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(Research Article)

Effect of acid and alkaline treatment on the adsorption capacity of cuttlefish bone

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Abstract

As a center of textile industry in Indonesia, city of Pekalongan faces environmental issue due to wastewater effluent from textile industry. The wastewater from textile industry contains dye, mostly synthetic dye, used for coloring the fabrics. One of the dyes commonly used is sulphur blue for producing dark blue color. One of simple methods to reduce the dye in the wastewater is adsorption. Cuttlefish bone was used as the adsorbent. It is abundantly available and cheap because it is a waste of fishing industry. The effect of acid and alkaline treatment to the cuttlefish bone on its adsorption capacity toward sulphur blue dye was investigated. The acid and alkaline treatments were conducted using hydrochloric and sodium hydrochloric solutions, respectively. The concentrations of both solutions were varied (0.0 N, 0.25 N, 0.5 N, 0.75 N, 1.0 N). The concentration of acid and alkaline affect the adsorption capacity of the cuttlefish bone. The cuttlefish bone treated with 0.25 N hydrochloric solution is able to reduce the concentration of the dye solution from 217.67 to 87.67 Pt-Co, while that treated with 0.25N sodium hydroxide solution lowers the concentration of the dye solution to 74.33 Pt-Co. The alkaline-treated cuttlefish bone showed higher adsorption capacity than the acid-treated cuttlefish bone.

Keywords: Adsorption; Cuttlefish Bone; Dye; Sulphur Blue

1. Introduction

One of the textile industry centers in Indonesia is city of Pekalongan, where many small and medium textile enterprises can be found. The textile industry plays an important role in the economy of city of Pekalongan. However, textile industries raise severe environmental issues, mainly due to liquid waste.

Dyeing is an important production stage in textile industry. Most of the industries use synthetic dyestuffs. It is estimated that over 7×10^5 tons of dyestuffs are produced annually all over the world. It is estimated that 10-15% of the dye is lost during the dyeing process and released with the effluent [1]. The existence of dye in the water body prevents light penetration through water, which leads to a reduction in photosynthesis rate [2] and dissolved oxygen levels affecting the aquatic biota [3]. The dyes are toxic, carcinogenic, and mutagenic and their existence in the effluent can cause some serious environmental and health problems [4]. Moreover, they are not biodegradable [1]. Therefore, the dye must be removed from wastewater.

One of the dyes widely used in jeans coloring is Sulphur blue ($C_{26}H_{16}N_4S_6$) with a molecular structure depicted in Figure 1. The main feature of this dye is the thiozine ring.

Water soluble dyes such as acid dyes and reactive dyes are not easily removed in conventional physicochemical coagulation methods. Coagulation, flocculation, ozonation, and adsorption are found to be well known treatment

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methods for the treatment of wastewater. Adsorption has been considered as one of the best methods for removal of dye from wastewater because it is simple, insensitive to toxic substances, ease of operation, and low maintenance [1].

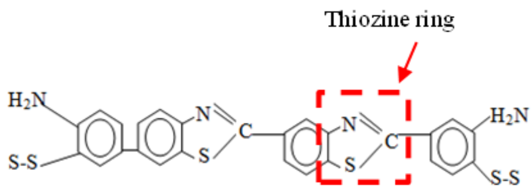

Figure 1 Molecular structure of Sulphur blue dye

There are many types of adsorbents that can be used in wastewater treatment, ranges from natural to synthetic adsorbent with various prices [5]. Low-cost adsorbents can be derived from natural materials such as agricultural waste and by-products of industries (such as fishery waste). Cuttlefish bone (endoskeleton of Sepia) or cuttlebone is the cuttlefish processing waste in fishery industry that can be used as adsorbent. Basically, the main constituents of the cuttlebone are calcium carbonate and organic matter [6].

The aim of this work was to exploit cuttlefish bone as an adsorbent for the Sulphur blue dye. The effect of the acid and alkaline treatments on the adsorption capacity of the adsorbent was investigated.

2. Materials and method

2.1. Materials

The materials used in this work were cuttlefish bone, Sulphur blue dye, sodium hydroxide, and hydrochloric acid. The cuttlefish bone was obtained from a local market. The dye was obtained from a local supplier, while sodium hydroxide (S5881) and hydrochloric acid (258148) were purchased from Sigma-Aldrich.

2.2. Method

The cuttlefish bone was brushed and washed thoroughly to remove dirt and any adhered materials. It was then rinse with deionized water and dried at 105°C for 24 h. Then it was ground using a mortar and sifted using a 100-mesh sieve. The cuttlefish bone powder (CBP) was kept in a closed container for further use. The CBP was analyzed for chemical compositions.

The acid treatment of the adsorbent was done by mixing 100 g of the CBP with 1 L of hydrochloric acid solution with various concentrations (0.00, 0.25, 0.50, 0.75, 1.00 N). The mixture was heated at 50°C for 2 h with constant stirring. After that, the mixture was filtered. The CBP was washed until it was neutral and dried at 105°C for 24 h. It was then kept in a closed container for further use.

The alkaline treatment was conducted with the same procedure as the acid treatment, except that the solution used was the sodium hydroxide solution with various concentrations (0.00, 0.25, 0.50, 0.75, 1.00 N).

The dye solution was prepared by dissolving the dye in the deionized water. The experiment was done by mixing 300 mg of CBP with 100 mL of dye solution. The mixture was stirred (200 rpm) for 2 h and the mixture was filtered afterward. The concentration of the solution before and after the adsorption experiment was determined using a UV-Vis Spectrophotometer with a wavelength 0f 450-465 nm.

3. Results and discussion

3.1. Chemical Composition of CBP

The chemical composition of CBP is shown in Table 1. It appears that CBP contains fat (0.95%), protein (4.50%), carbohydrates (2.82%), and ash (89.69%). The result is in line with the result reported by Rohmah et al. [7] and Henggu

[8], that cuttlefish bones have a moisture content of 2.17–3.02%, protein 2.35–2.65%, and ash 93.75–94.14%. The high ash content in cuttlefish bones is mainly due to the $CaCO_3$ content.

Table 1 Chemical Compositions of CBP

Component	Composition (%)	Information
Moisture	3.04 ± 0.01	wet basis
Ash	89.69 ± 0.04	dry basis
Fat	0.95 ± 0.01	dry basis
Protein	4.50 ± 0.25	dry basis
Carbohydrate	2.82 ± 0.22	dry basis

3.2. Effect of Alkaline Treatment on The Adsorption Capacity of CBP

The CBP that has been treated with alkaline (NaOH) with various concentrations were used to adsorb Sulphur blue dye. The initial concentration of the dye, expressed by a color intensity, is 217.67 Pt-Co. The concentration of the dye solution after being adsorbed with alkaline-treated-CBP is shown in Fig. 2

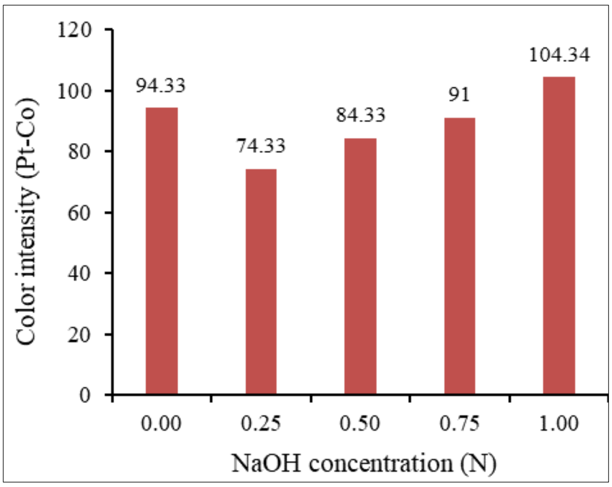

Figure 2 Effect of NaOH concentration for treatment on CBP on color intensity of the dye solution

Figure 3 The CBP before (a) and after (b) being used for the adsorption of sulphur blue dye

It can be seen in the figure that the color intensity of the solution decreases to 94.33 Pt-Co after being adsorbed with original CBP (without treatment). Meanwhile, when the CBP used to adsorb was treated with 0.25 N, 0.50 N, 0.75 N, and

1.0 N NaOH, the color intensity of the solution decreases to 74.33, 84.33, 91.0, and 104.33 Pt-Co. The lowest color intensity was achieved when the solution was adsorbed with CBP which had been treated with 0.25 N NaOH solution.

The CBP before and after being used to adsorb the dye is shown in Fig. 3. It is seen in the figure that the CBP before being used for adsorption is white, while that has been used for adsorption is blue. Meanwhile, the solution before and after adsorption is shown in Fig. 4. It is observed in the figure the color difference between both solutions. After being adsorbed, the color intensity of the solution is lower.

Figure 4 The sulphur blue dye solution: (a) before and (b) after being adsorbed with CBP

3.3. Effect of Alkaline Treatment on The Adsorption Capacity of CBP

The CBP was also treated with acid (HCl) with various concentrations (0.0 – 1.0 N). The initial concentration of the Sulphur blue dye solution was 217.67 Pt-Co. The concentration of the dye solution after being adsorbed with CBP which has been treated with various concentrations is shown in Fig. 5. It can be seen in the figure that the concentration of the dye decreased to 87.67, 94.33, 104.33, and 137.67 Pt-Co after being adsorbed with CBP treated with HCl acid with concentrations of 0.25 N, 0.50 N, 0.75 N, and 1.0 N, respectively. The lowest color intensity of the dye solution was obtained when the solution was adsorbed with CBP which had been treated with 0.25 N HCl solution.

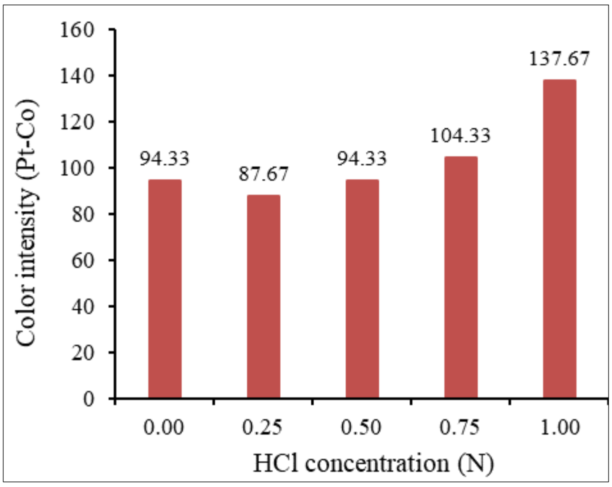

Figure 5 Effect of HCl concentration for treatment on CBP on color intensity of the dye solution

4. Conclusion

Based on the results, it can be concluded that the alkaline treatment of CBP can increase its ability to adsorb sulphur blue dye compared to acid treatment. The best treatment is alkaline (NaOH) with a concentration of 0.25 N. There are indications that the excessive addition of chemicals in acid (HCl) or alkaline (NaOH) conditions can damage functional groups on cuttlefish bones in helping adsorption on waste.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest.

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