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ADSORPTION OF METHYLENE BLUE USING OIL PALM (ELAEIS GUANEENSIS) FRONDS AS ACTIVATED CARBON

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ABSTRACT

The application of underutilized resources and eco-friendly adsorbents is studied as the substitute for the commercially available activated carbon which occurred at high cost. The carbon type adsorbents were prepared from oil palm frond (OPF). It is a domestic waste that comfortably used to eradicate basic dye, which is methylene blue (MB) from aqueous solution using the adsorption removal method. The oil palm frond activated carbon is used to adsorb methylene blue as one of the effluents from the textile industry by varying the concentration, mass of adsorbent used and contact time. The findings disclose that the most efficient condition to remove the color intensity of methylene blue is by using 0.4g mass of OPF activated carbon at 10 minutes of contact time, which was tested on the lowest concentration of 20 ppm. The results from this research have proven that the percentage removal of dye decreases as the initial dye concentration increases. The percentage removal on the effect of adsorbent dosage increases with the increase of adsorbent dosage used. In overall, the findings give us hope to have a better water quality which is free from pollution.

Keywords: decolorization, adsorbent, oil palm biomass, basic dye.

1. INTRODUCTION

Palm trees or their scientific name is Elaeis Guaneensi is very well known in Malaysia. They are planted on 4.49 million hectares of land in Malaysia by 2008 [1], and they are identified as one of the economic sources for Malaysia. However, the oil palm fronds are one of the agricultural wastes from the oil palm industry [2] which are usually left aside in the plantation field and could cause the environmental pollution. They fall to the ground in the plantation and are left to decay between the rows of the palm trees in the plantation, thus making them as underutilized waste [3]. Hence, choosing the oil palm frond wastes as one of the available adsorbents helps to reduce the environmental pollution in Malaysia.

Adsorbent is produced when it is carbonized at a high temperature. As a result, activated carbon is generated. A good adsorbent is described to have a large surface area, high capacity, low cost and it can be regenerated [4]. There are many types of adsorbent that can be identified such as silica gel, activated alumina, carbons, clay, zeolites and so forth. As for the carbon type of adsorbent, it can be generated from the things around us that are left aside and unused. One of the examples is biomass from oil palm trees. Since oil palm frond wastes are available throughout the whole year and their cost is low, they can be exploited in the production of activated carbon at a low cost which can be applied in the wastewater treatment. Thus, this could help in overcoming the problem of high cost which commercially available activated carbon.

Activated carbons are a non-graphitic form of black carbonaceous with a porous structure. It is always known as a very different and versatile component used for adsorption due to its large surface area, microporous structure, high capacity of adsorption and they have a reactive surface area [5].

Adsorption is the most suitable method to be used in the removal of dye due to its effortlessness of design and ease of operation. It is the building up of a substance at the interface between two different phases, where it is a liquid-solid interface or a gas-solid interface [6]. In other words, adsorption can be simplified as the sticking of particles on a free surface.

Due to the initial cost, flexibility and simplicity of design, ease of operation, insensitivity to toxic pollutant and adsorption has been found to be more preferred as compared to other techniques for water treatment [1]. There is no formation of dangerous substances in the adsorption process. It is extensively used to remove certain groups of chemical contaminants from water [6].

Furthermore, the adsorption by activated carbon shows the pros where it is a good removal of a wide variety of dyes [6]. On the other hand, the limitation to this removal technique is that the commercially available activated carbon is very expensive. Activated carbon cannot be distinguished by any typical chemical formula. The existence of elements for example oxygen, sulfur, hydrogen and nitrogen in the forms of functional group is often related to activated carbon. They are bonded chemically to the structure of the activated carbon [7].

Methylene blue is one of the types of basic dye which is available in a powdered form, with the physical appearance of shimmering-dark-chocolate-colored. The molecular formula for methylene blue is $C_{16}H_{18}N_3SCl$, while molecular weight is 319.85 g/mol as found by [8]. It is found that the wavelength of the methylene blue is 665 nm after analyzed with the Ultra Violet-Visible (UV-VIS) spectrophotometer. Methylene blue has the melting point in the range of 100-110°C. It is also known as basic blue.

The medical field is one of the applications of methylene blue. Recently, the severe central nervous system toxicity which is variously expressed as

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encephalopathy, serotonin syndrome (SS) or serotonin toxicity is claimed to be originated by methylene blue [9]. Methylene blue can expose harmful and bad effects such as difficulty to breath, diarrhea, nausea and also vomiting to human beings even though it is not classified as a toxic chemical [10].

2. MATERIALS AND METHODS

Adsorbents

The samples of oil palm fronds (OPFs) were taken from the nearby oil palm plantation in Bukit Besi, Terengganu. Only one quarter of the end side of the frond was taken as the sample. The OPFs were cut into small pieces by using a chopper obtained from the nearby local. Then, they were washed with distilled water to eliminate the impurities, oven-dried for 3 hours at 200°C and then carbonized in the furnace for 3 hours at 500°C to produce activated carbon. The powdered adsorbent was crushed in a domestic grinder and sieved to obtain the desired size of particle (45-150 μm). The adsorbent was stored in an airtight polyethylene bag until it was used. A Fourier transform infrared spectroscopy (FTIR) spectrum was used to detect the functional groups composed in OPF. These groups were responsible for the binding of the MB dye and OPF activated carbon.

Adsorbate

The main stock dye solution of 1000 ppm was prepared. About 1 g of methylene blue powder was weighed by using the weighing machine, and was diluted into 1000 ml volumetric flask with distilled water. Next, it was wrapped completely with aluminum foil. Different concentrations of dye solution were prepared from the main stock dye solution. Consequently, some amount of the main stock dye solution was withdrawn by using a micropipette and was diluted with distilled water to prepare different concentrations of methylene blue solution.

Batch adsorption procedure

About 50 ml of methylene blue solution at 20 ppm concentration and constant initial pH value of 6.5 and 0.2 g of adsorbent were poured into an Erlenmeyer flask of 100 ml. The mixture was stirred at 100 r.p.m for 10 minutes, then the mixture of the powdered adsorbent and methylene blue solution was separated using a centrifuge at 2500 rotations per minute (r.p.m). The obtained color intensity of methylene blue solution was tested by using the UV-VIS spectrophotometer at a wavelength of 665 nm. The experiment was then repeated with different initial dye concentrations (30 and 40 ppm), different adsorbent doses of 0.4 and 0.6 g and contact time of 30 minutes.

The percentage of dye removal was expressed as follows, where C_0 and C_f refer to the initial and the final dye concentration (ppm) respectively.

3. RESULTS AND DISCUSSION

The Effects of initial dye concentration

Figure-1 shows the percentage removal at 10 minutes. For adsorbent dosage of 0.2 g, the trending of the percentage removal decreases from 88.5% to 47.8% and then increases to 58.5% at 40ppm as the initial dye concentration increases. This can be resulted from the increase in the intra particle diffusion [11].

The trend on the 0.4 and 0.6 g is suitable with the general findings that stated the percentage removal decreases with the increase of initial dye concentration [6]. Based on Figure-2 and Figure-3, the pattern of the graph is similar with Figure-1.

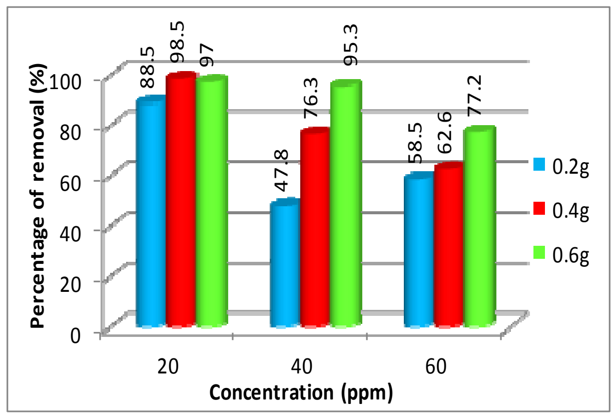

Figure-1. The effects of initial concentration and adsorbent dose on the percentage removal of dye at a constant initial pH and contact time of 10 minutes.

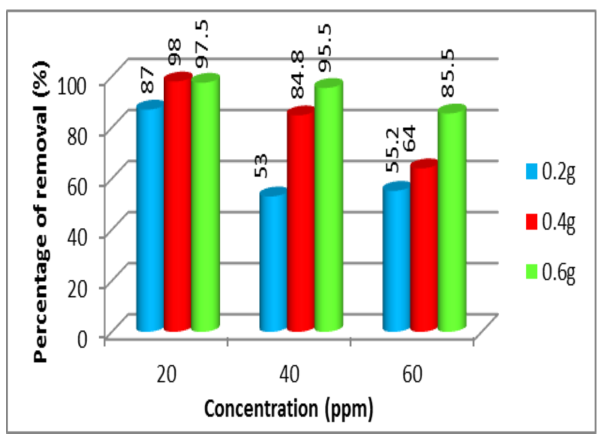

Figure-2. The effects of initial concentration and adsorbent dose on the percentage removal of dye at a constant initial pH and contact time of 20 minutes.

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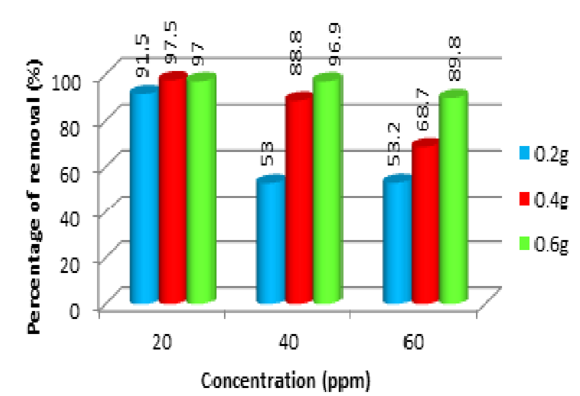

Figure-3. The effects of initial concentration and adsorbent dose on the percentage removal of dye at a constant initial pH and contact time of 10 minutes.

The effects of adsorbent dosage

The amount of surface available for an adsorption process and the mass of adsorbent can considerably affect the adsorption efficiency since adsorption is mainly a surface phenomenon [11]. Consequently, the effects of OPC activated carbon dosage on the removal of methylene blue dyes have been investigated at a constant initial pH of 6.5. It varied in initial dye concentrations (20, 40 and 60 ppm) and a range of contact time between 10-30 minutes.

The percentage of dye removal escalates as the amount of adsorbent dosage rises. The percentage removal of methylene blue at 20 ppm is represented in Figure-4. The trends show on the graph are similar, where it increases as the increase of adsorbent dosage to the amount of 0.4g. Afterward, it faces a slight drop when the adsorbent dosage is at 0.6g. This may happen because during the adsorption process, where there is a high number of unsaturated adsorption [11].

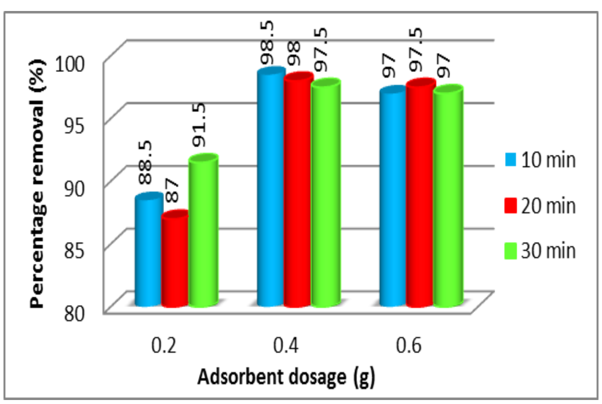

Figure-4. The percentage removal on the effect of adsorbent dosage at 20 ppm.

Figure-5 and Figure-6 represent the percentage removal on the effects of adsorbent dosage at 40ppm and 60ppm respectively. The observation from both graphs leads to the conclusion that they have a similarity, which is the pattern of the graph. Both graphs show that the percentage removal increases with the increment of adsorbent dosage. It enhances from 47.8% to 95.3% at 40ppm for 10 minutes of contact time while at 60ppm, the percentage removal increases from 58.5% to 77.2% for 10 minutes contact time. Thus, it can be concluded that both of the graphs obey the general finding.

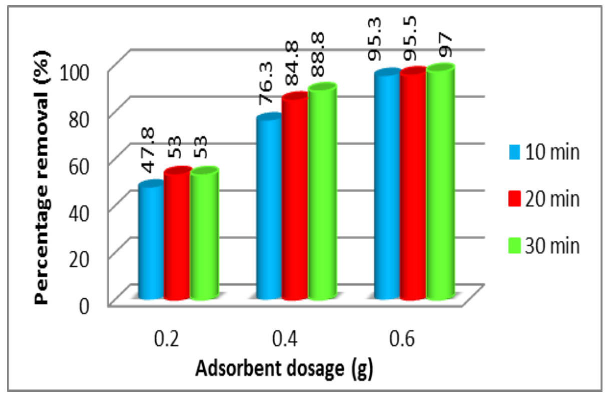

Figure-5. The percentage removal on the effect of adsorbent dosage at 40 ppm.

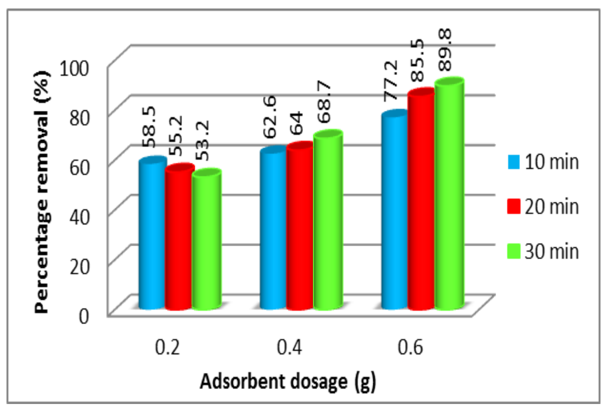

Figure-6. The percentage removal on the effect of adsorbent dosage at 60 ppm.

4. CONCLUSIONS

The production of natural adsorbent is the solution to the problem as it is available at a low cost. In this research, oil palm fronds were chosen to be the source of the natural adsorbent. This is due to the abundant large pile of oil palm fronds at many Malaysian plantations, which are underutilized that can lead to the environmental pollution to the nearby localities. Thus, water and environmental pollutions can be reduced by using the oil palm fronds to produce natural adsorbent. It also to replace the commercially available activated carbon, which is expensive. The results show that the new adsorbent from oil palm fronds is a capable adsorbent. It is cost effective for the removal of methylene blue with the removal efficiency of 98.5%. The data from the analysis has shown that the activated carbon from oil palm fronds with the highest removal efficiency decolorizes the methylene blue solution at the minimum time of 10 minutes only.

As for the recommendations, the adsorbent can be treated with chemicals such as NaOH and ZCl_2. These chemicals can help to enhance the capacity of adsorption. Next, the methylene blue solution which is very sensitive to UV light should be wrapped properly with aluminum foil so that the reaction between methylene blue solutions with the UV light could be slowed down. Moreover, the contact time of the mixture of the dye solution and adsorbent can be decreased to less than 10 minutes in order to observe the time taken for the equilibrium to take place. Subsequently, small particle size should be used to enhance the efficiency if the percentage removal of dye. The smaller the particle size of the adsorbent, the greater the surface area is available for the contact with the dye solution. Hence, the adsorption capacity increases.

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