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A STUDY ON VARIOUS DESIGN SHAPE OF COMMERCIAL GRANULAR ACTIVATED CARBON FOR TEXTILE WASTEWATER FILTERATION

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ABSTRACT

In Malaysia, an increasing number of hazardous compounds are being discharged into the mainstream and downgrade the water quality. Textile industry was an example from which pollutants produced and discharged to our mainstream. The main pollution source of textile wastewater comes from the dyeing and finishing process included with the present of high suspended solid (SS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), colour, phosphate and other soluble substances. Most of these can be harmful if discharged directly to the mainstream without any precaution. Polluted water can be treated with the use of activated carbon as a media of adsorber. Therefore, this project is aimed to study the effect of using various design shape of commercial granular activated carbon (GAC) for the textile wastewater filteration purposes. Seven types of pollutants contributor will be observed which are total suspended solid (TSS), BOD, COD, colour, phosphate, nitrate and sulfate to determine the best design shape. As a result four types of different GAC design show different results of filteration with the best BOD, colour, COD, TSS, nitrate and sulfate removal was hollow cylinder granular activated carbon (HCGAC), solid granular activated carbon (SGAC)-I, SGAC-II, SGAC-I, SCGAC-III and SCGAC-I respectively. SCGAC-I design presented to be the best design shape for the filteration. All the design failed to remove phosphate because of GAC source. This finding could help textile industries to determine and consider the novel filteration system in order to ensure textile effluent treated effectively.

Keywords: textile industry, pollutants, granular activated carbon, design shape, novel filteration system.

INTRODUCTION

Water pollution is a terrible disaster among developed and developing countries. This happened when the wastewater is discharged directly to the sea or river without properly filtered. In the textile industry, the main pollution source of wastewater comes from the dyeing and finishing. High suspended solid, COD, BOD, heavy metals, colour, acidity and other soluble substances are commonly present in textile wastewater.

Many researchers claimed they have successed to remove colour, BOD, and COD and treating the non-biodegradable textile effluent. Reduction-biological treatment system for the decolourization of non-biodegradable textile dyeing is reported to be a successful technique to remove BOD, COD, and total suspended solid (TSS) (Ghoreishi and Haghighi, 2003). Dyestuff wastewater having high salinity, colour and non-biodegradable organic concentration can be treats using Fenton's oxidation, physical adsorption and fixed bed biofilm process (Dae-Hee *et al*., 1999).

Anaerobic treatment of textile wastewater studied was possible to remove COD, BOD and color with the supplementation of an external carbon source in the form of glucose (Walker and Weatherly, 2001). An anaerobic technique has been applied to azo-reactive dye aqueous solution and cotton textile wastewater in order to eliminate the colour. The biodegradation ability of cotton textile wastewater was also examined without the addition of external substrate supply (acetic acid) resulting to poor decolourization results. However, anaerobic digestion of the same wastewater using the acetate-consuming bacteria and acetic acid as an external substrate supply lead to the complete decolourization (Jen and Demirer, 2003).

GAC is the common material applied in wastewater treatment. The selection of activated carbon particle size and figure are depending on the application. Economically, carbon is made from waste material such as oil palm shell, coconut shell and nutshell or utilize from coal. For example, bamboo waste activated carbon (BMAC) was produced using chemical activation and then treat textile wastewater. The effects of three preparation variables activation temperature, activation time and H_3PO_4: precursor (wt%) impregnation ratio on the color and COD removal were investigated. The optimum condition was obtained by using temperature of 556 ◦C, activation time of 2.33 h and chemical impregnation ratio of 5.24, which resulted in 93.08% of color and 73.98% of COD (Ahmad and Hameed, 2009).

Another researchers indicated that AC could be used as an adsorbent to remove the anionic dyes from single and binary pollutants systems (Niyaz Mohammad *et al*., 2011).

The use of commercial GAC made from coconut shell study was reported by using GAC-SBR (sequencing batch reactor) system. The objective is to treat wastewater containing direct dyes (Suntud and Jutarat, 2008).

In this study, commercial GAC was formed into different design shape called as SGAC and HCGAC. SGAC consists of three types whereas HCGAC only one type. Raw textile wastewater will be treated using these 4 types of GAC and the performance of filteration will be observed to determine the best GAC design.

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CHARACTERIZATION

Effluent

Textile wastewater effluent samples were accumulated from Ramatex Textiles Industrial Sdn Bhd factory, which is situated in Batu Pahat, Johor Bahru, South of Malaysia. Table-1 shows the result by chemical and biological treatment system implemented in the factory.

Table-1. Effluent characterization.

Parameters	Unit	Value
pH value	pH	7.3
BOD	mg/L	37.7
COD	mg/L	361
TSS	mg/L	230
Nitrate	mg/L	13
Sulfate	mg/L	299
Phosphate	mg/L	18.9
Color	ADMI	260

From the table colour, COD, TSS and sulfate are the major problem faced by the factory to be removed. Therefore, more efficient treatment system should be designed in order to maximize the remediation result**.**

Raw textile wastewater

Table-2 shows the results for raw wastewater characterization collected from Ramatex Textile Industries Sdn Bhd. Samples are collected for 5 times according to Monday, Tuesday, Wednesday, Thursday and Friday. Each day shows the different parameters value.

Table-2. Raw textile wastewater characterization.

Parameters	Unit	Value
pH value	pH	8.10 – 9.92
BOD	mg/L	70.0 – 83.6
COD	mg/L	500 -610
TSS	mg/L	140 - 300
Nitrate	mg/L	7.5 – 14.0
Sulfate	mg/L	250 - 350
Phosphate	mg/L	15.0 – 13.1
Colour	ADMI	200 - 500

MATERIAL AND METHOD

Source of granular activated carbon

In this work, commercial GAC is used. The material is taken from Asian Pasific Company in Johor Bahru. The GAC is activated by steam method and made from oil palm shell. Naturally, GAC also can be made from various nutshells (Farid Nasir *et al*., 2002), oil palm biomass (Farid Nasir and Arshad, 2011) either by physical or chemical activation method.

Characterization of activated carbon

Porous properties of the commercial activated carbon are evaluated by nitrogen adsorption method. Adsorption and desorption isotherms of N_2 on the activated carbon is measured at 77 K by an adsorption apparatus (Micromeritics ASAP machine). Brunauer, Emmet and Teller (BET) surface area was determined by BET method and the value is 800 m^2/g.

Schematic diagram for the filteration rig

Figure-1 shows the schematic diagram for the textile wastewater filteration rig. The flow rate of the raw textile wastewater is fix to 0.07 L/min.

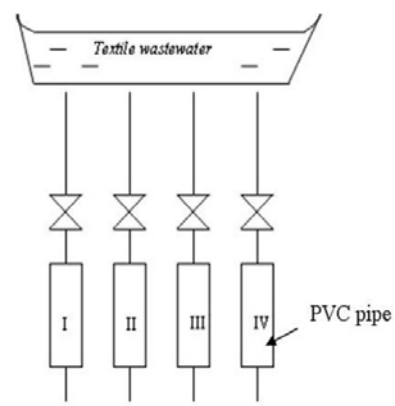

Figure-1. Rig schematic diagram (Column I,II,III- SGAC with inner diameter 3.4, 5.7 and 8.5 cm respectively. Column IV- HCGAC with GAC thickness 2.25 cm).

Design shape of GAC

Mass of GAC is fixed to 200 grams per filtration and the size is approximately 0.3 cm. Table-3 shows the details of SGAC and HCGAC design. Sepiolite binder is used to support the HCGAC form before the treatment process can be started. Treatment process was done by subjected GAC to heat under nitrogen at 500 ºC. This treatment makes the GAC strong enough to be used in adsorption from solution process (Rodriguez-Reinoso *et al*., 2001). Figure-2 shows the overall design concept together with the cross section view of SGAC and HCGAC.

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Table-3. GAC design shape detail descriptions.

Items	Abbreviation	Descriptions
I	SGAC-I	Solid Granular Activated Carbon, Polyvinyl Chloride (PVC) pipe inner diameter: 3.4 cm
II	SGAC-II	Solid Granular Activated Carbon, PVC pipe inner diameter: 5.7 cm
III	SGAC-III	Solid Granular Activated Carbon, PVC pipe inner diameter: 8.5 cm
IV	HCGAC	Hollow Cylinder Granular Activated Carbon, Thickness: 2.25 cm

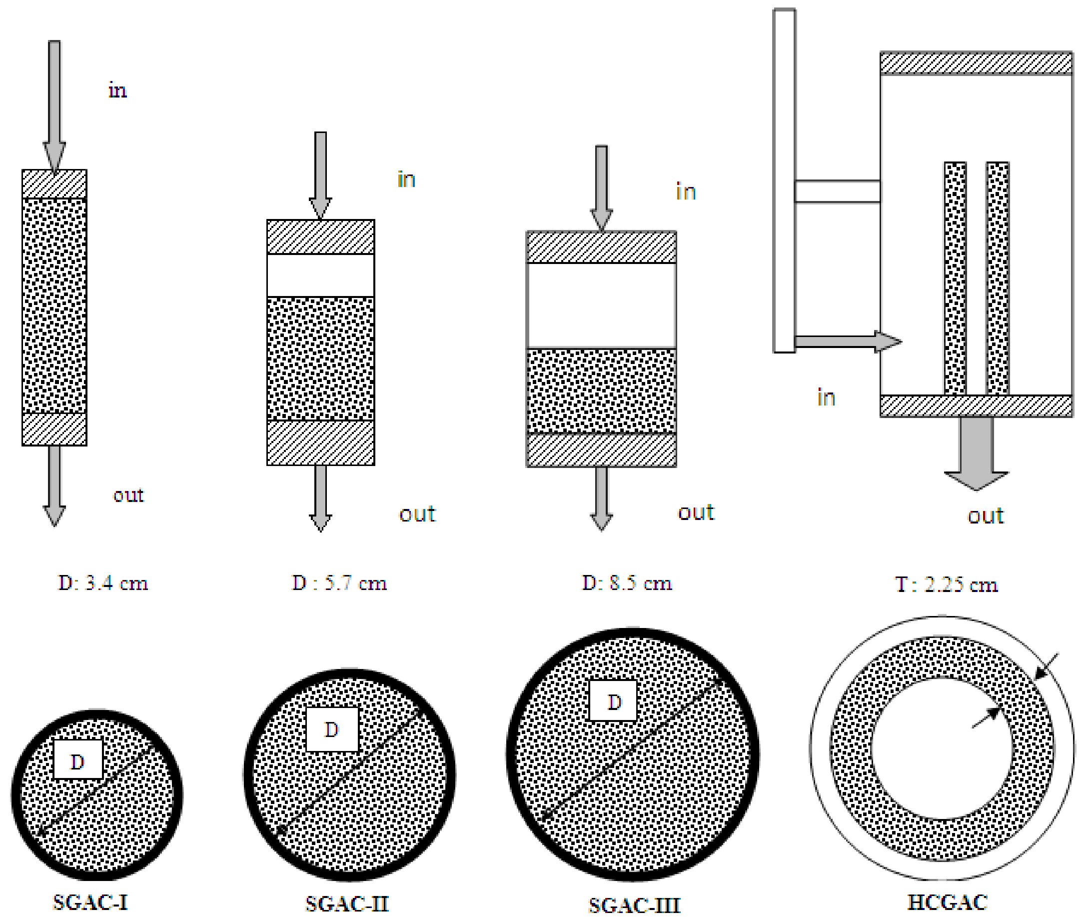

Figure-2. Design concepts and the cross section view of SGAC and HCGAC.

Table-4. Treatment (%) by GAC shape.

Shape	Percentage(%) of Removal						
	BOD_5	COLOR	COD	TSS	NITRATE	SULFATE	PHOSPHATE
SGAC-I	7.9	67.8	8.3	92.9	60	35.7	-246.5
SGAC-II	18.6	56.8	50.4	64.3	53	32.9	-317.2
SGAC-III	22.4	50.7	29	57.1	33.3	14.3	-115.9
HCGAC	31.8	34.7	3.5	74.3	11.1	11.4	-49.3

RESULT AND DISCUSSIONS

As shown in Table-4, all GAC shape successfull to treat the textile wastewater pollutants except phostphate. The value of phosphate was increased and the highest was shown by using SGAC-II design. It must be a correlation between phosphate and oil palm shell based

GAC. After further research about the oil palm shell characteristic, it was confirm that phosphate is naturally exist in the oil palm shell in the form of phosporous. Using a special reagent, a mix GAC and distill water solution was prepared. After 5 minutes the solution color change from no colour to deep blue colour, indicating that the solution was rich with the phosphate ion. Although carbonization and activation process was done but the phosphate still cannot be removed. SGAC-II leads with the highest phosphate additional value with almost 320% increasing. Column dimension was the main factor can be highlighted. The smaller column diameter and the shorter column the more phosphate will flush into the container. For the next experiment, GAC from oil palm shell can be avoided in order to make sure phosphate can be removed.
SGAC-I removed 92.9% of TSS, 67.8% of color, 60% of nitrate and 35.7% of sulfate. Retention time was the factor to these achievements. Wastewater took much time to go through the small column and contact to GAC efficiently. HCGAC and SGAC-II remove 31.8% BOD_5 and 50.4% COD respectively. GAC surface area contact was the cause that contributes to the effectiveness of BOD_5 and COD removal.

Level arrangement in terms of removal performance of applied GAC design shape can be shown as below. Performance of TSS, colour, nitrate and sulfate removal can be explained as below:

SGAC-I > SGAC-II > SGAC-III > HCGAC →
Less performance

Performance of BOD_5 removal:

HCGAC > SGAC-III > SGAC-II > SGAC-I →
Less performance

Performance of COD removal:

SCGAC-II > SGAC-III > SGAC-I > HCGAC →
Less performance

Performance of phosphate removal:

HCGAC > SGAC-III > SGAC-I > SGAC-II →
Less performance

From the performance arrow, it can be seen that SGAC and HCGAC have their own strength in terms of textile wastewater treatment. Hybrid design could be suggested to be the best way to get high performance of treatment but for sure to treat phosphate from textile wastewater other raw material need to replace oil palm shell.

CONCLUSIONS

Different shape design of GAC gave the variety of filteration result. GAC from oil palm shell based fail to remove phosphate from the textile wastewater. Phosphate exist in oil palm shell naturally. It cannot be remove by burn or wash it with distill water. Therefore other raw material need to use to replace oil palm shell. GAC from oil palm shell success full removed other pollutants. Design shape was additional method that could help to optimize the filteration process. The treatment or filteration process shows, SGAC and HCGAC treat the wastewater and remove other pollutants by selective. Therefore, combined SGAC and HCGAC together in a hybrid treatment system could be the other way to ensure all pollutants in textile wastewater removed successfully.

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