

Removal of Azo Dye from water By jute (*Corchorus Capsularis*) stick activated Carbon: a cost-effective ecofriendly approach

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Abstract

The textile industry consumes a lot of water during production and generates a massive amount of effluents, including synthetic dyes, into the environment, which raises public concern. Azo dyes that are predominantly utilized in the textile sector are regarded to offer serious health hazards. Jute sticks are a typical fuel source in Bangladeshi villages. After using jute sticks as fuel, we turn them into highly cost-effective activated charcoals which are capable of removing Levafix Amber (most used azo dye) from textile effluent. In this article we reported for the first time a cost effective, ecofriendly jute stick extracted adsorbent for the removal of Levafix Amber dye from textile effluents. The most notable benefits of our approach are its low cost, simplicity, and lack of the need for costly instruments.

Keywords: Waste Water treatment, Azo dye, adsorbent, activated charcoal, Jute sticks.

Highlights

- Cost-effective removal of azo dye using jute stick activated carbon.
- Eco-friendly solution for textile effluent treatment.
- Utilization of jute sticks as a sustainable resource for water purification.

Acknowledgements

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1 Introduction

Water is a part of parcel of life but due to rapid industrialization as well as human unawareness regarding of water pollution, day by day this life materials going to contaminated at alarming rate. So now a days it's an important concern for environment scientist to develop the method for recovery the waste water for human requirement. Pollutant emissions into the environment have grown due to the recent rapid industrialization [1], [2]. Water contamination results from the disposal of industrial, municipal, and other pollutants into bodies of water [3], [4]. Industries pollute water and soil by discharging untreated or insufficiently treated effluent into the environment. The manufacturing processes of the pharmaceutical, textile, food, paper & pulp, cosmetic, and leather industries are found to use synthetic dyes most frequently. A significant amount of water is used during the fixing, dyeing, and washing stages of the textile industry's dyeing process [5]. The dyes are soluble organic substances, more precisely those that fall under the categories of direct, reactive, acidic, and basic [6]. Because dyes are very soluble in water, they are more challenging to remove using conventional methods [7]. Industrial dyes and their byproducts are the principal carcinogenic and hazardous pollutants. As a result, they have negative consequences on the environment [8]–[10]. Numerous studies show that azo dyes harm plants development as well as germination [11]–[13]. So, this is too much important concern to remove such kinds of dye from waste water.

Levafix Blue dye (LA) is an azo dye, vastly used in the textile industry. It was purchased from DyStar (Levafix Amber CA). The chemical structure of commercial Levafix Amber CA reactive dyes is not disclosed. Colour: Yellow It is one of most important textile dye used in the different dyeing factories in Bangladesh. It is a reactive dye. Dye-containing wastewater is very difficult to manage since dyes are refractory organic chemicals that are resistant to aerobic digestion and durable to light. Traditional techniques cannot effectively remove a synthetic dye from wastewater. This is because the large-scale treatment of dye wastewater in the textile and paper sectors is very expensive and has disposal problems. There are three different categories of color removal techniques: biological, chemical, and physical [14]. Each of them has advantages and disadvantages. Comparing biological treatment to other physical and chemical treatments, it is frequently the most affordable option. Industrial effluents are frequently treated using biodegradation techniques like fungal decolorization, microbial degradation, adsorption by (living or dead) microbial biomass, and bioremediation systems because many microorganisms, such as bacteria,

yeasts, algae, and fungi, can gather and degrade different pollutants [15], [16]. However, due to technical limitations, their use is frequently limited.

Chemical methods can involve coagulation, flocculation, flotation, filtration, precipitation-flocculation using Fe(II)/Ca(OH)₂, electro-flotation, electro-kinetic coagulation, conventional oxidation by oxidizing agents (ozone), irradiation, or electrochemical processes. The accumulation of concentrated sludge creates a disposal problem even when the colors are eliminated using these chemical techniques. Additionally, there's a danger that using chemicals excessively will cause a related environmental problem. For the breakdown of pollutants, other newly discovered techniques known as "advanced oxidation processes," which rely on the creation of very intense oxidizing agents such hydroxyl radicals, have proved successful. These methods are successful in cleaning up contaminated water, but they are also very costly and unattractive from a commercial standpoint. The use of chemical reagents and the rising demand for electrical energy are two significant problems [17].

A variety of physical techniques are also often utilized, including adsorption methods and membrane filtration processes (such as nano-filtration, reverse osmosis, and electro dialysis). The main drawbacks of membrane processes are their short lifespan before membrane fouling sets in, which necessitates the inclusion of periodic replacement costs in any consideration of their economic feasibility. According to the extensive literature data, liquid-phase adsorption is one of the most widely used techniques for removing contaminants from wastewater because it results in high-quality treated effluent with suitable adsorption process design. If the sorbent is cheap and doesn't need a separate pre-treatment step before being applied, this approach offers a compelling option for the remediation of polluted waterways. [18]. Adsorption is a well-known equilibrium separation technique that works well for decontaminating water [19]. In comparison to other methods for reusing water, adsorption has been proven to be more advantageous because to its low initial cost, adaptability, and simplicity of design, as well as its resistance to hazardous contaminants. Adsorption and ion exchange are the two mechanisms that lead to decolorization [20]. These two processes are regulated by a variety of physio-chemical parameters, including the interaction between the dye and the sorbent as well as the surface area and particle size of the sorbent. Additionally, adsorption does not lead to the creation of hazardous substances [21]. Adsorption is defined as the presence of a higher concentration of any specific material at the surface of a liquid or solid phase compared to the bulk of the medium as a result of inelastic collisions experienced by molecules on the surface [22]. Adsorption is



Fig 1. Jute sticks

the process by which a gas or liquid gathers on the surface of a solid or liquid. Surface forces are constantly out of balance. Therefore, when a gas or liquid solute comes into contact with the surface of a solid or liquid, adsorption takes place between the former materials and the later materials (adsorbent). As opposed to absorption, which occurs when a substance diffuses into a liquid or a solid to produce a solution, both reactions are referred to as sorption, whereas desorption is the opposite process [5]. Adsorption is a result of surface energy, just as surface tension. All of the bonding needs—whether ionic, covalent, or metallic—of the material's component atoms are satisfied by other atoms in the bulk substance. Adsorbate can be attracted to atoms on the surface of the adsorbent because they are partially surrounded by other adsorbent atoms. The specifics of the interacting species will determine the bonding's exact nature [23]. Adsorption occurs often in a wide range of physical, biological, and chemical systems and is a widespread industrial technique. During the sorption processes of adsorption, ion exchange, and chromatography, certain adsorbates are preferentially transferred from the fluid phase to the surface of insoluble, hard particles suspended in a tank or crowded in a column.

Activated carbon, which is created from jute sticks after they have been used as a fuel source, is used in this article to try and remove azo dye from the waste water from the textile industry. This is the ideal approach to get rid of azo day because it's simple to prepare, doesn't involve any expensive equipment, is feasible financially, and uses recycled materials.

2 Methodology

2.1 Chemicals

The following analytical grade chemicals were used without any further treatments: I) Levafix Red. II) Concentrated Sulphuric acid (H_2SO_4) III) Zinc Chloride ($ZnCl_2$) IV) Hydrochloric acid (HCl) V) Sodium hydroxide ($NaOH$, Merk, Germany)

2.2 Instruments

The treated jute sticks were prepared, characterized, and dye adsorption was observed using the following tools: The treated jute sticks were prepared, characterized, and

dye adsorption was observed using the following tools: I) Thermostated Mechanical Shaker (SWB-20, HAAKE, Fisons Ltd, Germany) II) Digital Balance (Model: FR-200, JAPAN) III) Microwave Oven (NDO-450ND, EYELA) IV) UV- Visible Recording Spectrophotometer (UV-1650 PC, Shimadzu, Japan). V) pH Meter (HM-26S, TOA Electronics Ltd, Japan) VI) FT-IR Spectrometer (IR-Prestige, Shimadzu, Japan) VII) Scanning Electron Microscopy, SEM (Philips XL30, Holland).

2.3 Stock Solution of Levafix Amber

The LA stock solution was made by dissolving the proper amount of solid material in water. We utilized a volumetric flask with a capacity of 250.0 mL to hold 1000 mg of LA, and we used deionized water to dissolve it. Once the necessary amount of deionized water had been added, the LR solution containing 1000 ppm had been made. More dilution was used when necessary. The concentration range for the experiment was 5 ppm to 250 ppm.

2.4 Preparation of Activated Charcoal from Jute Stick

Physical activation and chemical activation are the two methods used to prepare activated charcoal. Chemical activation offers two significant benefits over physical activation. One is that the procedure is carried out at a lower temperature. The other is that while burning char is not necessary, chemical activation tends to have a higher overall yield. Jute sticks were collected, cleaned, and dried thoroughly. After that, concentrated H₂SO₄ was splashed onto a portion of the dried jute stick in a quantity sufficient to thoroughly cover the raw material, mix vigorously for 30 minutes, and then leave for two hours. After mixing, the slurry underwent a 24-hour drying process at 100°C in an oven. With ZnCl₂, the jute stick was also chemically activated. 100 mL of a concentrated solution containing 10g of ZnCl₂ were well mixed with 10g of jute stick [24], [25]. For one hour, the mixing was done at 50°C. The slurry underwent 24 hours of drying at 100°C after mixing. To get rid of any remaining organic and mineral components, the product was washed three times in succession with 0.5M HCl, hot water, and then cold distilled water [26]. It was then dried at 110°C. The dry charcoal was ground in a mortar and a sieve was used to remove the 90-micron particles.

In Fig 1, a flow chart for preparation of activated charcoal is illustrated.

2.5 Determination of various parameters for removal of dye from industrial effluent:

2.5.1 Determination of temperature:

In the reagent vial, 3.0g of treated jute sticks were placed. The particle was 90µm in size. It was filled with 50ml of a 100ppm dye solution. A 0.01M NaOH solution was added to the solution to keep the pH at 6.60. Then, a thermostatic shaker set at 30°C temperature was used to continually shake the reagent bottle. After the solution was filtered, the filtrate's absorbance was calculated. Similar to this, a number of samples were performed at different temperatures, including 30, 40, 50, and 60°C. The acquired findings are shown in Table-4 and Fig-8.

2.5.2 Determination of Initial Concentration:

In the reagent vial, 3.0g of treated jute sticks were placed. The particle was 90µm in size. It was filled with 50ml of a 100ppm dye solution. A 0.01M NaOH solution was added to the solution to keep the pH at 6.60. Then, a thermostatic shaker set at 30°C temperature was used to continually shake the reagent bottle. After the solution was filtered, the filtrate's absorbance was calculated. Similar to this, a number of samples were performed at different initial concentrations, including 5, 10, 20, 50, 100, 150, and 200 ppm. The obtained findings were shown in Table 5 and Fig-9.

2.5.3 Determination of Adsorbent dose:

Exactly 0.5g, 1.0g, 1.5g, 2.0g, 2.5g and 3.0g treated jute sticks were taken in each of the five well stoppered reagent bottles and 50 mL of 100 ppm dye solution was taken in each bottle. The reagent bottles were placed in a thermostatic shaker maintained at 30°C temperature and shaken continuously. The reagent bottles were successively withdrawn after a short period of time. The solution was filtered through Millipore 0.45 micrometer filter paper. The clear solutions of the filtrate were taken for spectrophotometric analysis to determine the concentration of the LA solutions. The initial concentration in the absence of charcoal was determined. The results obtained were given in the Table-6 and Fig-10.

2.5.4 Determination of pH:

3.0g of treated jute sticks was taken in reagent bottle and 50ml of 100 ppm dye solution was taken in it. The pH of solution was maintained to 6.60 by adding .01M NaOH solution. Then the reagent bottle was placed in a thermostatic shaker maintained at 30°C temperature and shaken continuously. The solution was filtered and the absorbance

of the filtrate was determined. Similarly, several samples were run in various PH such as 2.01, 4.08, 5.21, 6.12, and 8.12 to 10. The results found were given in the Table-7 and Fig-11.

Table 1. Ftir analysis of adsorbents

Functional group	stand-ard	Un-treated jute sticks	Treated jute sticks	Jute sticks after ad-sorp-tion	Comm-ent
C-H stretch-ing	3000-2850	2928	2925	2920	C-H pre-sent
Zn=O	1650-1350	1630, 1507, 1428	1611, 1428	1636, 1510	Zn=o may pre-sent
C-N	1350-1000	1190	1180	1175	C-N pre-sent
C-C	1250-1150	1195	-	1247	C-C may pre-sent
Si-O	1150-900	1111, 1061, 1032	1113, 1060, 1031	1036	Si-O pre-sent
C-Cl	785-540	725	720	710	C-Cl may pre-sent

2.6 Modeling of Water Sample

Waste water sample was collected from dyeing industry of Gazipur, Dhaka. Gazipur which is near from capital Dhaka city. The river 'Turag' which flows through between Dhaka and Gazipur. Industrial effluent falling into this river. Water of this river contains high concentration of different dye and other chemical species. The sample was analyzed with UV-Visible spectrophotometer. Waste water was collected in plastic bottles that were cleaned numerous times at the sampling locations with 5% HNO₃, distilled de-ionized water, and lastly with the waste water. After collecting water sample, it was immediately divided into two parts, one part was adjusted to pH 2-3 by adding nitric acid and other part was collected as original form. Water sample was kept in freeze at temperature below (4-5) °C.

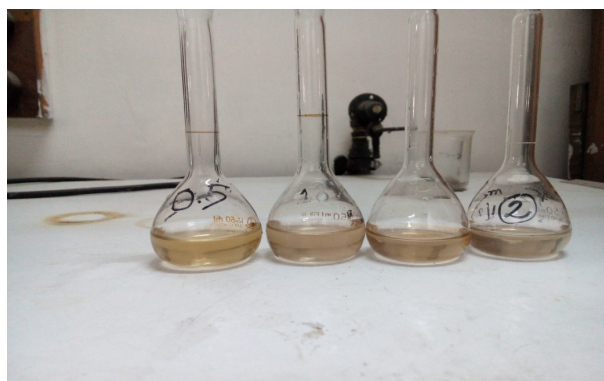


Fig 2. Dye solution before adsorption and Dye solution after adsorption.

3 Results and Discussion

3.1 Characterization of Adsorbent

3.1.1 Characterization by FT-IR:

Jute sticks' formation was confirmed by FT-IR measurements, which were also used to detect any species that had been adsorbed onto the crystals' surface. ATR-FTIR spectra of jute sticks were recorded between 500 cm⁻¹-4000 cm⁻¹. Results of the FTIR spectrum of jute sticks are given in Fig.3, 4,5.

FTIR spectra of untreated jute sticks, treated jute sticks and jute sticks after adsorption were shown in Fig. to. According to existing data, the FTIR peak was examined for the presence of several bonds, including C-H stretching, Zn=O, Si-O, C-N, C-C, and C-Cl, and the results are shown in table-1. According to the FTIR study, the treated jute sticks' C-H peak changed from 3000 cm⁻¹ to 2925 cm⁻¹. Additionally, for absorbed jute sticks, the C-H peak changed to 2920 cm⁻¹.

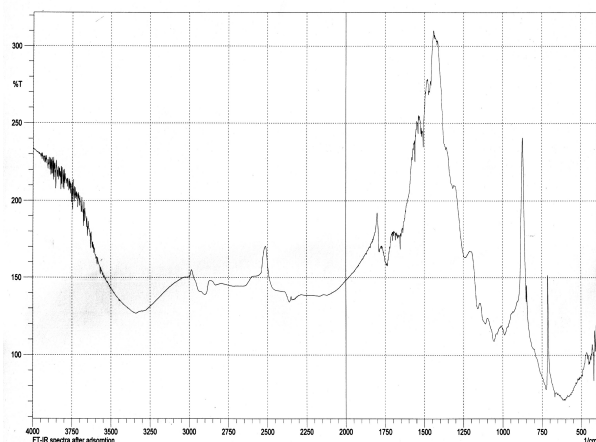


Fig 3. FT-IR spectra of untreated jute sticks

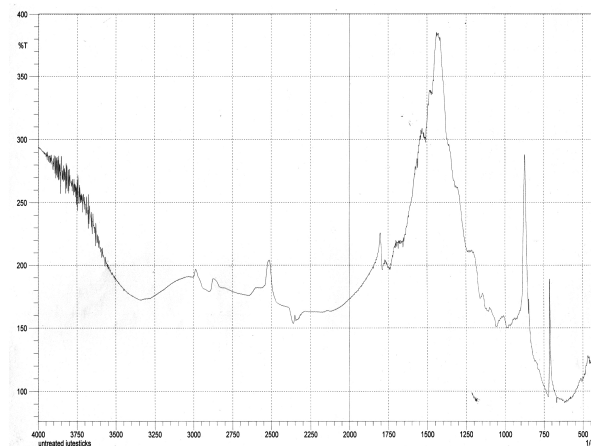


Fig 5. FT-IR spectra after adsorption

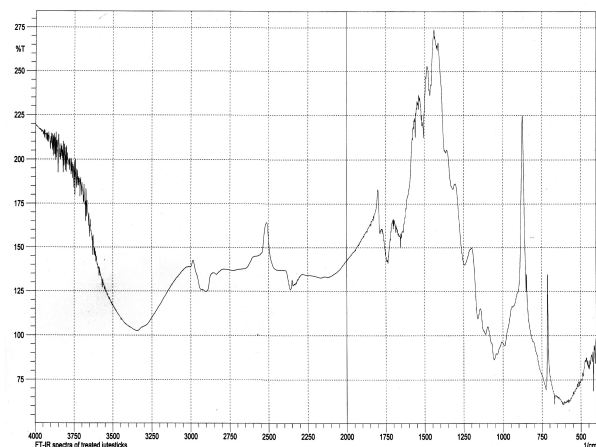


Fig 4. FT-IR spectra of treated jute sticks

3.2 Zero-point charge (pHzpc):

3.2.1 pHzpc of jute sticks:

The pH of jute-sticks surface at zero-point charge was determined. pHzpc of jute sticks was 4.6 ± 0.1 . pHzpc of jute-sticks value cannot be compared due to paucity of information in the literature.

pHzpc of jute sticks

Volume of CO ₂ free water	Amount of jute-sticks	Time of shaking
10 ml	0.5 g	48 hours

3.3 Adsorption analysis

3.3.1 Determination of Absorbance maxima (λ_{max}) of Levifox Amber:

The absorbance maximum (λ_{max}) of aqueous solution LA was determined spectrophotometrically from its absorption spectrum.

Reference	λ max of LR solution	Temperature	pH
Water	414.50 nm	25 0C	6.60

3.3.2 Construction of a calibration curve and determination of molar adsorption co-efficient of LA:

Using λ_{max} , a calibration curve was constructed. The straight line of the absorbance vs. concentration of LA passing through the origin in Fig-6. suggested the validity of Beer- Lambert law. The value of the slope was equivalent to 1. As a result it was found that the molar absorption coefficient (ϵ) of LA was $1.29 \times 10^{-2} \text{ L mg}^{-1} \text{ cm}^{-1}$ at 25°C.

3.3.3 Optimization of contact time for adsorption of LA on activated carbon:

The experimental conditions and the results are given below:

Table 2. Absorbance of la solution at different concentration

No. of observations	Concentration/ ppm	Absorbance
1	5	0.077
2	10	0.169
3	20	0.169
4	50	0.765
5	100	1.450
6	150	2.274

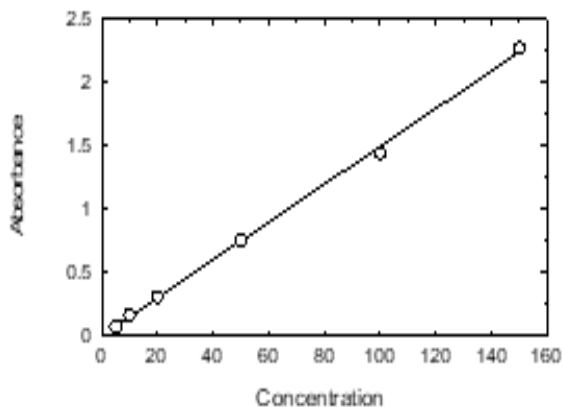


Fig 6. Calibration curve for different concentration of standard Levafix Amber Solution.

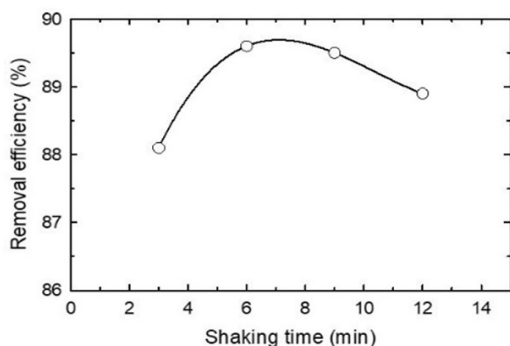


Fig 7. Effect of shaking time for removal of dye.

3.3.4 Effect of time on various adsorbents:

In each experimental investigation, 3.0 g of adsorbents were combined with 50 ml of dye solution with a specified concentration and pH of 6.60 in a 250 ml reagent container kept at room temperature. The mixture was then shaken. The comparative results make it abundantly evident that the duration impact is crucial to the color removal adsorption process [27]. All of the adsorbents are fairly efficient;

Sample	Levafix Amber
Amount of adsorbent	3.0g
Volume of solution	50.0 mL
Temperature	30.0 0C
pH	6.60
Concentration	100 ppm
Particle size	90 μm

Table 3. Determination of contact time for adsorption of levafix amber on charcoal

No. of observance	Time (hr)	Removal efficiency (%)
1	3.00	88.1
2	6.00	99.60
3	9.00	87.71
4	12.00	86.89

however, jute sticks were discovered to be particularly effective when compared to activated Carbon. The adsorbents' color removal efficiency reaches a breaking point after three hours, after which no further color removal occurs. Jute stick was discovered to be incredibly efficient, removing color with a 99.60% effectiveness. Under these conditions the equilibrium time for the adsorption of LA was found to be 6 hours shown in table-3 and fig-7. The data demonstrate that the adsorbate is rapidly absorbed during the adsorption phase. However, after the first four hours, the adsorption rate rose slightly to a nearly constant amount with prolonged contact duration. This pattern is consistent with other research' findings. The maximum amount of Levafix Amber was adsorbed onto the jute sticks after six hours of contact at the highest starting concentration, making six hours the ideal contact period. Typically, the quantity adsorbed increased with longer contact times and higher starting concentrations before decreasing.

3.3.5 Effect of temperature:

Several experiments were carried out at temperatures of 30°C, 40°C, 50°C, and 60°C to examine the impact of temperature on the adsorption of dye on charcoal. The effect of temperature on the adsorption of dye onto charcoal is shown in Fig-8. Figure 8 illustrates how elimination of LA reduces as temperature rises. This implies that LA is adsorbed on charcoal using an exothermic method.

3.3.6 Effect of concentration:

At a concentration of 100 ppm, it was observed that Levafix red adhered to prepared activated carbon the greatest.

Table 4. Optimization of temperature

Sample	Levafix Amber	
Amount of adsorbent	3.0 g	
Volume of solution	30.0 mL	
Temperature	Temp./°C	Removal Efficiency/%
	30	99.60
	40	91.41
	50	93.20
	60	95.03
pH	6.60	
Concentration	100 ppm	
Particle size	90 μm	

Table 5. Optimization of initial concentration

Sample	Levafix Amber	
Amount of adsorbent	3.0g	
Volume of solution	50. x0 mL	
Temperature	30.0 0C	
pH	6.60	
	Concentration (ppm)	Removal efficiency (%)
	5	65.8
Concentration	10	78.20
	20	82.45
	100	87.68
	150	85.63
	200	82.54
Particle size	90μm	

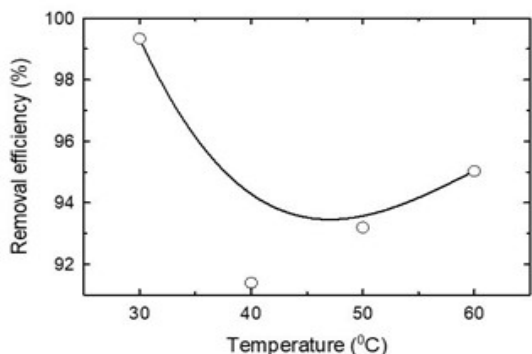


Fig 8. Effect of temperature for removal of dye.

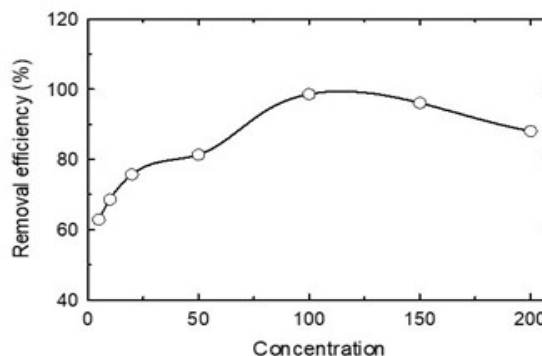


Fig 9. Variation of concentration for removal of dye.

The optimal dye concentration is the one at which the maximum quantity of dye absorption was seen [28]. Primarily, as the initial concentration of the Levafix Amber dye raised, so did the removal efficiency. This trend shifts after a certain concentration, which is 100 ppm. After these concentrations, any additional increases in the starting concentration do not boost removal efficiency; rather, removal efficiency falls as concentration increases. This could be due to a lack of active sites, which were necessary to support the dye’s high initial concentration [29]. At low concentrations, the adsorption sites absorbed the available solute more quickly [30]. Results are shown in table-5 and fig-9.

3.3.7 Optimization of initial volume:

To develop a magnificent approach for removing Levafix Amber, the optimum conditions must be attained. Investigation into the impact of initial volume is also necessary. Different starting volumes were applied to activated carbon made from jute sticks with an optimal concentration

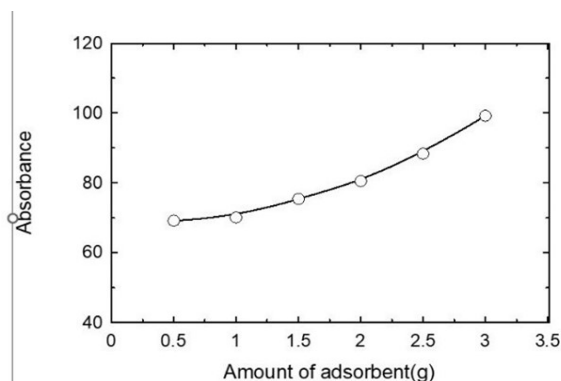
of 100 ppm. It demonstrates that removal effectiveness declines with an increase in the starting volume of the Levafix Amber solution, which was 99.60% at a volume of 50.0 ml. The removal efficiency was 92.81% for an initial volume of 100 ml, 90.56% for an initial volume of 150 ml, and similarly declined for increasing starting volumes. This removal effectiveness declines most likely as a result of increasing adsorbate interaction with the available adsorbent site.

3.3.8 Optimization of adsorbent dose:

On how much activated charcoal was employed to remove dye, a study was conducted. Fig. 10 demonstrates that 3.0 g of activated charcoal successfully absorbed roughly 90.22 % of the dye. With more adsorbent used, color removal effectiveness steadily improved. The removal efficiency improved with the increase in adsorbents (from 0.5g to 3.0g) while maintaining the same particle size of 90μm. Consequently, 3.0 g of adsorbent were selected for the next experiment. Optimization of adsorbent dose:

Table 6. Optimization of adsorbent dose

Sample	Levafix Red	
	Adsorbent Amount, g	Removal efficiency (%)
Amount of adsorbent	0.5	69.15
	1.0	70.43
	1.5	75.43
	2.0	80.53
	2.5	88.36
	3.0	99.22
Volume of solution	50.0 mL	
Temperature	30.0 0C	
pH	6.60	
Concentration	100ppm	
Particle size	90µm	

**Fig 10.** Effect of amount of adsorbent for removal of dye.

3.3.9 Optimization of pH:

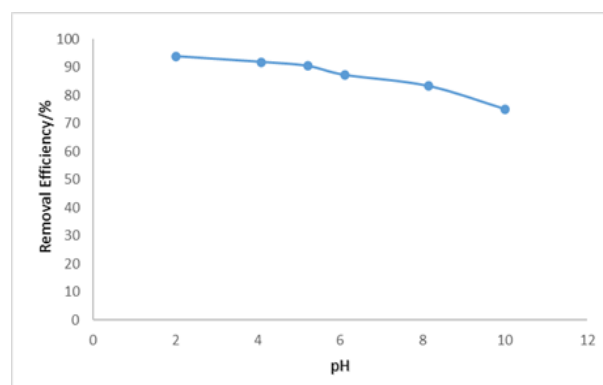
Effect of pH on adsorption of LA on activated jute-sticks: Fig-11 shows that the adsorption of LA on jute-sticks follow an exponential decay with the increase of pH. It may be concluded that acidic medium favors adsorption of LA on Jute-sticks. The result can be explained with the help of pH_{zpc}. The pH_{zpc} of jute-sticks is 4.6±0.1. The surface becomes positively charged when the pH of the solution is lower than the pH_{zpc}. LA is a anionic dye. Due to electrostatic force of attraction molecules of LA are adsorbed on the surface of Jute sticks [31].

3.4 Application of the Developed Treatment System to industrial waste water (Real sample)

The efficacy of the treated jute sticks was assessed for the treatment of waste water samples contaminated with Lev-

Table 7. Optmization of PH

Sample	Levafix Red	
	pH	Removal efficiency (%)
Amount of adsorbent	3.0 g	
Volume of solution	50.0 mL	
Temperature	30.0 0C	
pH	3.01	91.89
	4.08	87.90
	5.21	85.23
	6.12	80.84
	8.12	77.45
	10	75.09
Concentration	100 ppm	
Particle size	90 µm	

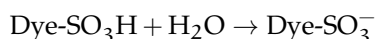
**Fig 11.** Variation of PH and removal efficiency of dye.

afix Amber. The samples had 100ppm of Levafix red in total. The pH of the sample water is reduced to 3.5 by adding a 0.01M HCl solution since the pH of the water samples being around 11.33. For this study, 3.01g of adsorbent made from jute sticks is used. It's a matter of joy that the Levafix Amber was successfully extracted from actual waste water by utilizing our developed adsorbent with high removal efficiency.

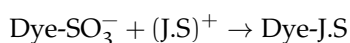
3.5 Proposed mechanism

Jute sticks that have been treated typically have a non-polar surface, however the oxidation process might produce a very minor polarity. Jute stick adsorbents are often hydrophobic and organophilic as a consequence. As a result, they are frequently utilized in systems for solvent recovery and water purification to adsorb organic contaminants. The dye solution's pH level has a significant

impact on the entire adsorption process, but especially on the adsorption capacity. Any oxide surface generates a surface charge (positive or negative). The pH of the solution that the oxide particles are immersed in directly relates to this charge. The pH required to generate zero net surface charge is a useful indicator of a surface's propensity to become positively or negatively charged as a function of pH. Jute sticks have a point of zero charge at a solution pH of 4.60, which is known as the point of zero charge (pHZPC). This suggests that the jute sticks' surface has a positive surface charge below the pHZPC and a negative surface charge above it. The jute sticks are protonated in the first stage while submerged in a pH pzc (pH 3.5) solution. The separation of the dye agglomerates in the aqueous solution is the second stage. In the aqueous solution, dyes are ordered in addition to being hydrated. Before the dye is adsorbed, its self-association in the aqueous solution needs to be broken up. Additionally, the dye must be dehydrated before being adsorbed. We presume that this procedure is quite quick for LA dye. The third phase involves the negatively charged dye being electrostatically attracted to the positively charged jute stick surface at a pH of 3.5. The structure of the dye and the surface characteristics of the adsorbent are only two examples of the numerous elements that may affect the adsorption behavior. An anionic dye with a sulfonic acid and hydroxyl group in its structure is called Levafix Amber (LA). In aqueous solution it dissociates as a negative anion-



The presence of positive charges on the surface on the jute sticks has the tendency to attract anionic dye as follow



4 Conclusion

Adsorbent derived from jute stick; an agricultural waste demonstrated outstanding capability in removing Levafix Amber dye from aqueous solution. According to the findings of the current study, the adsorption technique is quite successful at decolorizing textile wastewater, as we can achieve 99% decolorization in a short period of time. Before releasing wastewater into the aquatic environment, it is necessary to improve the adsorption process efficiently by changing parameters in order to reduce the values to acceptable levels for wastewater. The effects of time, adsorbent dose, temperature, concentration, initial volume, and pH were all evaluated in relation to the removal of color from aqueous solutions and wastewaters using activated carbon made from jute sticks. The ideal pH for effective dye adsorption was discovered to be 3.5 according to the

adsorption experiments, the optimal period for jute stick adsorption was discovered to be 6 hours, with an adsorbent dose of 3.0 g. Adsorption worked well to remove color from textile wastewaters. Activated carbon was the most efficient sorbent, but other inexpensive sorbents may be employed to remove color. Economics will determine which sorbent is used in the end. Batch experiments and column studies support the usage of this inexpensive material in place of expensive adsorbent. Our technique can be employed on an industrial scale, and we think it will play a significant role in the textile wastewater treatment system since it is affordable, environmentally benign, and economically feasible.

References

- [1] D. P. VanderWiel, M. Pruski, and T. S. King, "A kinetic study on the adsorption and reaction of hydrogen over silica-supported ruthenium and silver-ruthenium catalysts during the hydrogenation of carbon monoxide," *Journal of Catalysis*, vol. 188, no. 1, pp. 186–202, 1999.
- [2] Kostedt, J. Drwiega, D. W. Mazyck, *et al.*, "Magnetically agitated photocatalytic reactor for photocatalytic oxidation of aqueous phase organic pollutants," *Environmental science & technology*, vol. 39, no. 20, pp. 8052–8056, 2005.
- [3] Y. J. Ferdosi, A.-N. Chowdhury, and M. M. Hossain, "Copper-cobalt mixed oxide matrix: A better adsorbent for the treatment of textile dye," *Asian Journal of Water, Environment and Pollution*, vol. 10, no. 2, pp. 1–9, 2013.
- [4] G. D. Parfitt and C. H. Rochester, "Adsorption from solution at the solid/liquid interface," (*No Title*), 1983.
- [5] *Concerns about mtbe*, <https://archive.epa.gov/mtbe/web/html/faq.html>, Accessed: Date, Year.
- [6] *Environmental performance report 2001*, <https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/Collection/T1-14-2002E.pdf>.
- [7] *State of the environment, issue: Air quality*, <https://soe.dceew.gov.au>.
- [8] D. W. A. Sharp, "The penguin dictionary of chemistry," (*No Title*), 1983.
- [9] G. Mckay, M. El Geundi, and M. Nassar, "Equilibrium studies during the removal of dyestuffs from aqueous solutions using bagasse pith," *Water research*, vol. 21, no. 12, pp. 1513–1520, 1987.

- [10] W. Tsai, C. Chang, M. Lin, S. Chien, H. Sun, and M. Hsieh, "Adsorption of acid dye onto activated carbons prepared from agricultural waste bagasse by ZnCl_2 activation," *Chemosphere*, vol. 45, no. 1, pp. 51–58, 2001.
- [11] S. Raghuvanshi, R. Singh, C. Kaushik, and A. Raghav, "Kinetics study of methylene blue dye bioadsorption on bagasse," *Applied Ecology and Environmental Research*, vol. 2, no. 2, pp. 35–43, 2004.
- [12] M. Arami, N. Y. Limaee, N. M. Mahmoodi, and N. S. Tabrizi, "Removal of dyes from colored textile wastewater by orange peel adsorbent: Equilibrium and kinetic studies," *Journal of Colloid and Interface Science*, vol. 288, no. 2, pp. 371–376, 2005.
- [13] C. Pearce, J. Lloyd, and J. Guthrie, "The removal of colour from textile wastewater using whole bacterial cells: A review," *Dyes and pigments*, vol. 58, no. 3, pp. 179–196, 2003.
- [14] T. Robinson, G. McMullan, R. Marchant, and P. Nigam, "Remediation of dyes in textile effluent: A critical review on current treatment technologies with a proposed alternative," *Bioresource technology*, vol. 77, no. 3, pp. 247–255, 2001.
- [15] Y. Fu and T. Viraraghavan, "Fungal decolorization of dye wastewaters: A review," *Bioresource technology*, vol. 79, no. 3, pp. 251–262, 2001.
- [16] G. McMullan, C. Meehan, A. Conneely, et al., "Microbial decolourisation and degradation of textile dyes," *Applied microbiology and biotechnology*, vol. 56, pp. 81–87, 2001.
- [17] S. Ghoreishi and R. Haghighi, "Chemical catalytic reaction and biological oxidation for treatment of non-biodegradable textile effluent," *Chemical engineering journal*, vol. 95, no. 1-3, pp. 163–169, 2003.
- [18] K. M. Doke and E. M. Khan, "Adsorption thermodynamics to clean up wastewater; critical review," *Reviews in Environmental Science and Bio/Technology*, vol. 12, no. 1, pp. 25–44, 2013.
- [19] A. Dąbrowski, "Adsorption—from theory to practice," *Advances in colloid and interface science*, vol. 93, no. 1-3, pp. 135–224, 2001.
- [20] Y. M. Slokar and A. M. Le Marechal, "Methods of decoloration of textile wastewaters," *Dyes and pigments*, vol. 37, no. 4, pp. 335–356, 1998.
- [21] Pink, d. h. (2006). *investing in tomorrow's liquid gold*, <https://search.yahoo.com>.
- [22] *Public law, 2002, 107-303*, <https://www.congress.gov/107/plaws/pub1303/PLAW-107pub1303.pdf>.
- [23] D. L. Pavia, G. M. Lampman, G. S. Kriz, and R. G. Engel, "Organic laboratory techniques," *Brooks/Cole*, 1995.
- [24] Y. Ho and G. McKay, "A two-stage batch sorption optimized design for dye removal to minimize contact time," *Process safety and environmental protection*, vol. 76, no. B4, pp. 313–318, 1998.
- [25] E. Voudrias, K. Fytianos, and E. Bozani, "Sorption-desorption isotherms of dyes from aqueous solutions and wastewaters with different sorbent materials," *Global Nest Int. J.*, vol. 4, no. 1, pp. 75–83, 2002.
- [26] M. Haque and Nawab, *Principles of physical chemistry, dhaka 1974. 3rd edition, student publication*, <http://182.160.97.198:8080/xmlui/handle/123456789/726>.
- [27] P. E. Meissner, G. Mandi, B. Coulibaly, et al., "Methylene blue for malaria in africa: Results from a dose-finding study in combination with chloroquine," *Malaria journal*, vol. 5, pp. 1–5, 2006.
- [28] *Silbelzor, j. serb. chem soc*, <https://doiserbia.nb.rs/img/doi/0352-5139/2004/0352-51390401025Z.pdf>.
- [29] R. Qadeer and J. Hanif, "Temperature and concentration dependence of kinetics of thorium adsorption on activated charcoal from aqueous solutions," *Journal of Islamic Academy of Sciences*, vol. 7, no. 1, pp. 56–60, 1994.
- [30] J. DiVincenzo and D. Sparks, "Sorption of the neutral and charged forms of pentachlorophenol on soil: Evidence for different mechanisms," *Archives of Environmental Contamination and Toxicology*, vol. 40, pp. 445–450, 2001.
- [31] E. Voudrias, K. Fytianos, and E. Bozani, "Sorption-desorption isotherms of dyes from aqueous solutions and wastewaters with different sorbent materials," *Global Nest Int. J.*, vol. 4, no. 1, pp. 75–83, 2002.



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