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Removal Of Cresol Red And Reactive Black 5 Dyes By Using Spent Tea Leaves And Sugarcane Baggase Powder

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Graphical abstract

Abstract

Textile wastewater will be the major problems regarding the chemical pollution due to the color effluent that the textile industrial produced. The synthetic dye that will be found in another manufacturing which was can damage not only towards the environment but also a human health. The purpose of this research was to identify the solution for treating the wastewater. One of the pre-treatment to treat the wastewater was by physical method. The method that will be used was adsorption process by using synthetic dyes (Cresol Red and Reactive Black 5) and synthetic water (distilled water). This research will be conducted to determine which agricultural wastes (Spent Tea Leaves and Bagasse Powder) react with the synthetic dyes. Experiments were carried out with agricultural waste sample and the synthetic dyes at 1000ppm concentration. 50ml of both dyes will then mix with the 5 g of agricultural waste for 24 hours to show how the agricultural waste was effective adsorption to the removal of synthetic dyes. The adsorption of Cresol Red and Reactive Black 5 were measured and the most effective adsorption was spent tea leaves on Cresol Red dyes which was the percentage rate removal of adsorption was 68.55 %. The results indicate the higher removal rate shows the more adsorption capacity of the adsorbent.

Keywords:

Abstrak

Tekstil air sisa akan menjadi masalah utama mengenai pencemaran kimia akibat efluen yang berwarna yang dihasilakan oleh industri tekstil yang dihasilkan. Pewarna sintetik yang akan ditemui dalam satu lagi pembuatan yang boleh merosakkan bukan sahaja terhadap alam sekitar tetapi juga kesihatan manusia. Tujuan kajian ini adalah untuk mengenal pasti penyelesaian untuk merawat air kumbahan. Salah satu pra-rawatan untuk merawat air kumbahan adalah dengan kaedah fizikal. Kaedah yang akan digunakan adalah proses penjerapan dengan menggunakan pewarna sintetik (Cresol Red dan reactive Black 5) dan air sintetik (air suling). Kajian ini akan dijalankan untuk menentukan sisa pertanian (Daun Teh dan Serbuk Tebu) dapat bertindak balas dengan pewarna sintetik. Eksperimen dijalankan dengan sampel sisa pertanian dan pewarna sintetik pada kepekatan 1000ppm. 50ml kedua-dua pewarna kemudian akan bercampur dengan 5g sisa pertanian selama 24 jam untuk menunjukkan bagaimana sisa pertanian dapat memberikan penjerapan berkesan untuk penyingkiran pewarna sintetik. Penjerapan Cresol Red dan Reactive Black 5 diukur dan penjerapan yang paling berkesan adalah daun teh di mana Cresol Red adalah pewarna yang merupakan penyingkiran kadar peratusan penjerapan adalah 68.55 peratus. Keputusan menunjukkan kadar penyingkiran yang lebih tinggi menunjukkan kapasiti penjerapan yang lebih bahan penjerap itu.

Kata kunci:

1.0 INTRODUCTION

Nowadays, there were many manufacturing industries such as textile, printing, paper and etc. Textile industry is one of the most complicated industries among the manufacturing industry [1]. The important component of the textile wastewater was the strong colors which are difficult to deal [2]. Generally, when the textile effluent flow out into the rivers or waterways, it is very difficult to treat due to the byproduct of multi-component wastewater [3]. Kim *et al*. [4] stated that the cleaning water, pre-treatment, dyeing and finishing process are the main sources of wastewater which contain high biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), acidity, basicity, color, heat and other organic pollutants were formed [5,6]. The wastewater characteristic such as color, pH and COD frequently changes due to the dyeing and finishing process and the transparency and aesthetics of the water were effluents even with the small concentration of dye [2, 7].

A dye is colored substances that disperse to a substrate in textile manufacturing and also can be applied in solution. Mohorcic *et al*. [8] had determined the characteristics and content of the textile wastewater that have different auxiliaries, chemical and classes of organic dyes. COD, BOD, AOX and pH are the parameter when the colored of the textile wastewater being determined. They have extreme value because of the different mineral oils, salts, surfactants, heavy metals and others.

The removal of dyes from waste effluents is always widely focused. Namasivayam and Sumithra [9] stated that the ecological balance of aquatic system was affected by dyes which accumulated in sediments at sites of landfill and wastewater discharge. Furthermore, even there is tiny amount of dye in water, it is toxic to creatures and highly colored the water [10, 11]. Ugurlu *et al*. [12] said that the dyes can also give bad health to the body especially the skin. It is called an allergic dermatitis and skin irrigation.

The conventional process such as biological methods, coagulation and flocculation were used to remove the color, however, the dye color are not easily bio-degradable and the color still present in the effluent [13]. Biological method involves anaerobic process, trickling filters, oxidation ponding, activated sludge process and etc. Biological method is simple to apply and the cost of the production also cheap [14]. Biological treatment methods can be divided into anaerobic and aerobic treatment depending on the oxygen demand. However, for textile wastewater, the color removal from the aerobic treatment was not effective [15]. In addition, biological treatment is not definitely effective for textile industry because of the low biodegradability caused by many textiles chemicals and dyes [16]. While the chemical method such as coagulation, flocculation and oxidation were claimed can manage potentially toxic and harmful aromatic compound [8]. Usually, for color removal, the chemical and physical treatment techniques were more effective compared to biological processes, however it use more energy and chemicals.

There are several successful treatment technologies have been widely applied including ion exchange treatment, coagulation and precipitation, adsorption and co-precipitation and oxidation [17, 18, 19, 20]. However, the oxidation methods are effective only in wastewater with a very low concentration of organic color. While the adsorption method showed the most effective and has no harmful byproduct. Furthermore, the removal of dyes by adsorption is known as the competitive methods due to economic feasibility and simplicity of design and operation [21, 22, 23].

Usually, the activated carbon was frequently used for the dye adsorption, however, their usage are limited due to high cost in preparation and production [24]. Therefore, many efforts have been done to develop more effective and cheaper adsorbents for the removal of dyes such as wood wastes, wool wastes, fly ash, coal, silica gel, agricultural wastes and clay minerals [18, 25]. The other low cost and easily available materials have been used such as apricot stone, almond barks, coffee seeds, tea waste, rice husk, cashew nut shell, banana peel, palm kernel fiber, orange peel, fly ash, rice husk and etc. [26, 27].

2.0 EXPERIMENTAL

2.1 Preparation of Adsorbent

Sugarcane bagasse and spent tea leave were collected from marketplace and restaurant in Johor Bahru. The sample was washed with tap water and repeated with distilled water to remove any impurities adhering to the surface and then the samples were cut into pieces and oven-dried at 105 °C for overnight. The dried samples were ground and sieved through 30-mesh to get a consistent size of adsorbent powder. The fine powders of these agricultural wastes were then preserved in plastic bags for use as adsorbents.

2.2 Preparation of Cresol Red and Reactive Black 5 Solution

The stock solution of Cresol Red and Reactive Black 5 were prepared by dissolve 1.0 g of dye in 1000 ml of distilled water. Distilled water were used to dilute the stock solution of Cresol Red and Reactive Black 5 depends to the desired of concentrations.

2.3 Batch Adsorption Studies

The Cresol Red and Reactive Black 5 adsorption onto sugarcane bagasse and spent tea leaves were determined by using batch adsorption study for 24 h. Then, all the samples were diluted by using dilution factor and the solutions were then filtrated by using Whatman no. 1 filter paper and determined the dye concentration by using a UV-Vis spectrophotometer (NANOCOLOR® VIS, Macherey-Nagel, Germany) at 597 nm for Reactive Black 5 and 271 nm for Cresol Red.

2.4 Analysis the Adsorption data

The adsorption data of the sugarcane bagasse and spent tea leaves obtained from UV-Visible spectrophotometer were calculated to determine the Cresol Red and Reactive Black 5 removal rate (%) and adsorption capacity (mg/g). The formulas of calculation are as follow:

Removal rate (%) = $$\frac{C_0 - C_x}{C_0} \times 100$$

Adsorption Capacity = $$A = \frac{(C_0 - C_x)V}{M}$$

Where A (mg/g) is the dye adsorption capacity, C_0 (mg/L) and C_x (mg/L) is respectively the initial and equilibrium dye concentrations in the solution, V (L) is the solution volume, and M (g) is the mass of adsorbent.

2.5 Characterization of the Adsorbent Materials

Surface texture and morphology of sugarcane bagasse and spent tea leaves were analyzed by the field emission scanning electron microscopy (FESEM JEOL 6335F-SEM, Japan) and elementary analyses were performed simultaneously using an EDX spectrometer. The Brunauer–Emmett–Teller (BET) surface areas and monolayer pore volumes of the adsorbents were determined by using provided software, surface analyzer (Quantachrome Instrument, USA). FTIR (Spectrum one, Perkin Elmer, USA) was used to analyzed the functional groups on the surface of sugarcane bagasse and spent tea leaves with the spectral range varied from 4000 to 400 cm^{-1}.

3.0 RESULTS AND DISCUSSION

The bar graph (Figure 3.1) shows that the removal of Cresol Red and Reactive Black 5 by using spent tea leave and sugarcane bagasse. Spent tea leaves shows more effective compared to sugarcane bagasse in removal of Cresol Red and Reactive Black 5 by 68.55% and 29.51% respectively. While, sugarcane bagasse showed the removal for Cresol Red and Reactive Black 5 only 44.85% and 22.91% respectively.

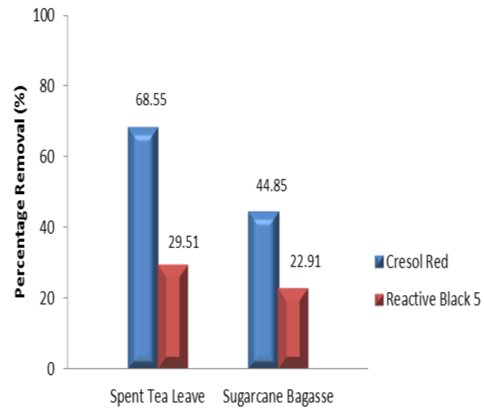

Figure 3.1 The bar graph of spent tea leave and sugarcane baggase for cresol red and reactive black 5 removals

FESEM for Spent Tea Leaves and Sugarcane Bagasse

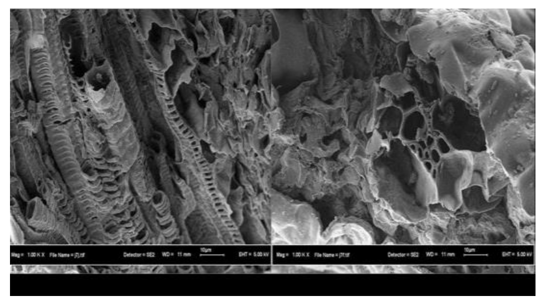

Figure 3.2 Spent tea leaves

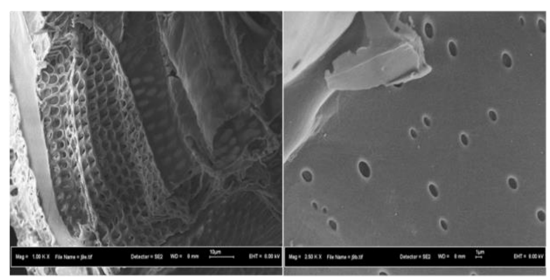

Figure 3.3 Sugarcane bagasse

The Figure 3.2 showed and described the morphology of spent tea leave exhibits a caves-like, uneven and rough surface morphology [28]. The spent tea leave structure appears like it has some cavities have pores on the surface. The BET analysis of the spent tea leave indicated a surface area of 1.76 m^2/g. While, Figure 3.3 the sugarcane bagasse has the structure appears like it has some small cavities on the surface. The BET analysis of the sugarcane bagasse indicated a surface area of 5.0 m^2/g. Usually, if the micro pores increases, the number of the accessible sites were also increase, hence increases the percentage of removal. Furthermore, a carbon sorbent with a high surface area exhibits more effective and a faster of dye adsorption than natural sorbents. However, factors for dye removal were not depends on surface area only, Tsai *et al.* [29] stated that modified by surfactant could make synthesized adsorbent exhibiting much better sorption ability for dye and there is also no direct correlation between the specific surface area and its adsorption characteristics.

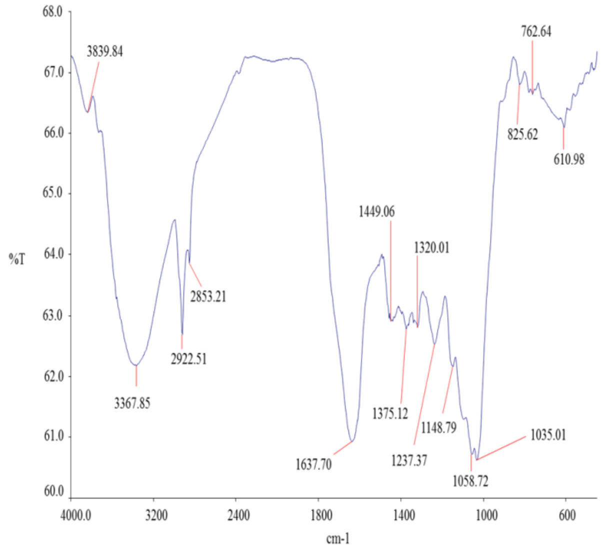

Figure 3.4 FTIR for spent tea leaves

Figure 3.4 illustrated the FTIR spectra of the spent tea leaves. The band shifting around the broad peak at 3367.85 cm⁻¹ has shown the possible involvement of hydroxyl groups. The peaks at 2922.51 cm⁻¹ and 2853.21 cm⁻¹ are due to the CH stretching causes vibrations of CH, CH_2, and CH_3 groups. The absorption bands are at around 1637.70 cm⁻¹ and 1449.06 cm⁻¹ show the characteristic of C=C bonds in aromatic rings. The C-O carboxyl bands at 1375.12 cm⁻¹ and 1058.72 cm⁻¹. Usually, the activity of carboxyl oxygen atoms causes the alterations in these bands area.

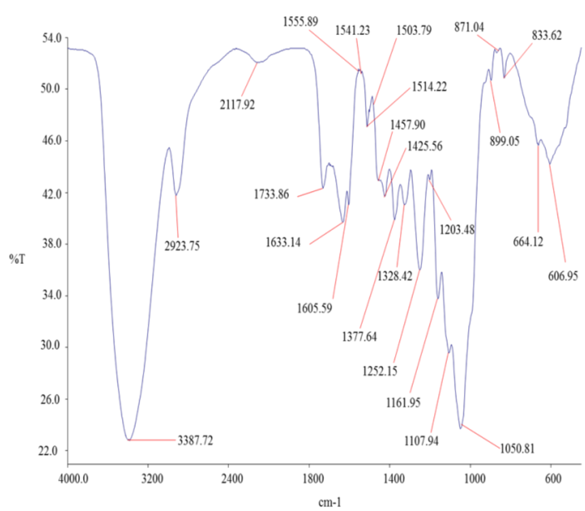

Figure 3.5 FTIR for Sugarcane Bagasse

Figure 3.5 shows the FTIR spectra of the sugarcane bagasse. Band shifting around the broad peak at 3387.72 cm⁻¹ has shown the possible involvement of hydroxyl groups. This is due to the stretching vibrations of hydroxyl groups that present in lignin, hemicellulose and cellulose of sugarcane bagasse. There are also C−H stretching at the peaks of 2097.51 cm⁻¹ and 2923.75 cm⁻¹ which causes the vibrations of CH, CH_2, and CH_3 groups. The absorption bands are at around 1605.59 cm⁻¹ show the characteristic of C=C bonds in aromatic rings. This band is attributed to the bending mode of the absorbed water. The spectra peak can be seen are at the increments in the C−O carboxyl bands at 1457.90 cm⁻¹. Usually, the activity of carboxyl oxygen atoms causes the alterations in these bands area. Besides, the figure showed CH_2 bends, OH bends, and C–O skeletal vibrations at the bands of 1425.56, 1367.44, and 1328.42 cm⁻¹ respectively. While C–O is stretching in hemicellulose at the band of 1244.82 cm⁻¹.

4.0 CONCLUSION

From the two results of dye removal, it can be concluded that although the concentration of dye solution and weight of adsorbent are constant, but not all of them have the same adsorption capacity as the removal varies from one sample to another. This mainly affected by the characteristics of the structure itself. From this experiment, spent tea leaves have the highest efficiency to decolorize Cresol Red dye which is 68.55 percent.

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