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ADSORPTIVE REMOVAL OF METHYLENE BLUE DYE COLORATION FROM AQUEOUS SOLUTION BY ADSORPTION USING JUTE WASTAGES

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Abstract: In this research, treated and untreated waste jute fabric has been used to remove basic dye from aqueous solution by using the dye bath method. Wastage jute fabric was treated by scouring and bleaching. The effect of adsorbent mass on dye removal %, reflectance, and whiteness index has been examined. Furthermore, the effect of pH on dye removal % has been investigated. Maximum dye removal % achieved within 30-45 minutes while 14g treated waste jute fabric used as adsorbent. The adsorption capacity increased from 59.5 to 96 %, with increasing the pH of the aqueous solution from 3 to 10.5 while using treated adsorbents. Whiteness index and reflectance was increased with increasing the adsorbent mass.

Keywords: *Jute waste, Adsorption, Methylene Blue, effluent, Dye bath method.*

1. INTRODUCTION

Now a day's water pollution has become a major global problem. Many industrial sectors, including textile, paper, paint, pharmaceuticals, food, leather, cosmetics, tannery, printing, and plastics, are the contributors to water pollution. Among them, the textile industry is one of the most significant contributors. Many textile manufacturers are using basic dye to give color to their products [1]. Dyes and pigments are the primary group of pollutants. These dyes and chemicals are discharged from various industries, such as dyestuff manufacturing, dyeing, printing, and textile finishing [2]. Textile effluents contain various kinds of dyes whose molecular weight are high and contain a complex chemical structure; as a result, their biodegradability becomes low. Hence, direct deposition of these effluents into sewage networks, produce high biological oxygen demand (BOD), high chemical oxygen demand (COD) and highly colored, hot, alkaline and contain high amounts of dissolved solids. The discarding of dyes and pigment into water destroy the environment. Also these discarded synthetic chemicals are hazardous to human and living organisms as dyes can be converted into carcinogenic compounds [3], [4]. Most of the dyes are stable against photo-degradation, bio-degradation, and oxidizing agents [5]. Researchers have tried different method such as physical, chemical, biological to remove dye molecules from aquatic environment. Dyes, even in low concentrations, affect aquatic life and human being, causing its removal from wastewater imperative. Absorption is an efficient and economically cheap process to remove pollutants such as colors, dyes, and metal impurities from effluents [6], [7]. Usually, rice husk, apricot stone, almond shell, cotton stalks, wood, sunflower stalks, charcoal, sugarcane baggage, jute, and orange peel are successfully used as an adsorbent for the removal of dyes from aqueous solutions [3], [8]–[10]. Maghraby and Deep found rice hulls as more effective than commercial adsorbent. They concluded that biosolid like rice hulls could be an important alternative for the removal of methylene blue dye coloration though they didn't investigate the remote sensing quality of the treated water [1]. In another research, Fabon et al. stated that activated carbon found from sugarcane bagasse is effective for the decolorization of basic dye integrated water [2]. But that process needs an extra step to get the activated carbon from sugarcane bagasse. Activated carbon is the commonly used adsorbent for color removal, but it is relatively expensive. The major objective of this research is to study the efficiency of jute waste for removing basic dye i.e methylene blue from aqueous solution. The removal of methylene blue from any wastewater is necessary due to the serious environmental damage that can occur as a result of contact with it, usually in the case of human beings [3]. In this research, both treated and untreated jute wastages has been used as an adsorbent to remove methylene blue from aqueous solution by applying dye bath method.

2. MATERIALS AND METHODS

A. Materials

Materials used for the preparation of adsorbent are wastage jute fabrics obtained from the local market of Chattagram, Bangladesh. For combined scouring and bleaching of jute fabric, we used sodium hydroxide (Marcel Pvt. Ltd., India), hydrogen peroxide (ASM Chemical Ltd., Bangladesh), wetting agent (Dynotex MH-40, China), sequestering agent (Masquol P210N, China), stabilizer (Chromableach RLP, Chromatech, USA) and basic dye (methylene blue) was taken as adsorbate (Rung international, India). All these materials were used without any further purification and modification. Figure 1 represents the chemical structure of methylene blue dye.

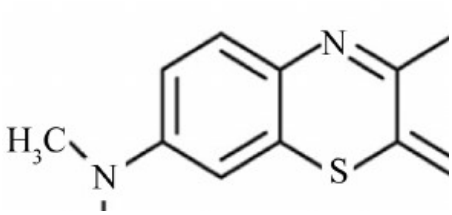

Figure 1: Chemical structure of Methylene Blue Dye [11]

B. Methods

Preparation of Adsorbent

Untreated Jute Fabric:

Jute fabrics were washed one time with normal tap water and then dried under natural sunlight for 24 hours.

Treated Jute Fabric:

For treating the jute fabric combined scouring and bleaching was carried out with the following recipe:

Table 1: Recipe

Chemicals	**Amount (g/l)**
Caustic soda	:4
Hydrogen peroxide	:5
Wetting agent	:1
Sequestering agent	:2
Stabilizer	:3
Material to liquor ratio	1:10

Combined scouring and bleaching was done at laboratory winch dyeing m/c (L.W-039, R.B.E Electronics & Engineering Pvt. Ltd., India) for making the fabric more hydrophilic and increasing the absorptivity. This treatment was carried out at temperature 100^0C and carried out for 45 minutes. After desirable time the liquor was dropped out. The scoured and bleached waste jute fabric then treated by acetic acid (pH 5.5-6) in 60^0C temperature for 15 min and then rinsed with cold water for a few minutes as after treatment process.

C. Preparation of Adsorbate

Methylene blue dye was used in this study as adsorbates. The stock solution of methylene blue was prepared by dissolving 1000mg of dye in 1L of distilled water. Therefore, the concentration of methylene blue in the aqueous solution is 1000 mg/l

D. Adsorption Process: Treatment of Dyed Waste Water in Dye Bath

In this process, the dye molecule concentration in aqueous solution and temperature were fixed; only the amount of wastage jute fabric in the dye bath was changed. Firstly 10g of wastage jute fabric was immersed in the dye liquor and treated in 80^0C up to 75 minutes. Then the treated water has been preserved for testing in UV spectrophotometer (data color 650, USA). The same process was repeated two times by using 12g and 14g fabric at the same temperature and time.

E. Testing Methods

The percentage of dye removal is defined as the ratio of the difference in dye concentration before and after absorption (C_i-C_t) to the initial concentration of dye in the aqueous solution (C_i) and was calculated using the equation:

$$\text{Dye uptake \%} = [(C_i - C_t)/C_i] \text{ X } 100\%$$

A spectrophotometer was used to measure the CIE whiteness indexes and reflectance values of aqueous solution in $D_{65\text{-}10}$ degree illuminant.

3. RESULTS AND DISCUSSION

A. Effect of treated and untreated adsorbent mass on dye removal from aqueous solution

For untreated jute wastage, from figure 2, it is observed that with increasing the amount of adsorbent, the adsorption rate increased. Maximum dye removal was achieved within 30-45 minutes, after which a decrease in methylene blue concentration in the aqueous solution observed, which is very negligible. As the adsorbent mass increases, the percentage of dye removal also increases. This may be happened due to the increase of adsorbent surface area as well as the availability of more adsorption sites. For the first 35 minutes the adsorbent absorbed

the dye molecules from the aqueous solution quickly and after that time, the absorption continued gradually.

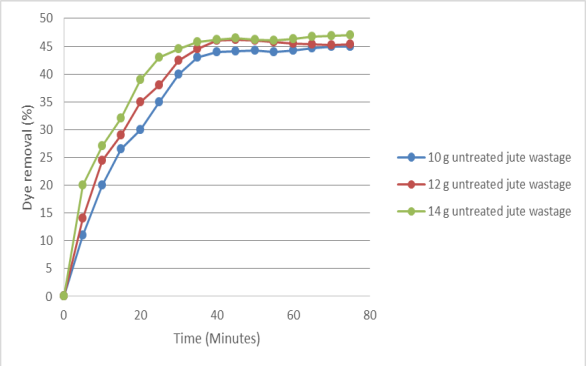

Figure 2: Effect untreated Jute waste mass on the removal of dye from aqueous solution

For the treated jute wastage, also dye removal increased with the increase of adsorbent mass. Figure 3 shows the effect of adsorbent mass on the dye removal percentage from the fabric.

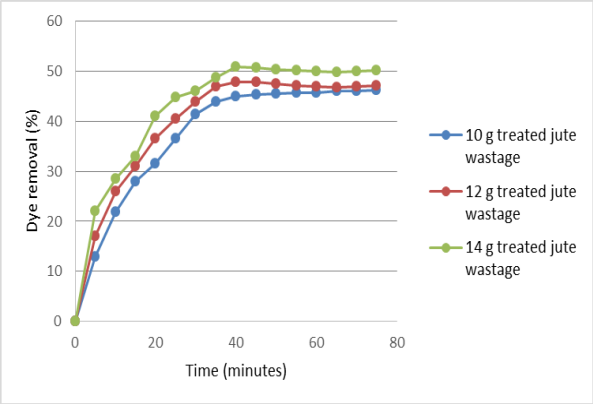

Figure 3: Effect of treated Jute waste mass on the removal of dye from aqueous solution

B. Comparison of treated and untreated adsorbents mass on dye removal from aqueous solution

Figure 4 shows the effect of treated and untreated adsorbent on dye removal percentage from the aqueous solution. From the figure, it can be seen that treated adsorbent has better dye removal percentage than the untreated adsorbent. As adsorbent was treated with scouring and bleaching agent, so perhaps this pretreatment increased the absorbency of the adsorbent.

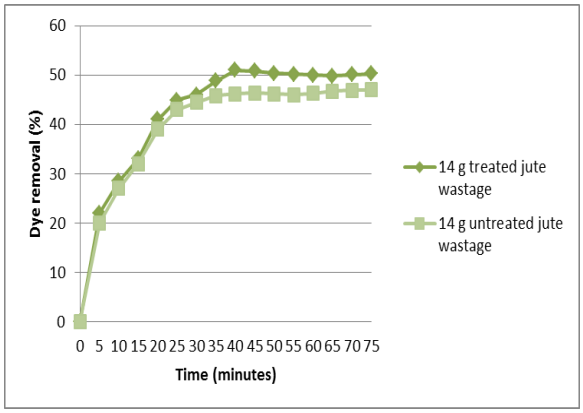

Figure 4: Comparison of Treated and untreated jute wastage mass on the removal of dye

C. Effect of pH of the aqueous solution for dye removal by the adsorbents

For the adsorption process, the pH of aqueous solution is considered as an important parameter [12]. 14g adsorbent was used in 1000mg/l methylene blue dye aqueous solution for studying the influence of pH. Figure 5 shows the relationship between the pH value and the removal of methylene blue from aqueous solution. It can be seen from the figure that as the solution pH increases, the adsorption capacity increases. With the increase of pH the number of hydroxyl groups also increases, which subsequently increases the number of negatively charged sites and increases the attraction between dye and adsorbent surface [13].

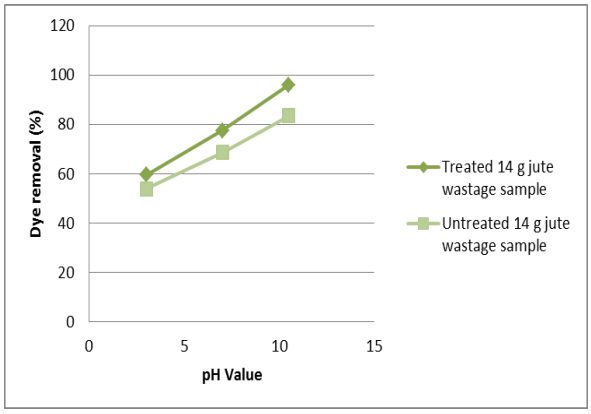

Figure 5. Relationship between the pH value and the removal of methylene blue from aqueous solution.

D. Effect of treated and untreated absorbent mass on whiteness index of aqueous solution

The whiteness index indicates how much the surface is ideal for reflecting the light in identical intensities in all directions. In this experiment, whiteness index values were examined with respect to how much the aqueous solution is transparent after the treatment with wastage jute. From the figure 6, it can be estimated that the sample which is treated in the dye bath process at 80^0C for 75 minutes by using 14gm fabric has greater whiteness value than the other sample of this process. This may have happened because the higher mass of absorbent removed more dye molecules than the other sample and as the dye concentration reduced, whiteness index value increased.

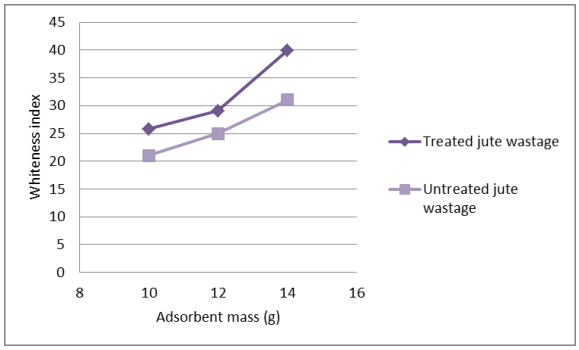

Figure 6: Effect of Adsorbent mass on Whiteness index

E. Effect of treated and untreated absorbent mass on reflectance of aqueous solution

The radiance scattered out of water is one of the parameters of sensing water quality [14]. From the figure 7, it is seen that the reflectance value of the aqueous solution processed by adsorbent was found almost similar with 10g and 12g adsorbents. Better reflectance value was found to the sample which was treated with 14g absorbent.

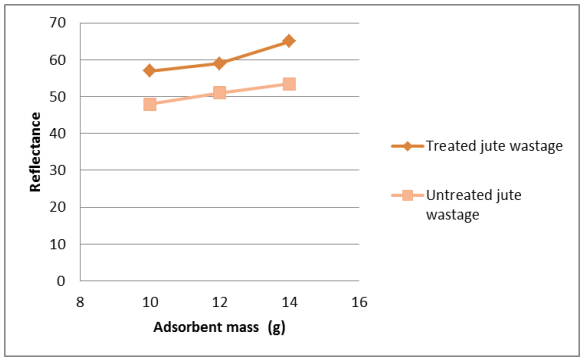

Figure 7: Effect of adsorbent mass on reflectance value of aqueous solution

4. CONCLUSION

Considering jute wastage as natural resources and cheap product, the experiment was done in the dye bath method to remove basic dye coloration in different experimental conditions. The analysis of the result and discussion showed that absorbent mass greatly affects the treatment while there is little difference in treated and untreated absorbent. Within 35 to 40 minutes, maximum dye removal observed in the alkaline condition of the dye bath. For measuring the remote sensing quality of treated water, whiteness index and reflectance were examined and found satisfactory result by using a 14g adsorbent mass of wastage jute. Future research on this topic can be done by using cotton fabric, coconut tree sawdust, banana peels, banana pith, orange peel, etc.. Along with basic dye different types of a dye such as reactive dye, sulfur dye, etc. can be used to perform this experiment.

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