TREATMENT OF POLLUTED WATER (RIVER) BY USING ACTIVATED CARBON FROM COIR PITH

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ABSTRACT

Coconut coir pith waste is a highly porous by product generated during separation of coconut fibers from its shell. Its accumulation in fiber production units causes problem of disposal and environmental pollution. Due to its highly porous structure and fixed carbon content, it has been tried as a raw material for the production of activated carbon (AC). A physical activation method has been implemented to produce activated carbon from cleaned coconut coir pith. The coir pith has been put in the small porcelain with lid and burned in the furnace with temperature range of 500°C for 2 hours. The activated carbon then impregnated with acid sulphuric and distilled water to balance the pH value. The AC divided into two sizes which is Granular Activated Carbon (GAC) and Powdered Activated Carbon (PAC). AC was characterized with SEM and particle size analysis. The SEM pictures of activated carbon particles showed enlargement of pore volume. The polluted water was taken from Sg Galing, Kuantan and all eleven parameters has been tested which are pH, turbidity, Total Coliform, Total Dissolve Solids, COD, BOD_5, Total Suspended Solid, iron, zinc, chromium and cuprum. All the parameters were compared with Malaysia Drinking Water Quality Standard. Sg Galing treated with GAC and PAC show decrement in iron, zinc, chromium and cuprum concentration. According to Malaysia Standard, the water is safe to be used for drinking.

ABSTRAK

Sisa sabut kelapa merupakan bahan buangan berliang yang terhasil daripada pemisahan kulit dan tempurung kelapa. Pengumpulan sisa sabut kelapa di dalam industri pengeluaran menyebabkan masalah pembuangan dan pencemaran terhadap alam sekitar. Merujuk kepada juzuknya yang berliang dan mengandungi kadar karbon yang tinggi, sabut kelapa telah digunakan sebagai bahan mentah untuk menghasilkan karbon teraktif. Kaedah aktiviti fizikal telah dilaksanakan untuk menghasilkan karbon teraktif yang terhasil daripada sabut kelapa yang bersih. Sabut kelapa telah diletakkan ke dalam porselin kecil yang bertutup dan dibakar ke dalam ketuhar dalam jangka suhu 500°C selama 2 jam. Karbon teraktif dibasuh dengan asild sulfurik dan air suling untuk menyeimbangkan nilai pH. Karbon teraktif dibahagikan kepada dua saiz iaitu butiran karbon teraktif (GAC) dan serbuk karbon teraktif (PAC). Ciri - ciri karbon teraktif telah dianalisis melalui ujian SEM dan analisis saiz zarah. Gambarajah SEM telah menunjukkan pembesaran saiz karbon teraktif. Sampel air iaitu Sungai Galing merupakan sungai yang tercemar di daerah Kuantan telah diuji dengan beberapa ujian iaitu pH, kekeruhan, jumlah bakteria berbahaya, jumlah bahan terlarut, keperluan oksigen kimia, keperluan oksigen biokimia, jumlah bahan terampai, besi, zink, kromium dan tembaga. Semua parameter telah dibandingkan dengan Standard Kualiti Air Minum Malaysia. Sungai Galing yang telah dirawat menggunakan butiran karbon teraktif (GAC) dan serbuk karbon teraktif (PAC) telah menunjukkan penurunan nilai besi, zink, kromium dan tembaga di dalam kandungan air. Merujuk kepada Standard Kualiti Air Minum Malaysia, air sungai yang telah dirawat selamat untuk digunakan.

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$ZnCl_2$	-	Zinc chloride
H_3PO_4	-	Acid phosphoric
HCl	-	Acid hydrochloric
NaOH	-	Natrium hidroxide
Fe	-	Ferum
Mn	-	Manganese
Pb	-	Plumbum/Lead
Zn	-	Zinc
Cu	-	Cuprum
Cd	-	Cadmium
Cr	-	Chromium
SEM	-	Scanning Electron Microscope
CP	-	Coir pith
AC	-	Activated Carbon
GAC	-	Granular Activated Carbon
PAC	-	Powdered Activated Carbon
EAC	-	Extruded Activated Carbon
BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
TSS	-	Total Suspended Solid
TDS	-	Total Dissolved Solid
TC	-	Total Coliform
MB	-	Methylene Blue
NTU	-	Nephelolometric Turbidity Units
Sg	-	Sungai

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The demand of water usage in Malaysia is increasing begin this year approximately 17,000 liter per day when the number of citizen become to 30 million people. Therefore, the process of the water treatment is also increases. Filtration is a process where unwanted materials in any solution or mixture are removed. These materials are normally related to health problems or environmental pollution (S. Piarapakaran, 2008). According to World Health Organization report, 1.1 billion people lack access to an improved drinking water supply, 88% of the 4 billion annual cases of diarrheal disease are attributed to unsafe water and inadequate sanitation and hygiene, and 1.8 million people die from diarrheal diseases each year. The WHO estimates that 94% of these diarrheal cases are preventable through modifications to the environment, including access to safe water. Simple techniques for treating water at home, such as chlorination, filters, and solar disinfection, and storing it in safe containers could save a huge number of lives each year. Reducing deaths from waterborne diseases is a major public health goal in developing countries (WHO, 2007). Effectively produce clean and safe water consistently in Malaysia water treatment is hard to be implemented. This problem is more serious in rural areas and point of sources nearest to pollution area, where the water quality is worst compare than other places.

Carbtrol Corporation (1992) reveal carbon has been used as an adsorbent for centuries. Early uses of carbon were reported for water filtration and for sugar solution purification Granular activated carbon is 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. A carbon filters have been used in home water purification systems primarily to remove taste and odour. Taste and odour, although undesirable, are generally not considered unhealthy. In recent years, carbon filters have been used to remove some of the contaminants that have been discovered in water supplies.

Abdul Halim Abdullah (2001) reveal the preparation of activated carbon with different pore sizes can be achieved by using physical or chemical activation process. In both methods, the development of porosity is different in term of practical procedures and mechanism. In physical activation the generation of porosity took place via selective elimination of the more reactive carbon of the structure and further gasification led to the production of the activated carbon with the sought pore structure. In chemical activation process, the precursor is mixed with a chemical such as $ZnCl_2$ or H_3PO_4, carbonized and washed to produce the activated carbon. Following the thermal decomposition of the precursor, the chemical reacts with the product causing reduction in the evolution of volatile matter and inhibition of the particle shrinkage. Once the chemical is removed by exhaustive washing, a large amount of porosity is formed.

Coconut coir pith is an organic matter that has been used as the granular activated carbon. In south-east Asia, coconut production is widespread. Coir pith is produced from coconut husks, so the available amount will be replenished yearly. Coir pith is 100% organic, has high water absorbent property, within its cellulose structure, and maintains humidity for a long time. (Sri Rajathi Coir Products, 2008) Of the various agricultural precursors, coconut pith waste has drawn considerable attention of the researchers because of its high porosity, light weight and high carbon content. Several authors have reported effectiveness of activated carbon (AC) produced from coconut pith for vivid applications (J.L.Gumaste, 2008). The agricultural sector in Malaysia produces abundance of agricultural wastes such as coconut coir pith. This byproduct has not been put into beneficial use by the planters. The unused coconut coir pith can be turned into activated carbon (M. Normah & A.A. Ramlan, 1991). Coir pith constitutes around 70% of the coconut husk and is a light, fluffy, material generated in the process of the separation of the fibers from the coconut husk in coir-fibre industries (Champan, 1981). About 3.6 million t/year of coir pith is produced in the world (Pillai et al., 1981). Coir pith is now being disposed of as waste and its accumulation around coir-processing factories creates big problems. (Ajithkumar, 1991). Therefore, this research will investigate the application and characteristics of activated carbon (AC) produced from coir pith to treat polluted water.

1.2 Problem Statement

The purpose of water treatment is to provide safe drinking water that does not contain objectionable taste, odour or colour; to provide adequate quantities of water for domestic, commercial, industrial and fire protection needs. All water produced by public water systems must achieve drinking water quality, even though only about 1% of water produced is used for drinking and cooking. Enjoying for clean and treated water should be accessible to all people and not only confined to the urban population where all the facilities and amenities are provided for them.

This study will investigate the characteristics and properties coir pith as an activated carbon. AC 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. The two main reasons that chemicals adsorb onto AC are a not attraction of the water, and attraction to the AC. Adsorption of most contaminants results from a combination of these reasons. Many organic compounds, such as chlorinated and non-chlorinated solvents, gasoline, pesticides ıd trihalomethanes (THM) can be absorbed by AC (Pascal Roche, 2007). AC is ffective in removing chlorine and moderately effective in removing some heavy ıetals. AC will also remove metals that are bound to organic molecules. Currently, ctivated carbon has been using charcoal as the medium filtration which is too xpensive, so by replacing coconut coir pith can reduce the cost. The outcome of this udy will suggest the coir pith as an activated carbon (AC) to treat polluted water.

.3 Objectives

The aim of this study is to investigate the application and characteristics of ctivated carbon (AC) produce from coir pith to treat polluted water. By carry out ıis study, the following objectives below will be achieve:

i. Identification the properties and characteristics of coir pith
ii. Investigation the potential of coir pith as activated carbon and coir fiber filter.
iii. Evaluation and asses the BOD, COD, turbidity, acidity and heavy metal in water intake after treated using coir pith filter.

1.4 Scope of Study

Scopes of this study include the following:

i. Using coir pith with specified size (0.3mm - 5mm) for Granular Activated Carbon and (≤ 0.3mm) for Powdered Activated Carbon
ii. Laboratory testing to obtain the required coir pith parameters such as porosity and adsorbent
iii. Laboratory testing to assess and evaluate the BOD, COD, turbidity, acidity and heavy metal in water intake
iv. Sources of water from river from Sg Galing, Kuantan

1.5 Significant of Study

This study will serve the good application of water and environmental engineering theories into practice by giving the opportunity for the student to carry out laboratory testing for the analysis of the particle size of the coir pith, BOD, COD, turbidity, acidity and heavy metal in water intake. The adsorption process provides an attractive alternative treatment, especially if the adsorbent is inexpensive and readily available. The activated carbon is the most popular adsorbent and has been used with great success. The investigation of the application and characteristics of coir pith as an activated carbon can be used in filtration process to treat polluted water.

By using coir pith as an activated carbon, the cost of treatment process can be reduce and this method is simple than the usual water treatment in our country. Coir pith a byproduct of coconut, is being used for the production of charcoal, fuel and brooms. According to the Department of Statistical Malaysia (2000), Malaysia produced a total of 120,195,000 coconuts in 1984 and increasing until 2000.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Activated carbon is produced from organic based materials such as coconut shells, palm-kernel shells wood chips, sawdust, corn cobs, seeds etc. Manufacture of activated charcoal is one glaring example of extracting useful product from what was considered wasteful hitherto. Activated charcoal has found use in various industries starting from water filtration to detoxification of body.

Activated carbon can be used for removal of organic chemicals, chlorine, lead, unpleasant tastes and odors in effluent or coloured substances from gas or liquid streams by the mechanism of adsorption. Adsorption can be classically defined as absorption on the surface of the material due to capillary condensation inside the multitude of pores and active sites available. Modern water purifiers come with activated carbon filter. Activated carbon water is very effective in removing chlorine from water which is cancerous if consumed (NPCS , 2004-2010)

Table 2.1: Summary of Earlier Work by Researchers to Prepare Activated Carbons Using H_3PO_4 Activation (YII, 2008)

Researcher	Precursor	Experimental Condition	Results
Kirubakaran et al. [10]	Coconut Shell	Two stage in N_2 atm; A.T=400 to 600°C; A.time=2 hr.	S.A > 1000 m^2/g at I.R=1.5
Toles et al. [20]	Macadamia shell, pecan, walnut and almond	Single and two stage; N_2 and self-generated atm.; S.C.T.=170°C; S.C. time=30min.; A.T.=450°C; A. time=1h	S.A=1100 to 1600 m^2/g. Activation in self-generated atm gave the highest S.A.
Dastgheib and Rockstraw [15]	Pecan Shells	Three stage activation: 1) liquid-stage activation at 160°C 2) primary activation at 160-210°C 3) secondary activation at 300-500°C for 30 min. I.R.=3	S.A=1071 m^2/g. S.A. increases until secondary A.T of 450°C and reduces when temperature increases above 450°C.
Lafi [13]	Acorns and olive seeds	A single stage with self-generated atmosphere. A.T=400-800°C. A.time=1 h.	A.T=800°C produced the highest Methylene Blue no. of 130 mg/g
Ahmedna [11, 12]	Sugarcane bagasse	Two stage with N_2 atmosphere. A.T=450°C. A.time=1 h.	S.A=1200 m^2/g

S.A =surface area; S.C.T=semi-carbonization temperature; S.C. time=semi-carbonization time; A.T=activation temperature; A. time=activation time; I.R. impregnation ratio.

2.2 Classifications

According to W. B. Wan Nik (2006) activated carbon has the strongest physical adsorption forces of the highest volume of adsorbing porosity of any material known to mankind. Substances with high carbon content such coal, wood, and coconut shell can be used in the production of activated carbon. The raw material has a very large influence on the characteristics and performance of activated carbon. There are three main forms of activated carbon:

a) Powder Activated Carbon (PAC)

Pulverized carbon with a size predominantly less than 0.18 mm (US mess 80). These are mainly used in liquid phase applications and for flue gas treatment. They present a large surface to volume ratio with a small diffusion distance. PAC is made up of crushed or ground carbon particles, 95–100% of which will pass through a sieve.

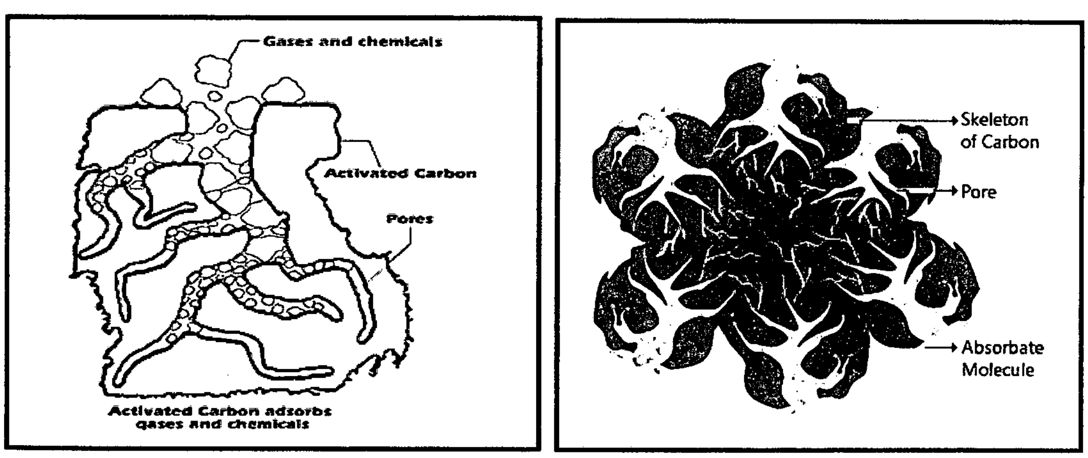

Figure 2.1: Activated carbon properties (Mehta Chemicals, 2009)

b) Granular Activated Carbon (GAC)

Irregular shaped particles sizes ranging from 0.2mm to 5mm. This type of activated carbon is used in both liquid and gas phase applications. It has relatively larger particle size compare to powder activated carbon. GAC have a highly adsorbent material used to remove contamination from water. U.S. Department of the Interior (2009) state that GAC is manufactured from materials with high carbon content such as coal, wood, coconut shells, or walnut shells. GAC has a random porous structure, containing a broad range of pore sizes ranging from visible cracks and crevices down to molecular dimensions. GAC uses this porous structure to remove dissolved contaminants from water in a process known as adsorption.

c) Extruded Activated Carbon (EAC)

Extruded and cylindrical shaped with diameters from 0.8 to 5mm. They are mainly used for gas phase applications because of their low pressure drop, high mechanical strength and low dust content.

2.3 Properties of Activated Carbon (AC)

2.3.1 Physical Activation

Granular activated carbons (GAC) are well known for their high surface area, porosity and adsorption behavior. (J L Gumaste, 2008)

Table 2.2: Characteristics of activated carbons prepared by physical activation (Kadirvelu, 1997)

Parameter	Carbonisation temperature (°C)				
	400	500	600	700	800
pH	7.79	8.47	8.63	8.92	9.41
Conductivity (μS/cm)	1.16	1.19	2.00	2.60	2.80
Specific gravity	0.61	0.89	1.02	1.20	1.07
Bulk density (g/ml)	0.10	0.11	0.13	0.14	0.14
Porosity (%)	82.40	86.77	86.40	86.40	86.90
Moisture (%)	2.70	4.00	3.15	3.90	5.60
Ash (%)	4.62	5.42	5.90	6.55	6.57
Volatile matter (%)	58.5	55.83	56.68	46.26	48.42
Fixed carbon (%)	38.80	40.17	44.15	49.89	45.90
Surface area (M^2/g)	346	352	392	496	507
Decolourising power (mg/g)	10.80	13.50	15.60	21.00	22.50
Ion exchange capacity (mequiv/g)	Nil	Nil	Nil	Nil	Nil
Solubility in water (%)	5.65	5.19	5.15	7.93	4.00
Solubility in 0.25 M HCl (%)	10.78	9.56	10.78	9.62	9.50
Sodium (W/W, %)	0.11	0.11	0.12	0.11	0.12
Potassium (W/W, %)	0.30	0.32	0.32	0.30	0.32
Calcium (W/W, %)	0.36	0.34	0.33	0.37	0.39
Iron (W/W, %)	0.16	0.18	0.16	0.18	0.16
Phosphorous (W/W, %)	0.03	0.03	0.03	0.03	0.03
Silica (W/W, %)	3.74	4.18	3.90	4.23	4.12
Iodine number (mg/g)	267	331	357	400	414

2.3.2 Adsorption

Lenntech (2009) reveal adsorption is a process where a solid is used for removing a soluble substance from the water. In this process active carbon is the solid. Activated carbon is produced specifically so as to achieve a very big internal surface (between 500 - 1500 m^2/g). This big internal surface makes active carbon ideal for adsorption. Carbtrol Corporation (1992) reveal adsorption is a natural process by which molecules of a dissolved compound collect on and adhere to the surface of an adsorbent solid. Adsorption occurs when the attractive forces at the carbon surface overcome the attractive forces of the liquid. Granular activated carbon (GAC) is a particularly good adsorbent medium due to its high surface area to volume ratio. One gram of a typical commercial activated carbon will have a surface area equivalent to 1,000 $meter^2$. This high surface area permits the accumulation of a large number of contaminant molecules. For many water treatment applications it has proved to be the least expensive treatment option. Adsorption is particularly effective in treating low concentration waste streams and in meeting stringent treatment levels.

According to K. Kadirvelu et al. (2000) as reported in Bailey et al. (1998) adsorbent process can be assumed as low cost if little processing is require, are abundant in nature, or are a by-product or waste material from another industry. The adsorption process takes place in three steps which is Macro transport: the movement of organic material through the macro-pore system of the active carbon (macro-pore >50nm), Micro transport: the movement of organic material through the meso-pore and micro-pore system of the active carbon (micro-pore <2nm; meso-pore 2-50nm) and Sorption: the physical attachment of organic material on the surface of active carbon in the meso-pores and micro-pores of the active carbon (Lenntech, 2009).

Factors on which adsorption depends are temperature, pressure, surface area and activation of adsorbent. Adsorption increases at low temperature conditions while as depicted by adsorption isotherm, with the increases in pressure, adsorption increases up to a certain extent till saturation level is achieved. After saturation level is achieved no more adsorption takes place no matter how high the pressure is applied. Adsorption is a surface phenomenon therefore it increases with increase in