A PRODUCTION OF ACTIVATED CARBON USING LOCAL AGRICULTURAL WASTE FOR GROUNDWATER TREATMENT IN UNIVERSITI MALAYSIA PAHANG

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ABSTRACT

The production of activated carbon from local agricultural wastes is one of the most environment-friendly solutions by transforming negative-valued to valueable materials. Two different types of activated carbon were use for production activated carbon which is rice husk and sugarcane baggase. These local agricultural wastes will undergo carbonization process by burn at temperature 500°c for 2 hour and cooled before washed using sulphuric acid to activate a pore surface for the carbon. These activated carbon are divided to two different particles size whish are powdered and granular to determine an effective activated carbon for groundwater treatment. The size for granular activated carbon is from 2 mm to 3.35 mm and powdered is from 300 μm to 63 μm. Activated carbons are tested for porosity, adsorption and define the pore surface using scanning electron microscope (SEM). The testing has been done show that powdered rice husk activated carbon (PAC RH have a porosity percentage highest compare to another type of activated carbon which is 90 %. A different types and particles size of activated carbon is filling into the filter media for filtering raw water purpose. Different retention time are used which are 15,30,45 and 60 minutes to determine an optimum hydraulic retention time (hrt) that needed to treat a groundwater. Base on observation from the testing that has done, an effective hrt is 30 minute because at this contact time, have a highest removal for several parameters that tested such as turbidity, color, heavy metal and total suspended solid. After this optimum hydraulic retention time, 45 and 60 contact time show a decreasing of removal because of an activated carbon is not functioning well after optimum time.

ABSTRAK

Penghasilan karbon teraktif daripada sisa pertanian adalah salah satu langkah meyelesaikan masalah alam sekitar yang mesra alam dengan mengubah sisa pertanian yang tidak digunakan kepada bahan yang yang bernilai. Dua jenis sisa pertanian yang berlainan digunakan untuk tujuan penghasilan karbon teraktif ini iaitu sekanm padi dan hampas tebu. Sisa pertanian ini akan melalui proses pengkarbonan dijalankan pada suhu 500°c selama 2 jam dan kemudian disejukkan sebelum dibasuh dengan asid sulfurik untuk tujuan pengaktifan liang-liang pada karbon tersebut. Karbon teraktif yang terhasil akan dibahagikan kepada dua saiz yang berlainan bagi membuat perbandingan saiz yang paling effektif untuk tujuan merawat air bawah tanah. Bagi karbon teraktif bersaiz kasar,saiz yang digunakan adalah 2mm – 3mm manakala untuk karbon teraktif bersaiz halus pula adalah 300 μm hingga 63 μm. Karbon teraktif akan diuji dari segi kebolehtelapan, kadar serapan dan liang-liang yang terhasil pada setiap karbon teraktif dapat dilihat dengan menjalankan ujian mikroskopik terhadap karbon terktif. Ujikaji yang telah dijalankan menunjukkan karbon teraktif daripada sekam padi yang bersaiz halus mempunyai nilai kebolehtelapan yang paling tinggi iaitu 90 % dan liang-liang permukaan yang paling berbanding karbon teraktif bersaiz kasar dan juga karbon teraktif daripada hampas tebu. Karbon teraktif berlainan saiz dan jenis dimasukkan ke dalam media yang berfungsi menapis air mentah yang belum dirawat. Masa tahanan yang berbeza digunakan iaitu 15, 30, 45 dan 60 minit untuk menentukan masa tahanan yang paling optimum yang diperlukan untuk merawat air bawah tanah tersebut. Berdasarkan pemerhatian terhadap ujikaji yang dijalankan, masa tahanan yang paling effektif dalam merawat air bawah tanah adalah pada masa 30 minit di mana pada masa tahanan tersebut kadar kekeruhan, warna, logam terlarut dan jumlah kandungan terjerap yang dapat disingkirkan lebih tinggi berbanding masa tahanan yang lain. Selepas masa tahanan 30 minit iaitu pada masa tahanan 45 dan 60 minit tahap penyingkiran setiap parameter yang dikaji menurun kerana tahap karbon teraktif yang dihasilkan hanya optimum pada minit ke 30 dalam menyingkirkan bahan-bahan organik, logam terlarut dan warna air mentah yang digunakan.

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LIST OF ABBREVIATIONS

AC	=	Activated Carbon
PAC RH	=	Powdered Activated Carbon Rice Husk
GAC RH	=	Granular Activated Carbon Rice Husk
PAC SB	=	Powdered Activated Carbon Sugarcane Baggase
GAC SB	=	Granular Activated Carbon Sugarcane Baggase
HRT	=	Hydraulic Retention Time
TSS	=	Total Suspended Solid
UMP	=	Universiti Malaysia Pahang
WASRA	=	Water Supply For Rural Area

LIST OF SYMBOLS

mL	-	Mililiter
mg/L	-	Miligram / liter
°c	-	Degree celcius
mm	-	Milimeter
μm	-	Micrometer
%	-	Percent
g	-	Gram
t	-	Time

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CHAPTER 1

INTRODUCTION

1.1 Background

Activated Carbon (AC) is the common term used for a group of absorbing substances of crystalline form, having a large internal pore structures that make the carbon more absorbent (Strand, 2001). The term of activated carbon is come from the word *"carbon"* and *"active"* which carbon mean raw material undergoes a carbonization process (burning in high temperature) while active a material in carbon condition undergoes activation process to open a pore surface area as maximum as can to increase adsorption rate of activated carbon.

Generally, the raw materials for the production of AC are those with high carbon but low inorganic contents such as wood, lignite, peat and coal. Besides that, lots of agricultural waste and by product have successfully converted to AC for examples macadamia nutshell paper mill sludge and peach stones (Nurul Ain Jabit, 2007).

In Malaysia there are potential raw materials resources for the production of the activated carbon. In this research, three local agricultural wastes which are sugarcane baggase and rice husk were used to produce an activated carbon due to the availability and inexpensive material with high carbon and low inorganic content. A number of researches have been reported in the literature in production of activated carbon using sugarcane baggase and rice husk as a raw materials.

At the moment, a lot of research has been done on AC to improve the application of activated carbon. One of the fastest growing areas is in environmental applications such as water and wastewater treatment. In the treatment of wastewater, it is used for purification, decolorization and the removal of toxic organics and heavy metal ions (Kim, et al., 2001). Recently, researches have been focused more on removal of heavy metal ions such as copper, zinc and chromium and mercury. But only few researches have done on removal of cyanide pollutants by activated carbon (Nurul Huda Amri, 2008)

Adams (1994) studied the effect of copper in the adsorption of cyanide onto activated carbon. It was found that the removal capacity was highly improved by the presence of copper. Williams and Petersen (1997) reported that 56.5% of free cyanide (20 mg/l) could be removed using silver impregnated carbon compared with plain carbon (11 % CN removal). In column test, Monser and Adhoum (2002) observed that silver and nickel impregnated activated carbons could adsorb up to 26.5 and 15.4 mg CN per unit mass of adsorbent respectively compared with 7.1 mg CN/g for plain carbon. Therefore, in this research the production of activated carbon will used to examine the potential application of local activated carbon produced by agriculture waste on removal of cyanide pollutants.

1.2 Problem Statement

The world production of AC was estimated it demand to be 375,000 ton in 1990, except Eastern Europe and China (Mozammel et.al, 2002). The demand of activated carbon were reached up to 200,000 ton per year in United States in year 2002 and AC demand were increase and market growth for these material for various application was estimated at 4.6% per year (Mozammel et. al, 2002). The positive market position held by AC relates to their performance in water application and low cost compared with other possible competitive inorganic material like zeolites and so on.

In Malaysia, activated carbon had been produced from variable material such as rubber wood sawdust and palm oil coconut shell (Mohd Zubir Hussien, 1993). Activated Carbon is used primarily as an adsorbent to remove organic compounds and pollutant from liquid and gas streams. The market has been increasing constantly as a consequence of environmental issues, especially water and air purification. Furthermore, as more and more countries are becoming industrialized, the need for activated carbon to comply with environmental regulation will grow at faster rate. Liquid phase applications represent the largest outlet for activated carbon. In these applications, AC is used in the purification of a variety of liquid streams, such as those used in water treatment and the processing of food, beverages and pharmaceuticals.

The growth of the activated carbon market in the last two decades in the most industrialized region will very probably continue in the near future as more developing areas of the world will realize the importance of controlling water and air pollution. This demand can be satisfied considering the large number of raw material available for the production of AC, the variety of activation processes described, and the available forms of AC. Thus, the continuous research has to be implementing to develop the high quality of AC for specific uses.

1.3 Objectives of the Study

The aim of this research is to produce activated carbon from the local agricultural waste which is rice husks and sugarcane baggase through physical activation for a particular application. Moreover, several testing is conducting to achieve the following objectives:

i. To produced activated carbon from rice husk and sugarcane baggase by fixed activation time and temperature.

ii. To examine the characteristic of activated carbon produced (porosity, adsorption capacity and pore size of AC produced).

iii. To determine the most effective removal of activated carbon with different particles size and optimum retention time.

iv. To evaluate the potential application of locally produced activated carbon in pollutants such as its removal performance in turbidity, color, total coliform, total suspended solid and heavy metal from raw water in Universiti Malaysia Pahang.

1.4 Scope of Study

The scopes of my research are:

i. Production of activated carbon only from two sources of local agriculture waste from rice husk and sugarcane baggase.

ii. Study the effectiveness rate of production activated carbon by analyzing in the fixed temperature of burning both wastes.

iii. Determine the adsorption rate of activated carbon extracted from rice husk, and sugarcane baggase by using the methylene blue solution and comparing the adsorption rate of both waste.

iv. iv. In this research, hydraulic retention time (hrt) uses is from 15 minutes to 60 minutes

CHAPTER 2

LITERATURE REVIEW

2.1 Activated Carbon

2.1.1 Introduction

Activated carbons form a large and important class of porous solids, which have found a wide range of technological applications. As a consequence, the porous structures of these materials and their adsorption of gases, vapors, and liquids have been extensively studied. In this section the micro structural and porous properties of the principal classes of activated carbon are reviewed. It is outside the scope of this contribution to consider in detail the very many industrial applications and processes

that employ activated carbon. There are different renewable resources such as sugarcane baggase, almond nutshells, rice husk, rice straw,coconuts shells which be used as alternatives(Khadija Qureshi, Inamullah Bhatti, Rafique Kazi,2007).

Activated come from word *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 which is it is a commercially used AC that limited non renewable resources.

This provides a basis understanding for the relationship of the pore structure of activated carbons to the fine structure of the solid carbon materials. An appreciation of the fine structure of activated carbons leads to an account of the surface forces in pores that give rise to the powerful adsorptive properties of activated carbons. The processing method involved two types of activation, physical and chemical activation. The development of porosity in activated carbons by "physical" activation, by reaction of the carbon with oxidizing gases such as steam carbon dioxide and air (Nurul Ain Jabit,2008).

2.1.2 Definition of Activated Carbon

Activated carbon (AC) is known as a solid, porous, black carbonaceous material and tasteless. Marsh (1989) defined AC as a porous carbon material, usually chars, which have been subjected to reaction with gases during or after carbonization in order to increase porosity. Activated carbons have been explained in different way of definition from several authors. Such as the sources from internet(Wikipedia,2000) defined activated carbon as activated charcoal or activated coal, 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.

Activated carbons are high porosity, high surface area materials manufactured by carbonization and activation of carbonaceous materials, which and extensive use in the industrial sector for adsorption of pollutants from gaseous and liquid streams. One can design activated carbon for adsorption of specific adsorbate, using appropriate precursor and by optimizing the activation process conditions. Either physical or chemical activation method is used for manufacture from a wide variety of precursor materials.

There are a couple of ways that activated carbon can be produced from substances such as wood, nutshells, or coal. One method involves a process called carbonization. In this process, carbon content is heated up to 600-900 °C, in an atmosphere of inert gases such as argon or nitrogen. Another method, called Oxidation, exposes the carbonized materials to oxidizing atmospheres such as oxygen, carbon dioxide or steam, at temperatures between 600-1200 °C. Activated carbon includes a wide range of amorphous carbon-based materials prepared to exhibit a high degree of porosity and an extended interparticulate surface area (Nurulhuda Amri, 2008). Activated carbon can be created in a variety of different physical forms. Powdered activated carbon blog has a large surface area to volume ratio and is generally used in raw water intakes, rapid mix basins, clarifiers, and gravity filters.

Granular activated carbon is larger than the powdered version and, consequently, has a smaller surface area to volume ratio. This substance is preferred in the adsorption of gases and vapors. Impregnated carbon, which name stems from being "impregnated" by several types of inorganic substances (Al, Mn, Zn, Fe, Li, Ca), has been used in air pollution control in museums and galleries. While activated carbon may take many different physical forms, its application is still the same to remove pollutants and other contaminates.

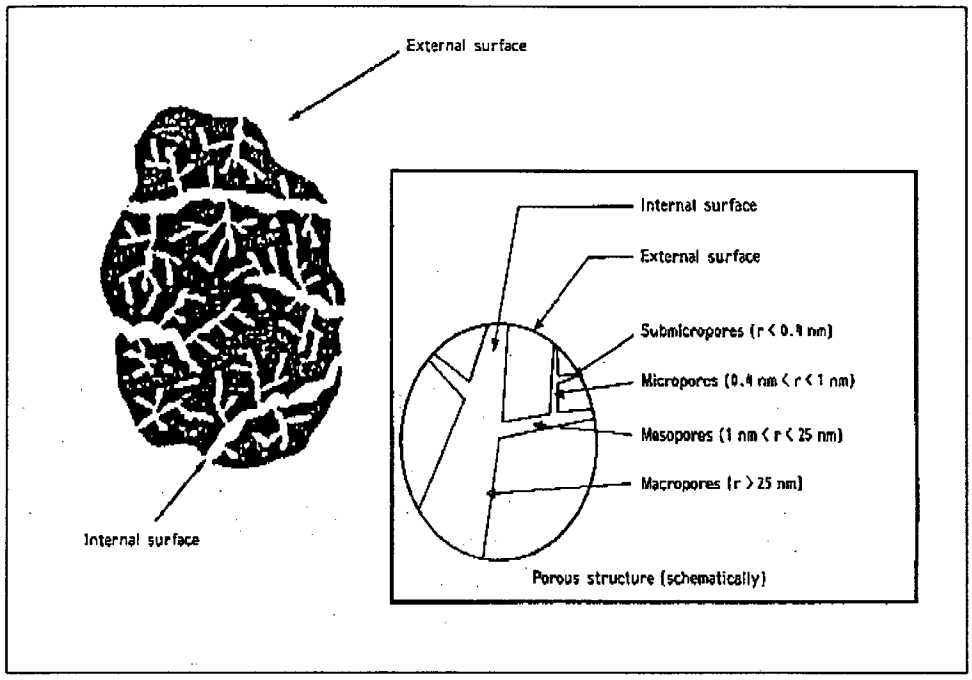

Figure 2.1: Schematic of activated carbon model (Henning J. Degel, 1990)

2.2 Characterization and Properties of Activated Carbon

Characterization for activated carbon (AC) is very important in order to classified AC for specific uses. Basically, AC characterized by physical properties and chemical properties. A characteristic of activated carbon depends on the physical and chemical properties of the raw materials as well as activation method used. (Guo and Lua, 2003). The process of activated carbon starts with the selection and classification of a raw carbon source. These sources are selected based on design specifications with different properties of activated carbon. Some of the more common raw sources include wood, sawdust, lignite, peat, coal, coconut shells, and petroleum residues (AWWA, 1971).

Activated carbon's physical properties involve its porosity and chemical makeup. Activated carbon is very porous; its surface area is nearly 1500 m^2/g, equaling one tablespoon. Its surface makeup is described as being sponge-like, riveted with microscopic holes and crevices similar to sandpaper (Nurul Ain Jabit, 2007). The physical structure of activated carbon is only viewable with a microscope, however, due to the small surface area of the holes and rivets. Activated carbon appears smooth and granite-like when observed by the naked eye.

Physical properties of AC, such as ash content and moisture content can affect the use of a granular AC and render them either suitable or unsuitable for specific applications. While the specific surface area of activated carbon and surface chemistry is classified as chemical properties. Furthermore, the porous structure of activated carbon also can be characterize by various techniques such as adsorption of gases (N_2, Ar, Kr, CO_2,) or vapors (benzene, water), scanning electron microscopy (SEM) and so on(Nurul Huda Amri, 2007)

The process of activated carbon begins with the selection and classification of a raw carbon source. These sources are selected based on design specifications with different properties of activated carbon. Some of the more common raw sources include wood, sawdust, lignite, peat, coal, coconut shells, and petroleum residues (AWWA, 1971). Abdul Rahim Yacob(2008) has been reported that palm kernel shell is one of the main agriculture wastes from the palm oil industries in Malaysia. It is estimated that for every one million tonnes of palm oil produced, 0.8 million tonnes of palm shells is created . Based on a total oil production of 7.4 million tonnes in 1993, the amount of palm shell generated in that year alone was about 6 million tonnes.

The important characteristics in choosing carbon types include pore structure, particle size, and total surface area and void space between particles (Clark, 1989). After selection of a source, preparations for use are made. These preparations most often include dehydration, carbonization, and activation. Dehydration and carbonization involve slow heating of the source in anaerobic conditions. Chemicals such as zinc chloride or phosphoric acid can be used to enhance these processes. The stage of activation requires exposure to additional chemicals or other oxidizing

agents such as a mixture of gases. Depending upon the specifics of the process and the source carbon, the newly activated carbon can be classified according to density, hardness, and other characteristics (AWWA, 1971).

Another important characteristic of activated carbon is the isotherm or breakpoint characteristic for each particular type. This is most often determined by modeling, testing, cost analysis, and pilot studies. The pilot studies ensure that the chosen carbon type effectively removes the desired substances for the particular raw water source and allows the plant to reach desired levels of quality before treatment continues. Once a breakpoint of a particular carbon has been determined the plant operators know approximately how long the carbon will effectively function. As this time approaches the carbon must be changed to ensure adequate removal (Clark, 1989).

The "spent" carbon, as it is called, is removed and sent for re-activation treatment. This is done primarily with granular activated carbon because PAC particles are too small to be effectively re-activated. This process allows for recovery of approximately 70% of the original carbon. This number also allows for any physically lost in the shipment process. The re-activated carbon is then mixed with a portion of new carbon for higher effectiveness and is then returned to its place in the plant process (Clark, 1989).

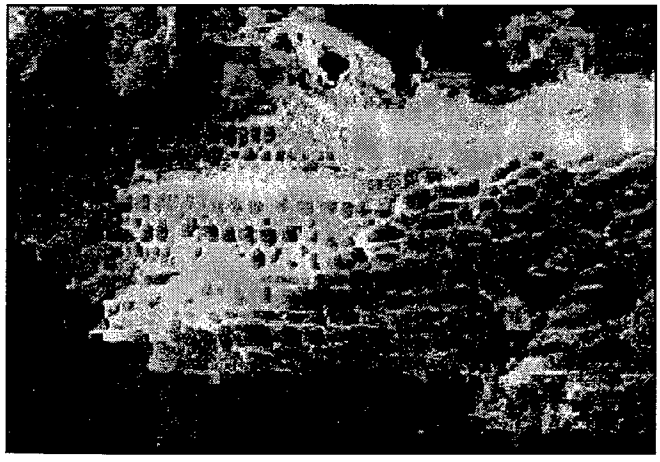

Figure 2.2: Scanning Electron Microscope Images of Pores (Hoehn, 1996).