the amount of suspended solids, but also on their content of specific inorganic and organic substances. Control can take place at the point of generation in the plant; wastewater can be pretreated for discharge to municipal treatment sources; or wastewater can be treated completely at the plant and either reused or discharged directly into receiving waters (Krantz and Kifferstein, 1997).

2.3 Wastewater and Treatment

Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources. Wastewater or sewage can come from human waste, septic tank discharge, sewage treatment plant discharge, washing water such as personal, clothes, floors, and dishes, rainfall collected on roofs, yards, and hard-standings, groundwater infiltrated into sewage, urban rainfall runoff from roads, car parks, roofs, sidewalks, or pavements, seawater ingress, highway drainage, storm drains, industrial waste, industrial site drainage such as silt, sand, alkali, oil, and chemical residues. The composition of wastewater varies widely. The partial lists of what it may contain are water (> 95%) which is often added during flushing to carry waste down a drain, pathogens such as bacteria, viruses, and parasitic worms, non-pathogenic bacteria(> 100,000 / ml for sewage), organic particles such as food, vomit, paper fibers, plant material, and humus, soluble organic material such as urea, fruit sugars, soluble proteins, drugs, and pharmaceuticals, inorganic particles such as sand, grit, metal particles, and ceramics (Wikipedia, 2010).

Raw sewage includes waste from sinks, toilets, and industrial processes. Treatment of the sewage is required before it can be safely buried, used, or released back into local water systems. In a treatment plant, the waste is passed through a series of screens, chambers, and chemical processes to reduce its bulk and toxicity. The three general phases of treatment are primary, secondary, and tertiary. During primary treatment, a large percentage of the suspended solids and inorganic material is removed from the sewage. The focus of secondary treatment is reducing organic material by accelerating natural biological processes. Tertiary treatment is necessary when the water will be reused; 99 percent of solids are removed and various chemical processes are used to ensure the water is as free from impurity as possible (Krantz and Kifferstein, 1997).

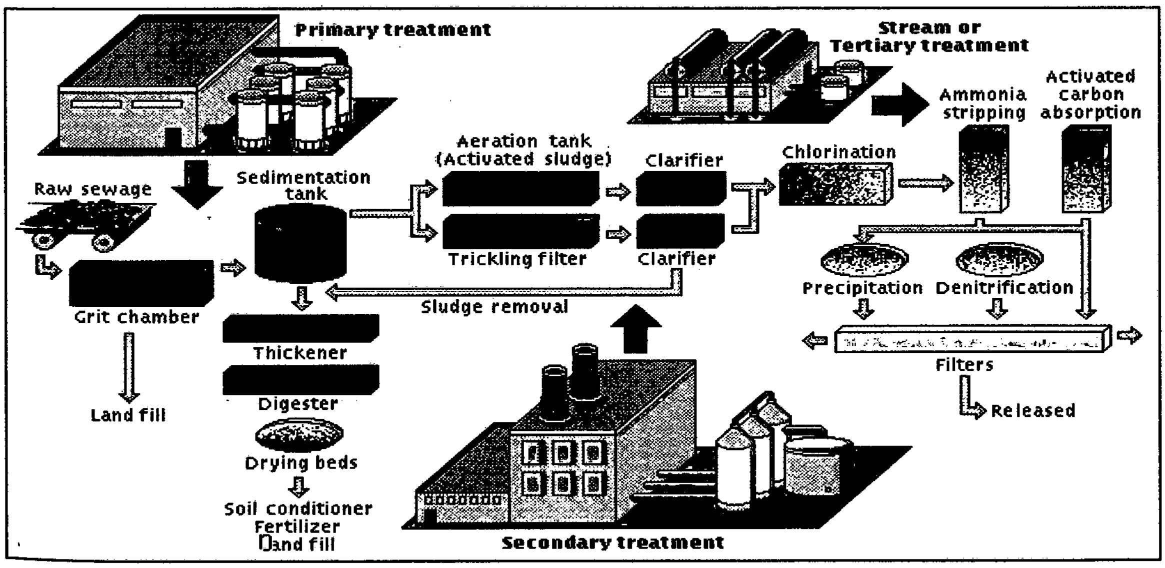

Figure 2.1: Flow treatment of wastewater systems (Krantz and Kifferstein, 1997)

2.4 Early History of Water Treatment

The term water treatment is widely understood as the step taken to purify water for drinking (potable) or industrial purposes. The process include are mainly physical and chemical while wastewater and sewerage are mostly applied biological treatment.

Traditionally, settlement has been the main method of clarifying water. In ancient times, the Egyptians treated the drinking water by keeping it in large containers to settle out the sediment to make water look and taste better (Darshan Singh Sarai, 2006).

Filtrations were also first practiced in ancient's time. It seems that the earliest example was infiltration wells dug on river bank and seashores. Riverside wells could be deemed to be an example of cross flow filtration in that the solid filtration in that the solid filtered out are carried on their way by the flow of river. Such infiltration wells date back to Roman times. The technology has been revived in recent years with shore wells being used as a source of clean water for reverse osmosis desalination plants (Stevenson, 1997).

In Greece, Hippocrates, the father of medicine, around 400 B.C found water as the carrier of water borne disease and suggested its boiling and cloth filtering to make it safe to drink. These ideas were the foundation for present day sedimentation, disinfection, and filtration, which are the three major phases of water treatment. Currently, water treatment is becoming more sophisticated for an effective removal of pathogens and harmful chemicals (Darshan Singh Sarai, 2006).

2.5 Activated Carbon

Activated carbon has been widely used in many fields, and can be produced from a variety of carbonaceous source materials. Coconut shell is suitable for preparing microporous activated carbon due to its excellent natural structure and low ash content. Activated carbon can be produced by chemical activation or physical activation. In chemical activation, problems concerning corrosion, wastewater treatment and production cost prohibited further development of this technology. Physical activation with steam or COz as activation agent is simple in process, which does not produce wastewater. However, using this approach, the overall yield of an activated carbon (surface area about 1000m2.g-') from coconut shell is about 8% (by mass). Air activation is economically attractive for its high yield, overall short activation time and low energy cost, but it is not often used as the high reactivity is very difficult to control. However, it has been shown that the high reactivity can be restrained under some condition. In the three-step process, charcoal needs to be heated to high temperature twice which means much energy is to be consumed and it needs several hours to be cooled down to the oxygenation temperature from the high carbonization temperature before the charcoal is Oxygenated (Su Wei et al, 2006).

Activated carbon is often used as a filter in water treatment systems, where water is directed downwards through a stationary bed of activated carbon, leaving organic material to accumulate at the top of the bed. Activated carbon is similarly used to lower radon level in water (John, 2003).

Activated carbon, is a form of carbon that has been processed to make it extremely porous and thus to have a very large surface area available for adsorption or chemical reactions. The word *activated* in the name is sometimes replaced with *active*. Due to its high degree of microporosity, just one gram of activated carbon has a surface area in excess of 500 m^2, as determined typically by nitrogen gas adsorption. Sufficient activation for useful applications may come solely from the high surface area, though further chemical treatment often enhances the adsorbing properties of the material. Activated carbon is usually derived from charcoal (Wikipedia, 2010).

2.5.1 Types of Activated Carbon

Normally, two types of activated carbon use which were, formed activated carbon (FAC) and granular activated carbon (GAC). Granular activated carbon is common in water treatment and very effective for micro-pollutant removal. While FAC is different in shape which is cylindric shape and effects better hydraulic condition and pore size distribution compared to GAC (John, 2003).

However, according to (Acardio et al, 2003), there were three types of activated carbon which are powder formed called powdered activated carbon (PAC), granular form called granular activated carbon (GAC), and activated carbon fiber (ACF).

2.5.1.1 Granular Activated Carbon (GAC)

It is defined as a highly porous adsorbent material, produced by heating organic matter, such as coal, wood and coconut shell, in the absence of air, which is then crushed into granules. Activated carbon is positively charged and therefore able to remove negative ions from the water such as ozone, chlorine, fluorides and dissolved organic solutes by absorption onto the activated carbon. The activated carbon must be replaced periodically as it may become saturated and unable to absorb. Activated carbon is not effective in removing heavy metals. Activated carbon is often used as a filter in water treatment systems, where water is directed downwards through a stationary bed of activated carbon, leaving organic material to accumulate at the top of the bed. Activated carbon is similarly used to lower radon levels in water. Also available in powdered form (Green Facts, 2007).

According to Wikipedia, Granular activated carbon has a relatively larger particle size compared to powdered activated carbon and consequently, presents a smaller external surface. Diffusion of the adsorbate is thus an important factor. These carbons are therefore preferred for all adsorption of gases and vapours as their rate of diffusion are