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Performance of Coconut Husk Activated Carbon (CHAC) for Polluted River Water Treatment

Dilaeleyana Abu Bakar Sidik*[1], Angel Leah Norman[1], Vyranath A/L Ko Mon[1], Pavitraa A/P Kuichalan[1], Aida Muhamad[1], Nurul Izzati Mohd Ismail[1], Nur Hanis Hayati Hairom[2,3]

[1]Centre for Diploma Studies,
Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, Pagoh, Muar, 84600, MALAYSIA

[2] Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, Hab Pendidikan Tinggi Pagoh, Jalan Panchor 86400, Muar, Johor, MALAYSIA

[3]Microelectronic and Nanotechnology - Shamsuddin Research Centre, Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Parit, Raja, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

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Abstract: In this study, the coconut husk activated carbon (CHAC) was synthesized via chemical activation and the performance in the treatment of polluted river water with palm oil mill secondary effluent (POMSE) were evaluated. CHAC was produced by carbonizing the coconut husk fibers and activation via potassium hydroxide (KOH) and dried to form CHAC. The CHAC produced was used as an adsorbent in treating polluted river water with POMSE. The best condition of initial concentration of adsobates (0-100 %) and mixing time (30-120 min) in terms of color, COD and turbidity removal were evaluated. The result indicates 50 % diluted polluted river water with POMSE using CHAC at 60 mixing time resulting higher removal of colour (78.7 %), COD (69.0 %) and turbidity (66.7 %). Thus, it can be concluded that the coconut husk activated carbon has plays an important part in the treatment of palm oil mill secondary effluent in good quality.

Keywords: Activated Carbon, Adsorption, Coconut Husk, Palm Oil Mill Secondary Effluent

Corresponding author: dila@uthm.edu.my

1. Introduction

Malaysia is known as the second largest producer of palm oil mill after Indonesia due to having tropical climate and make this country prosperous in natural resources. In Malaysia, extensive research and development efforts have resulted in a smattering of notable pollution abatement success stories. Malaysia has gained great expertise in developing technology for both upstream and downstream processing as a result of its pioneering role in pursuing a sustainable palm oil business. While the oil palm sector has been acknowledged for its role to economic prosperity, it has also indirectly contributed to environmental degradation as a result of the huge volumes of by-product produced during the oil extraction process. The palm oil industry produces liquid waste called palm oil mill effluent (POME) which is one of the hardest liquid wastes to treat. Although, the POME has been treated before being released to the water stream, harmful organic pollutants are still present in the effluent. Pre-treated POME is known as palm oil mill secondary effluent (POMSE) has been through the treatment processes, it is still rich in colour, chemical oxygen demand (COD), biochemical oxygen demand (BOD) and turbidity which causes it to not meet the standard discharge criteria by the department of environment (DOE) [1]. It is vital to inspect the water quality of polluted river water with POMSE. This is due to the high concentrations of COD and BOD in the water, causing it to affect the quality of the river water.

Adsorption is a known method that is often used for filtering in water treatment systems. It has been found to be superior compared to other chemical and physical methods for wastewater treatment in terms of its capability for efficiently absorbing broad range of pollutants, fast adsorption kinetics and its simplicity of design. Commercially accessible activated carbons, on the other hand, are still expensive because of the utilization of non-renewable and relatively high-cost starting materials like coal, which is problematic in pollution control applications [2,3]. The adsorption on activated carbon has commonly been done for removal of dye [4,5], on the contrary, no study has utilized adsorption in the treatment of polluted river water with POMSE.

Activated carbon (AC) possesses small particle size and low-volume pores that increases the available surface area for adsorption or chemical reactions. AC from the biomass or natural based is ecologically friendly due to their efficacy in removing contaminants and heavy metals from the wastewater, as well as the availability of raw materials, cheap cost, and ease of process design [6,7]. Several researchers have manufactured AC using agricultural wastes such as bamboo [8,9], sugarcane bagasse [10] and corn cob [11,12]. In this study, coconut husk is utilized for the purpose of producing AC via chemical activation with KOH.

Coconut husk is an abundantly available agricultural waste that can be utilized for better purposes. One of the ways is to convert it into activated carbon. With this, synthesis of activated carbon from coconut husk gives dual advantage to the environment as well as the industry. Firstly, the process solves the problem of coconut husk disposal in the agricultural field. Moreover, this agricultural by-product can be converted into a useful resource which is AC for the removal of colour, chemical oxygen demand (COD) and turbidity in POMSE [13]. Therefore, this research aimed to synthesize coconut husk activated carbon via chemical activation with KOH. In addition, elucidation on the synthesis activated carbon towards polluted river water with POMSE treatment by assessing the colour, COD and turbidity removal.

2. Materials and Methods

2.1 Materials

Coconut husk were collected from an agricultural area in Perlis, Malaysia. The polluted river water was collected from Sg Benut River. Palm oil mill secondary effluent (POMSE) was obtained from

Sindora Palm Oil Mill located at Kluang, Johor, Malaysia. The samples were collected in air-tight container and stored in a chiller at 4 °C for the prevention of contamination. Potassium hydroxide (KOH) and hydrochloric acid (HCl), reagents were purchased from BT Scientific.

2.2 Preparation of coconut husk activated carbon (CHAC)

Coconut husk fibers were washed using tap water to eliminate impurities. The fibers were dried in the oven overnight at 105 °C before further crushed with a grinder to give powder form. The coconut powder is then placed into the furnace for 90 minutes at 400 °C. After that the carbonized samples was cooled down at room temperature. Then the carbonized samples were activated chemically with KOH using wet impregnation method. The carbonized sample was soaked in KOH solution with the ratio 2:1 (w/v %) in a water bath for one hour at 85 °C. The CHAC is dried in an oven for 240 minutes at 105 °C before further washing with 0.5 M of hydrochloric acid and distilled water. The washing step was done repeatedly until the filtrate solution reached pH 7. The neutralized samples were then filtered and the precipitate CHAC samples was dried in the oven for four hours at 105 °C.

2.3 Adsorption of polluted river water with POMSE

The performance of CHAC as an adsorbent was evaluated on the treatment of polluted river water with POMSE. The 5 g of CHAC was mixed with 10 ml of adsorbates aqueous solution (polluted river with POMSE) at different initial concentration (0, 50, and 100 %). The batch adsorption was carried out in an incubator shaker under constant agitation speed of 60 rpm at temperature 30 °C for 120 minutes to treat the polluted river with POMSE. Next, the treated solution with CHAC adsorbent was then separated by filtration. The adsorbates were collected prior to water quality analysis. The similar procedures were repeatedly for different time (30-120 minutes) to treat the polluted river with POMSE.

2.4 Analytical method

Adsorbates of polluted river water with POMSE before and after treatment were characterized in terms of colour, COD and turbidity. The colour intensity was determined with Hach Digital Reactor Block (DR6000) according to standard Hach method 8025. The colour intensity of samples were analyzed at wavelength 280 nm as per Platinum-Cobalt (Pt/Co). COD was digested by using COD reactor and determined using Hach Digital Reactor Block (DR6000). The data for turbidity was taken using Oakton T-100 turbidity meter. The percentage removal of the colour, COD and turbidity from the sample polluted river water with POMSE can be deduced by using the following equation:

$$R = \frac{C_0 - C_t}{C_0} \times 100 \qquad \textbf{Eq. 1}$$

where R is the percentage removal, C_0 is the initial parameter reading, and C_t is the parameter reading at reaction time, t (minute).

2.5 Fourier Transform Infrared (FTIR) characterization of CHAC

Functional group of CHAC was characterized by using FTIR (Agilent Tech cary 600 series) with wavelength ranging from 500-4000 cm^{-1}. FTIR spectroscopic was performed to represent the functional group compositional existence in coconut husk and CHAC before and after adsorption.

3. Results and Discussion

3.1 Adsorption of polluted river water with POMSE with different of initial concentration

The effect of initial concentration of polluted river water with POMSE ranging from 0 % to 100 % on the colour, COD and turbidity removal has been investigated.

Table 1: Characteristics of Polluted River with POMSE before and after treatment at different adsorbates concentration

Parameter	Concentration					
	0 %		50 %		100 %	
	Before	After	Before	After	Before	After
Colour (Pt/Co)	871	663	434	272	221	141
Chemical Oxygen Demand COD (mg/L)	622	536	316	232	177	166
Turbidity (NTU)	4.10	4.90	2.99	2.57	1.33	1.63

Table 1 shows the characteristic in terms of colour, COD and turbidity before and after treatment at different adsorbates concentration of 0 %, 50 % and 100 %. The result shows continuous reduction for colour and COD. However, the results show at 0 % dilution, both colour and COD of sample after treatment show a higher difference compared to 50 % and 100 % dilution. This occurrence might be due to the higher value of pollutants present at 0 % dilution which causes more pollutants to be adsorbed, thus producing a higher result compared to 50 % and 100 % dilution. On the other hand, the results at 50% dilution, the turbidity of sample after treatment is lowered compared to 0 % and 100 % dilution. This phenomenon might be due to the amount of pollutant on the sample at 50 % dilution is sufficient to complete the adsorption process compared to 0 % and 100 % dilution.

Figure 1 shows the results of percentage removal of colour and COD for concentration of polluted river with POMSE. The 50% dilution showed the higher in colour (37.3 %) and COD (26.6 %) removal respectively. The lower concentration of contaminants in 100 % might reduce the contaminants that occupy the CHAC active sites during the adsorption process, thus decrease the performance of colour and COD removal. Meanwhile at the higher concentration of pollutants (0 %) indicate lower colour (23.9 %) and COD (13.8 %) removal due to the more active sites of CHAC were occupy by the pollutant of polluted river with POMSE. Therefore, it will reduce the degradation of pollutant in the sample and resulting lower percentage removal for colour and COD after the adsorption process. As a result, it can be determined that a 50 % dilution is best condition for coconut husk activated carbon adsorption on polluted river with POMSE samples.

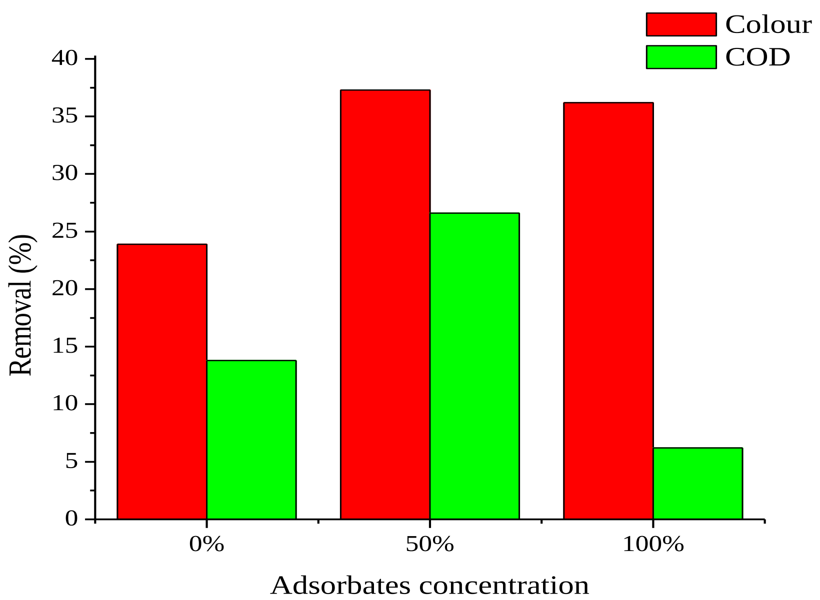

Figure 1: Adsorbates characteristic removal for different concentration

3.2 Adsorption of polluted river water with POMSE with different time

The effect of time on the adsorption performance of polluted river water with POMSE in terms of colour, COD and turbidity analysis were evaluated in this study.

Table 2: Characteristics of Polluted River with POMSE after treatment at different time

Parameter	Time (min)				
	0	**30**	**60**	**90**	**120**
Colour (Pt/Co)	663	272	141	281	271
Chemical Oxygen Demand COD (mg/L)	536	232	166	234	239
Turbidity (NTU)	4.90	2.57	1.63	2.02	1.81

Table 2 shows the data analysis of the water quality parameters of adsorbates from 0 to 120 minutes of adsorption process using 50 % diluted polluted river water with POMSE. The result has an improvement throughout the span of 120 minutes. It is clearly seen that the turbidity value at 60 minutes is 1.63 NTU and it was the lowest value compared to 30, 90 and 120 minutes. This indicates that after treatment, the sample has less suspended particles. The value of colour and COD at 60 minutes is 141 Pt/Co and 166 mg/L respectively. This phenomenon can be explained due to more time of contact between adsorbent and adsorbates thus will increase the rate of adsorption process and enhances the adsorptive removal of pollutants.

Figure 2 shows the comparison of percentage removal (%) of parameters colour, COD and turbidity on 50 % diluted polluted river with POMSE through adsorption process. The removal was increased rapidly within the first 60 minutes, followed by much slower uptake until 120 minutes was attained. After 60 minutes, the highest percentage removal of turbidity (66.7 %), colour (78.7 %) and COD (69.0 %) are recorded. The higher removal at 60 minutes which due to the more POMSE molecules to be adsorbed by the active sites on the activated carbon which makes the removal increasing. Thus, at 60 minutes gives most significant effect on the removal of colour, COD and turbidity of polluted river with POMSE samples.

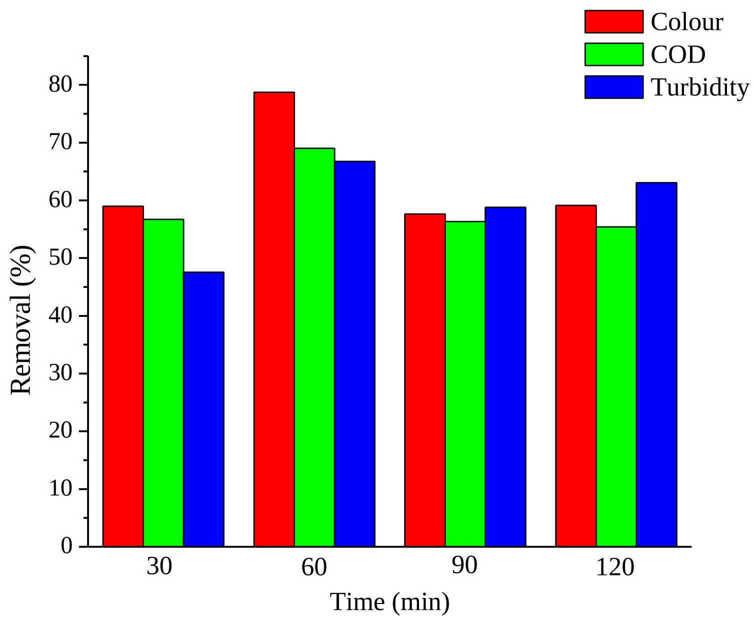

Figure 2: Adsorbates characteristic removal for different time

3.3 FTIR analysis of CHAC

The functional group composition of fresh coconut husk and CHAC at spectrum regions 500-4000 cm^{-1} is shown in **Figure 3**. The stretching vibration of O-H is shown in the wide band at 3724 cm^{-1}, indicating the presence of hydroxyl group in the coconut husk and CHAC. The stretching vibration of structural C=O groups, which characterize carbon from coconut husk, was shown by the active adsorption spectrum at 1600 cm^{-1} [14]. After activation of carbon with KOH, the peak at 2158 cm^{-1} and 2013 cm^{-1} is a characteristic of C≡C stretching vibration, indicating the presence of the alkyne group. The structure has several carbon bonds that act as hydrogen removers, and the oxygen atoms of that frequency may contain stretches of potassium (K) and alcohol (OH) groups [14.]

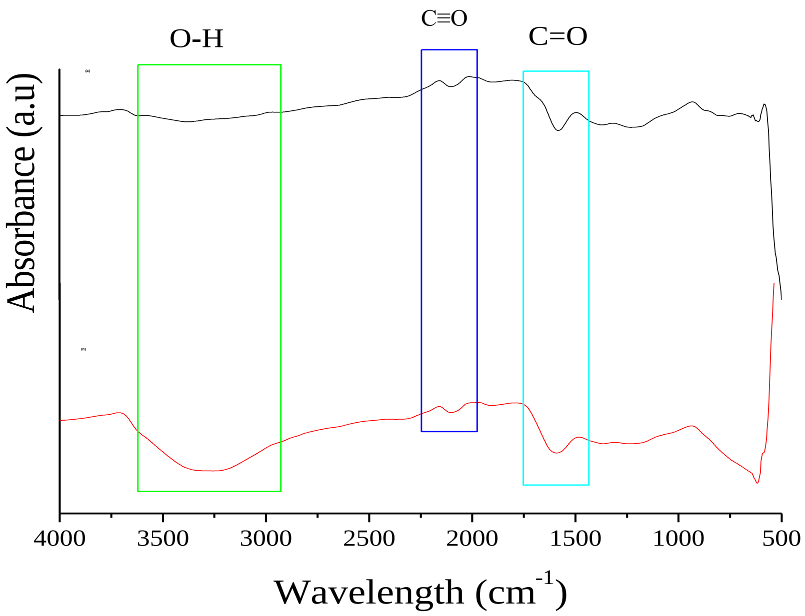

Figure 3: FTIR spectra of the fresh coconut husk and CHAC adsorbent

4. Conclusion

The CHAC absorption process is beneficial to the environment. The ability of coconut husk activated carbon to treat polluted river water with POMSE in terms of colour, COD, and turbidity removal was successfully studied in this project. The results revealed a considerable decrease in removal (%) absorption such as colour and COD from different sample concentrations of 0 %, 50 % and 100 %. It is found that adsorption in sample with 50 % concentration produced a significantly higher result compared to 0 % and 100 % with colour removal of 37.33 %, COD removal of 26.58 % and turbidity removal of 14.05 %. Palm Oil Mill Secondary Effluent (POMSE) is having tremendous difficulties achieving effluent regulation of removal absorption 80 % and above. Therefore, it is important to find a low-cost, long-term polishing solution while also reducing pollutants in our environment.

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