THE EFFECTIVENESS USING FILTER BASED ON BANANA PEEL ACTIVATED CARBON FOR INDUSTRIAL WASTEWATER TREATMENT

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ABSTRACT

Contamination of the river due to the wastewater discharged is becoming a serious problem nowadays. The wastewater from the industry contains pollutant such as heavy metals and organic materials. These types of contaminants are highly toxic and very dangerous to the mankind and living organism if untreated. Therefore, the wastewater need to be treated before discharging to the river. Unfortunately, the method had been used is unsatisfactory and very expensive. But, this study is a low cost treatment and very environmentally friendly by using activated carbon from banana peels waste. In this study, the filtration using banana peels activated carbon is been used to treat wastewater. Activated carbon is produced from banana peels waste to be used in the filter. Then, the test is conducted before treated and after treated to determine the contamination in the sample. From the analysis, the percentage removal concentration of heavy metal such as lead (Pb) is highly removing about 99.23%. Other than that, the percentage removal for copper, iron, zinc, and manganese is 98.75%, 96.44%, 93.70%, 98.75%, 38.71% respectively. While the percentage removal of oil and grease, COD, turbidity, TSS and BOD is 97.3%, 91.67%, 90.4%, 79.32%and 15.42% respectively. The percentage removal is due to an adsorption process occurs in the filter. From the analysis, the activated carbon from banana peels can remove heavy metal and the performance of water quality parameter increased with retention time increased. Therefore, this study has shown the effectiveness using a filter based on banana peels activated carbon for industrial wastewater treatment.

ABSTRAK

Pencemaran sungai daripada sisa industri yang dilepaskan menjadi masalah yang serius pada masa kini. Air sisa dari industri mengandungi pencemar seperti logam berat dan bahan-bahan organik. Jenis-jenis bahan pencemar adalah sangat toksik dan sangat berbahaya kepada manusia dan organisma hidup jika tidak dirawat. Oleh itu, air kumbahan perlu dirawat sebelum dilepaskan ke sungai. Malangnya, kaedah yang telah digunakan tidak memuaskan dan sangat mahal. Namun, kajian ini menawarkan rawatan kos rendah dan sangat mesra alam dengan menggunakan karbon teraktif daripada sisa kulit pisang. Dalam kajian ini, penapisan menggunakan kulit pisang mengaktifkan karbon yang digunakan untuk merawat air daripada sisa industri. Karbon teraktif dihasilkan terlebih dahulu daripada sisa kulit pisang untuk digunakan sebagai medium penyerap bahan-bahan pencemar. Seterusnya, ujian dijalankan sebelum dirawat dan selepas merawat untuk menentukan pencemaran dalam sampel air tersebut. Melalui analisis, peratusan penyingkiran logam berat seperti plumbum (Pb) sangat tinggi iaitu kira-kira 99,23%. Selain daripada itu, peratusan penyingkiran kuprum, besi, zink, dan mangan masing-masing adalah sebanyak 98.75% 96.44% 93.70% 98.75% 38.71%. Hasil analisis, mendapati karbon diaktifkan dari kulit pisang boleh menyingkirkan logam berat Manakala peratusan penyingkiran minyak dan gris, COD, kekeruhan, TSS dan BOD adalah 97.3%, 91.67%, 90.4%, 79.32% dan 15.42%. Peratus penyingkiran adalah disebabkan oleh proses penyerapan yang berlaku semasa penapisan seterusnya pencapaian kualiti air meningkat dengan peningkatan masa. Oleh itu,kajian ini menunjukkan keberkesanan menggunakan penapis daripda karbon teraktif kulit pisang untuk rawatan air sisa industri.

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LIST OF ABBREVIATIONS

CWA	Clean Water Act
GAC	Granular Activated Carbon
PAC	Powdered Activated Carbon
AC	Activated Carbon
EPA	U.S Environmental Protection Agency
POTW	Publicly Owned Treatment Works
IPM	Integrated Pest Management
WCR	Wider Carribean Region
RBC	Rotating Biological Contactors
CWA	Clean Water Act
NPDES	EPA's National Pollutant Discharge Elimination System
DOE	Department of Environment
COD	Chemical Oxygen Demand
BOD	Biological Oxygen Demand
SS	Suspended Solid
OD	Optical Density
Mn	Manganese
Cu	Copper
Pb	Lead
Fe	Iron
Zn	Zinc

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water covers 70.9% of the Earth's surface, and is vital for all known forms oflife. On Earth, 96.5% of the planet's water is found in the oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapor, clouds formed of solid and liquid water particles suspended in the air, and precipitation. Only 2.5% of the Earth's water are fresh water, and 98.8% of that water is in ice and groundwater. Less than 0.3% of all freshwater is in rivers, lakes, and the atmosphere, and an even smaller amount of the Earth's freshwater (0.003%) is contained within biological bodies and manufactured products. Water on Earth moves continually through the hydrological cycle of evaporation and transpiration, condensation, precipitation, and runoff, usually reaching the sea. Evaporation and transpiration contribute to the precipitation over land (Peavy, 1985). Safe drinking water is essential to humans and other life forms. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack accesses to adequate sanitation. There is a clear correlation between access to safe water and GDP per capita. However, some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability.

2.2 Types of Water Pollution

2.2.1 Surface Water Pollution

Surface water pollution is the most visible form of pollution and we can see it floating on our waters in lakes, streams, and oceans. Trash from human consumption, such as water bottles, plastics and other waste products, is most often evident on water surfaces. This type of pollution also comes from oil spills and gasoline waste, which float on the surface and affect the water and its inhabitants (Agarwal, 2008).

2.2.2 Groundwater Pollution

This type of pollution is becoming more and more relevant because it affects our drinking water and the aquifers below the soil. Groundwater pollution is usually caused by highly toxic chemicals and pesticides from farming that leak through the ground to contaminate the wells and aquifers below the surface (Agarwal, 2010).

2.2.3 Microbiological Pollution

Microbiological pollution is the natural form of water pollution that is caused by microorganisms in uncured water. Most of these organisms are harmless but some bacteria, viruses, and protozoa can cause serious diseases such as cholera and typhoid. This is a significant problem for people in third world countries who have no clean drinking water and/or facilities to cure the water (Agarwal, 2008).

2.2.4 Oxygen Depletion Pollution

Microorganisms that thrive in water feed on biodegradable substances. When there is an influx of biodegradable material from such things as waste or erosion from farming, the numbers of these microorganisms increases and utilize the obtainable oxygen. When these oxygen levels are depleted, harmless aerobic microorganisms die and anaerobic microorganisms thrive. Some of these organisms produce damaging toxins like sulfide and ammonia (Agarwal, 2008).

2.2.5 Nutrient Pollution

Nutrients are usually found in wastewater and fertilizers. These can cause excess vegetation in the water such as algae and weeds, using up the oxygen in the water and hurting the surrounding marine life and other organisms in the water (Peavy, 1985).

2.2.6 Suspended Matter Pollution

This type of pollution occurs when pollutants enter the water and do not mix in with the water molecules. These suspended particles form the fine silt on the waterbed, harming the marine life by taking away the nutrients and disturbing their habitat (Agarwal, 2008).

2.2.7 Chemical Pollution

Due to the nature of industry these days and the mass production in industrial plants and farms, lots of chemical runoff that flows into the nearby rivers and water sources.

Metals and solvents flow out of factories and into the water, polluting the water and harming the wildlife. Pesticides from farms are like poison to the wildlife in the water and kill and endanger the aquatic life. If birds or humans eat these infected fish the toxins are transferred to us and we swallow these dangerous pesticides and toxins, affecting our health. Petroleum is a different type of chemical pollutant that dramatically affects the aquatic life. This oil kills the fish and marine life and sticks to the feathers of birds, causing them to lose their ability to fly.

Regarding on the type of pollution above, the related to this study is surface water pollution. This is because the wastewater from the industrial discharges the wastewater directly to the river or sea without further treatment (Agarwal, 2008).

Other than that, chemical pollution is one of the massive problems because it can be hazardous and non hazardous waste. Therefore, wastewater from industrial need to treat before it can be discharged. This increasing pollution is usually comes from the high technology uses. The higher technology, the higher industrial waste produce.

2.3 Sources of Wastewater

2.3.1 Industrial Waste Water

Industrial use of water in a wide variety of suspended impurities of either organic or inorganic nature. Industrial wastewaters may contain a wide variety of turbidity-producing material. Soaps, detergents, and emulsifying agents produce stable colloids that result in turbidity. Although turbidity measurements are not commonly run on wastewater, discharges of wastewater may increase the turbidity of natural bodies of water (Peavy, 1985).

2.3.1.1 Characteristics of Industrial Wastewater

Industrial processes generate a wide variety of wastewater pollution. The characteristics and levels of pollutants vary significantly from industry to industry. The EPA has grouped the pollutants into three categories which are conventional pollutants, nonconventional pollutants, and priority pollutants (Peavy, 1985).

2.3.2 Domestic Sewage

Peavy (1985) found that domestic wastewater usually contains large quantities of suspended solids that are mostly organic in nature. Domestic sewage is 99.9 percent pure water, while the other 0.1 percent is pollutants. Although found in low concentrations, these pollutants pose risk on a large scale. In urban areas, domestic sewage is typically treated by centralized sewage treatment plants. In the U.S, most of these plants are operated by local government agencies, frequently referred to as publicly owned treatment works.

Municipal treatment plants are designed to control conventional pollutants: BOD and suspended solids. Well-designed and operated systems as secondary treatment or better can remove 90 percent or more of these pollutants. Some plants have additional sub-systems to treat nutrients and pathogens. Most municipal plants are not designed to treat toxic pollutants found in industrial wastewater. Cities with sanitary sewer overflows or combined sewer overflows employ one or more engineering approaches to reduce discharges of untreated sewage, including utilizing a green infrastructure approach to improve storm water management capacity throughout the system, and reduce the hydraulic overloading of the treatment plant, repair and replacement of leaking and malfunctioning equipment, increasing overall hydraulic capacity of the sewage collection system often a very expensive option. A household or business not served by a municipal treatment plant may have an individual septic tank, which treats the wastewater on site and discharges into the soil. Alternatively, domestic wastewater may be sent to a nearby privately owned treatment system such as rural community. (Peavy,1985)

2.3.3 Urban Runoff

Effective control of urban runoff involves reducing the velocity and flow of storm water, as well as reducing pollutant discharges. Local governments use a variety of storm water management techniques to reduce the effects of urban runoff. These include biological pest control to maintain control over pests, reduce reliance on chemical pesticides, and protect water quality (Bhatnagar, 2010).

2.4 Wastewater Characteristics

Domestic sewage is a significant contributor to marine pollution in the Wider Caribbean Region (WCR), the area shown in table below which includes sub regions III and IV containing the majority of countries defined as the Caribbean in this Regional Overview (CEP 1998). The Domestic sewage originates mostly from households, public facilities, and businesses. For wastes from communities where most homes and businesses have piped water, typical pollutant composition of domestic sewage is shown in table (CEP, 1998).

Table 2.1 : Typical pollutant composition of domestic sewage for WCR

Pollutant	Measurement (mg/L)
Total Suspended Solids (TSS)	200-300
5-day Biochemical Oxidation Demand (BOD)	200-250
Chemical Oxidation Demand (COD)	350-450
Total Nitrogen as N	25-60
Total Phosphorus as P	5-10
Oil and Grease	80-120

Table 2.2 : Typical pollutant composition of septage taken to wastewater treatment facilities

Pollutant	Measurement (mg/L)
TSS	10,000-25,000
5-day BOD	3,000-5,000
COD	25,000-40,000
Total Nitrogen as N	200-700
Total Phosphorus as P	100-300
Oil and Grease	2500-7500

Table 2.3: Typical industrial wastewater pollutant characteristics.

Industry	BOD Concentration (mg/L)	TSS Concentration (mg/L)	Oil & Grease Concentration (mg/L)	Metals Present	Volatile Compounds Present	Refractory Organics Concentration (mg/L)
Oil Refinery	100 to 300	100 to 250	200 to 3,000	Arsenic, Iron	Sulphides	Phenols 0 to 270
Tanneries	1000-3000	4000-6000	50-850	Chromium 300-1,000	Sulphides Ammonia 100-200	
Bottling Plant	200 to 6,000	0 to 3,500				
Distillery, Molasses, or Sugar Factory	600 to 32,000	200 to 30,000			Ammonia 5 to 400	
Food Processing	100 to 7,000	30 to 7,000				
Paper Factory	250 to 15,000	500 to 100,000		Selenium, Zinc		Phenols 0 to 800
Chemical Plant	500 to 20,000	1,000 to 170,000	0 to 2,000	Arsenic, Barium, Cadmium		Phenols 0 to 5,000

Even though domestic sources are a relatively small part of the total current pollution load, control of pollution from domestic sources is worthy of considerable attention. This is because pollution control from domestic sources is an important element of public education about environmental and public health issues, and because human health risk arises primarily from domestic sewage (CEP, 1998).

2.5 Types of Contaminants

2.5.1 Chemical

Ramalho (1977) found that the contaminants contain organic and inorganic compounds. The main concern resulting from pollution by organic compounds is oxygen depletion resulting from utilization of DO in the process of biodegradation of these compounds. In the case of inorganic compounds, the main concern their possible toxic effect, rather than oxygen depletion. There are, however, cases in which inorganic compounds exert an oxygen demand, so contributing to oxygen depletion. Sulfites and nitrites, for example, take up oxygen, being oxidized to sulfates and nitrates.

Heavy metal ions which are toxic to human are important contaminants. They occur in industrial wastewaters from plating plants and paints and pigment industries. Even their presence in trace quantities such as minimum detectable concentrations causes serious problems (Ramalho, 1977).

2.5.2 Biological

Biological contaminants are responsible for transmission of diseases by water supplies. Some of the diseases transmitted by biological contamination such as water cholera, typhoid, paratyphoid and shistomiasis (Ramalho, 1977).

2.5.3 Physical

Some physical contaminant includes temperature change (thermal pollution). This is the case relatively warm water discharged by industrial plants after use in heat exchangers (coolers).Color for example cooking liquors discharges containing suspended solids, turbidity caused by discharges containing suspended solid. Foams as detergents such as alkyl benzene sulfonate (ABS) constitute an important cause of foaming and radioactivity (Ramalho, 1977).

2.6 Wastewater Treatment

There are three reliability classes for wastewater treatment facilities established by the U.S Environmental Protection Agency (EPA). Class 1 reliability is required for those plants that discharge into navigable waters that could be permanent or unacceptable damaged by effluent quality by short term effluent quality for only a few hours. Class II reliability is required for those plant that discharge into navigable waters that would not be permanently (Davis, 2011).

2.6.1 History of Wastewater Treatment

The history of water treatment dates back to approximately the thirteenth century B.C. in Egypt. However, modern filtration began much later. John Gibb's slow sand filter, built in 1804 in Scotland, was the first filter used for treating potable water in large quantities. Slow sand filters spread rapidly, with the first one in the United States built in Richmond, VA, in 1832. A set of slow sand filters adapted from English designs was built in 1870 in Poughkeepsie, NY, and is still in operation.

A few decades after the first slow sand filters were built in the U.S., the first rapid sand filters were installed. The advent of rapid sand filtration is linked to the discovery of coagulation. By adding certain chemicals (coagulants) to turbid water, the material in the water could be made to clump together and quickly settle out. Using coagulation, clear water for filtration could be produced from a turbid, polluted streams. By the end of the nineteenth century, there were ten times as many rapid sand filters in service as the slow sand type. Currently, slow sand filtration is only considered economical in unusual cases. The diatomaceous earth filter was developed by the U.S. Army during WWII. They needed a filter that was easily transportable, lightweight, and able to produce pure drinking water. The diatomaceous earth filter is used in smaller systems, but is not commonly part of water treatment plant (Romalho, 1977).

2.6.1.1 Primary Treatment

The objective of primary treatment is the removal of settleable organic and inorganic solids by sedimentation, and the removal of materials that will float (scum) by skimming. Approximately 25 to 50% of the incoming biochemical oxygen demand (BOD5), 50 to 70% of the total suspended solids (SS), and 65% of the oil and grease are removed during primary treatment. Some organic nitrogen, organic phosphorus, and heavy metals associated with solids are also removed during primary sedimentation but colloidal and dissolved constituents are not affected. The effluent from primary sedimentation units is referred to as primary effluent (FAO, 1992).

2.6.1.2 Secondary Treatment

The objective of secondary treatment is the further treatment of the effluent from primary treatment to remove the residual organics and suspended solids. In most cases, secondary treatment follows primary treatment and involves the removal of biodegradable dissolved and colloidal organic matter using aerobic biological treatment processes. Aerobic biological treatment is performed in the presence of oxygen by aerobic microorganisms (principally bacteria) that metabolize the organic matter in the wastewater, thereby producing more microorganisms and inorganic end-products (principally CO2, NH3, and H2O). Several aerobic biological processes are used for secondary treatment differing primarily in the manner in which oxygen is supplied to the microorganisms and in the rate at which organisms metabolize the organic matter.

High-rate biological processes are characterized by relatively small reactor volumes and high concentrations of microorganisms compared with low rate processes. Consequently, the growth rate of new organisms is much greater in high-rate systems because of the well controlled environment. The microorganisms must be separated from the treated wastewater by sedimentation to produce clarified secondary effluent. The sedimentation tanks used in secondary treatment, often referred to as secondary clarifiers, operate in the same basic manner as the primary clarifiers described previously. The biological solids removed during secondary sedimentation, called secondary or biological sludge, are normally combined with primary sludge for sludge processing.

Common high-rate processes include the activated sludge processes, trickling filters or biofilters, oxidation ditches, and rotating biological contactors (RBC). A combination of two of these processes in the series as biofilter followed by activated sludge is sometimes used to treat municipal wastewater containing a high concentration of organic material from industrial sources (FAO, 1992).

2.6.1.2.1 Activated Sludge

In the activated sludge process, the dispersed-growth reactor is an aeration tank or basin containing a suspension of the wastewater and microorganisms, the mixed liquor. The contents of the aeration tank are mixed vigorously by aeration devices which also supply oxygen to the biological suspension. Aeration devices commonly used include submerged diffusers that release compressed air and mechanical surface aerators that introduce air by agitating the liquid surface.

Hydraulic retention time in the aeration tanks usually ranges from 3 to 8 hours but can be higher with high BOD5 wastewaters. Following the aeration step, the microorganisms are separated from the liquid by sedimentation and the clarified liquid is secondary effluent. A portion of the biological sludge is recycled to the aeration basin to maintain a high mixed-liquor suspended solids (MLSS) level. The remainder is removed from the process and sent to sludge processing to maintain a relatively constant concentration of microorganisms in the system. Several variations of the basic activated