Adsorption of Remazol Blue and Yellow Dyes Using Carbon from Bidara Arab Leaves (*Ziziphus spina-christi*)

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**Abstract.** The adsorption of a mixed dyes solution of remazol brilliant blue R and remazol yellow FG using carbon derived from bidara arab leaves (*Ziziphus spina-christi*) has been carried out. Liquid dye waste from the dyeing or washing process in the batik industry is a source of environmental pollution if discharged directly into water bodies. Therefore, it is necessary to reduce its concentration before releasing it into the environment. The adsorption method is considered one of the most effective techniques due to its ability to reduce the concentration of dye waste. In this study, the parameters investigated included contact time (10; 20; 30; 40; 45 and 50 minutes), adsorbent mass (30; 35; 40; 45; 50 and 55 mg), initial dye concentration (24; 26; 28; 30; 32 and 34 mg/L), and solution pH (2; 3; 4, 6; 8; 10 and 12). The adsorption performance was measured using UV-Vis spectrophotometer at the maximum wavelength of each dye. The optimum adsorption conditions were obtained at Contact time: 40 minutes, with removal percentages of 92.08% (remazol blue) and 20.96% (remazol yellow); adsorbent mass: 40 mg, with removal percentages of 94.20% (remazol blue) and 28.18% (remazol yellow); initial concentration: 24mg/L with removal percentages of 97.31% (remazol blue) and 36.32% (remazol yellow); pH: 2 with removal percentages of 100% (remazol blue) and 71.50% (remazol yellow).

# INTRODUCTION

# Synthetic dyes are widely used in the textile industry. The textile industry is an industry that processes fiber into yarn and then into clothing or other industries. This industry is one of the largest manufacturing industries both in Indonesia and in the world. One of the largest textile industries in Indonesia is the batik industry.

# One of the batik industries in Surabaya is the Putat Jaya Batik House. Before becoming a batik house industry, the Putat Jaya Batik House was formed to improve the economy of the Putat Jaya area [1]. The batik industry of Rumah Batik Putat Jaya has a positive impact as an increase in the economy of the residents, but there are also negative impacts because the liquid waste generated from the dyeing, coloring or washing process is a source of environmental pollution if it is directly discharged into water bodies without any waste management process first. The production of batik cloth produced from the Putat Jaya Batik House has a distinctive motif, namely the motif of leaves and jatropha fruit, while in the manufacturing process several types of textile dyes are used, including remazol, naphthol, and indigosol [2].

# Remazol is one type of synthetic dye used in the batik-making process at the Putat Jaya Batik House. Remazol is a dye that is classified as a reactive dye containing a vinyl sulfone reactive group, this group can react and bind directly to the fiber and become part of the fiber [3]. Remazol dyes have general properties such as being easily soluble in water, good fastness, the resulting bright color, easy to apply, and relatively affordable prices [4]. During the dyeing process, about 15% of the total dye product is released in the wastewater. All dye deposition in water bodies causes chromophore effluent with high chemical pollutants which are partially soluble in water. Removal of color from this type of waste is difficult because the dye has a high concentration of electrolytes which have characteristics of being resistant to light, resistant to oxidizing agents and difficult to degrade after being released into aquatic systems and the non-biodegradable chemicals used in staining remazol appear to be mutagenic and carcinogenic [5].

# Several methods can be used to reduce the concentration of dye waste, like coagulation and flocculation, membrane separation, activated carbon adsorption electrochemical removal, photochemical degradation, biological degradation, and adsorption. However, the adsorption method is considered the most effective. The adsorption technique has the potential to remove organic compounds from water because of its high efficiency and ability to separate various chemical compounds. The most widely used adsorbent is activated carbon [6], but the cost and the need for an regeneration system was expensive make it less economical as an adsorbent. So, we need other alternative adsorbents that are cheap, effective and efficient with high adsorption efficiency. Adsorbents that have been used to reduce the concentration of remazol dye solution with an adsorption process include using nata de coco as an adsorbent for adsorption of remazol blue dye [7]. The decrease in the concentration of yellow remasol dye has also been studied using activated charcoal as an adsorbent made from sawdust [8].

# Bidara arab leaves (Zizhipus spina-christi) can be used as an alternative adsorbent because it is easy to find, low production costs and easy to regenerate. Previous research on Zizhipus spina-christi leaves as an adsorbent has been carried out to reduce the concentration of sulfate ions in solution [9] and has also been conducted to reduce the concentration of Cr (IV) ions in solution [10]. Yousif, etal., 2022 also studied the use of *Ziziphus Spina-Christi* leavesas an adsorbent for Cd Adsorption [11].

# This study investigated the efficiency of carbon Bidara Arab leaves (*Zizhipus spina-christi*) as adsorbent in adsorption of a mixture of remazol blue and remazol yellow dye from solution by optimizing contact time, adsorbent mass, initial concentration, and pH. The results obtained from this study are expected to be a solution in solving the problem of environmental pollution due to dye waste from the Putat Jaya Batik House. To our knowledge, this is the first study using *Ziziphus spina-christi* carbon for simultaneous adsorption of Remazol Blue and Yellow dyes.

# EXPERIMENTAL

## Materials and Instruments

The instrument used in this study were watch glass, spatula, analytical balance, 100 mL volumetric flask; 250 mL; and 1000 mL, 50 mL beaker, 100 mL and 250 mL measuring pipette 25 mL, 10 mL volume pipette, suction ball, magnetic stirrer, Whatman filter paper, funnel, erlenmeyer, pH Meter (Hanna), 250 mL crucible, oven , furnace, mortar, pestle, Sieve 25 m, Shimadzu FTIR, SEM broker, PHILIPS-binary XRD, Genesys 10S UV-Vis spectrophotometer, and quartz cuvette. The materials used in this study were arabic bidara leaves (*Ziziphus spina-christi*), aqua DM (demineralized), Remazol Brilliant Blue R and Remazol Yellow dyes (obtained from Toko Warna Indah, Surabaya), NaOH (Merck) and HCl (Merck).

**Adsorbent Preparation**

## Arabic Bidara leaves (*Ziziphus spina-christi*) are dried in the sun until they are brownish yellow. The leaves were washed with aqua DM then put into a 250 mL crucible, oven for 24 hours at 80°C to dry. After that, the dried leaves were heated in a furnace at a temperature of 700°C for 3 hours to be carbonated. Next, the carbon is ground with a mortar and pestle until it becomes a powder. Then it was sieved using a 25 m Sieve (No. 500), and it was ready to be used as a adsorbent [12].

## Characterization

## The results of the adsorbent before adsorption were characterized using Fourier Transform Infrared (FTIR), Scanning Electron Microscope (SEM) and X Ray Diffraction (XRD). FTIR used to identify the functional groups present in the sample. SEM used to determine the morphological structure of the adsorbent, and XRD characterization was also carried out to determine the crystallite structure of the crystallinity degree of the sample [1]. The working solution of each dye was measured for the maximum absorbance at a wavelength of 300-700nm using a UV-Vis spectrophotometer with aqua DM as a blank to determine the wavelength of each dye (remazol blue and remazol yellow). Measurement of the maximum wavelength in the mixture of remazol blue and remazol yellow dye was carried out with 60 mg/L blue remasol solution and 60 mg/L yellow remasol solution each taken as much as 10 mL and mixed, then the maximum absorbance was measured at a wavelength of 300-700 nm using Uv-Vis spectrophotometer with aqua DM as blank [1].

## Adsorption Experiment

The remazol blue and remazol yellow solutions were prepared first by dissolving the remazol blue and remazol yellow dye powder as much as 1 gram each and dissolved in two different 1L volumetric flasks with aqua DM and homogenized. Determination of the maximum wavelength of each dye was carried out using a working solution of 60 mg/L by diluting a solution of remazol blue and remasol yellow solution 1000 mg/L to a working solution of 60 mg/L so that each was diluted.

The adsorption analysis was carried out using batch adsorption in a 100ml beaker glass with each solution of remazol blue and remazol yellow 60 mg/L taken as much as 5 ml and stirred with a stirrer at 450 rpm to study the effects of contact time, adsorbent mass, initial dye concentration and pH. All experiments were carried out in triples and the experimental results were averaged and reported.

The effect of contact time was analyzed with 40 mg of carbon Bidara Arab leaf adsorbent, and 5 ml of each solution of remazol blue and 60 mg/L remazol yellow was mixed in a beaker glass with variations of 10, 20, 30, 40, 45, and 50 minutes.

The optimum adsorbent mass was analyzed with the concentration of each dye 60 mg/L as much as 5 ml put into a beaker with a variation of the adsorbent mass 30; 35; 40; 45; and 50 mg for 40 minutes (optimum contact time). The effect of initial dye concentration was carried out by varying the concentration of each dye 24; 26; 28; 30; 32 and 34 mg/L as much as 5 ml and added 40 mg of adsorbent carbon Bidara Arab leaf adsorption was carried out for 40 minutes. The pH effect was carried out with a concentration of each dye of 60 mg/L as much as 5 mL mixed in a beaker then added HCl /NaOH and measured pH with a variation of pH 2; 3; 4; 6; 8; 10 and 12 and added 40 mg of adsorbent and carried out for 40 minutes.

After the batch adsorption process was carried out, the solution was filtered using filter paper to separate the dye solution from the adsorbent. The filtrate was taken and the absorbance of each dye in the mixture was measured at the maximum wavelength of the dye using a UV-Vis spectrophotometer. Aqua DM was used as a blank to measure the absorbance of remazol blue and remazol yellow in solution.

# RESULTS AND DISCUSSION

The adsorbent of the carbon bidara arab leaf (*Ziziphus spina-christi*) was characterized using FTIR in the range of 400cm-1 to 4000cm-1 to identify the functional groups present in the carbonated bidara arab leaf. The FTIR spectra of the adsorbent are shown in Fig. 1.

According to the Fig. 1, at wavenumber 3367.82 cm-1 the tensile stretching of –OH is observed. The results of the spectra also show the oxygen functional group in the C=O conjugate bond of the carboxylic group at wave number 1427.37 cm-1. At wavenumber 2874.03 and 2926.11 cm-1 showed the presence of the C-H stretching functional group of methylene. At wavenumber 2515.26 cm-1 indicates the presence of a functional group C≡C and -C≡N (or C=C=C-and -N=C=O) in the carbon structure. Wide peak at wavenumber 873.78; 711,76; 570.95 associated with the presence of a tensile vibration functional group C=C bending, S=O stretching, dan C-S stretching. This result is in accordance with previous research [10]

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**FIGURE 1.** FTIR spectra of Carbon *Ziziphus spina-christi* leaves

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| **TABLE 1.** Comparison of functional group indications on *Ziziphus spina-christi* adsorbent from research results and literature [10]only.   |  |  |  | | --- | --- | --- | | Wavenumber | | Functional Group | | This research | Literature | | 3367.82 | 3420 | -OH *stretching* | | 1427.37 | 1427 | C=O | | 2515.26 | 2516 | C≡C and -C≡N (or C=C=C-and -N=C=O) in the carbon structure | | 2874.03 and 2926.11 | 2852 and 2923 | C-H *stretching* metilen | | 873.78 | 873 | C=C *bending* | | 711.76 | 711 | S=O *bending* | | 570.93 | 573 | C-S *stretching* | |

The adsorbent was characterized using XRD to identify the crystalline phase and crystal structure formed from carbonated samples of activated carbon from Bidara Arab leaves. X-ray waves are performed with a measurement range of 5 (°2θ) to 60 (°2θ). The result of XRD characterization showing the relationship between intensity and angle of 2θ. The XRD of the adsorbent are shown in Fig. 2.

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**FIGURE 2.** XRD of Carbon *Ziziphus spina-christi* leaves

In the Fig 2 that has been shown, it can be seen that the peak is at 2θ= 29.40. This peak is related with the presence of activated carbon. In the picture it can also be seen clearly that the peak produced is the crystallinity of activated carbon. The results of previous studies [10].

The carbonized Bidara Arab leaf (*Ziziphus spina-christi*) adsorbent was characterized using SEM to determine the morphology of the carbonized Bidara Arab leaf. The results of the SEM characterization are shown in Fig. 3. The data with a magnification of 10.000 times using a maximum voltage of 10 kV which shows information that the presence of pores in the adsorbent. The resulting morphology allows for an adsorption process with carbonized Bidara Arab leaf. The presence of cavities and pores can make remazol blue and remazol yellow in the mixture as adsorbate enter the pores so that it can reduce the dye concentration in solution [13] so that adsorption can be carried out using carbonized Bidara Arab leaf (*Ziziphus spina-christi*) as adsorbent.

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**FIGURE 3.** SEM of Carbon *Ziziphus spina-christi* leaves

The initial step of this research is to determine the maximum wavelength of each dye (remazol blue and yellow). The maximum wavelength was measured using a Genesys 10S UV-Vis spectrophotometer in the wavelength range of 300-700 nm. The maximum wavelength of each dye is measured so that it can be used for absorbance measurements in the next steps.

The maximum wavelength of each dye can be seen from Fig. 4 and Fig. 5. The maximum wavelength of remazol blue, 595nm and 415nm for remazol yellow. The maximum wavelength of the remazol blue solution was the same as in previous studies at 595nm [14]. The maximum wavelength of the yellow remasol solution was the same as in previous studies at 415nm [15].

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**FIGURE 4.** Remazol Blue Maximum Wavelength

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**FIGURE 5.** Remazol Yellow Maximum Wavelength

In this study, the maximum wavelength in the mixture also measured, each dye produces a small peak that corresponds to the maximum wavelength of each dye, 415nm for remazol yellow and 595nm for remazol blue, this indicates an indication of remazol blue and remazol yellow dye in the mixture and there are no other compounds, and there is no reaction between each dye. The wavelength of the mixed solution can be seen in Fig. 6.

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**FIGURE 6.** Maximum Wavelength of Mixture Dye (remazol blue and remazol yellow)

The calibration curves of remazol blue and remazol yellow solutions were made at a concentration of 10; 20; 30; 40; 50; 60 and 70 mg/L. The absorbance of each solution was measured using a UV-Vis spectrophotometer at a wavelength of 415 nm, for a remazol yellow solution, and at a wavelength of 595 nm for a remazol blue solution. The regression coefficient (R2) produced in the blue remasol solution is 0,9995 and the yellow remasol is 0,9997 shows linear relations between the independent variable x (concentration) and the variable y (absorbance), which means if one variable is getting increase, other variables will also increase, if the correlation coefficient approaches the value of +1, there is a very strong positive correlation [16].

The variations of contact time in the adsorption process was carried out to determine the effect of the contact time required for the adsorbent to adsorb the adsorbate in the form of a mixture of dyes to produce an optimum adsorption process. Variation of time was performed at 10; 20; 30; 40; 45 and 50 minutes with the adsorbent mass 40 mg with a volume of mixed solution is 10 ml of and a stirring speed 450 rpm. The results can be seen in Fig. 7.

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**FIGURE 7.** Effect of contact time on adsorption of Mixture Dye (Remazol Blue and Remasol Yellow)

Fig. 7 shows that the adsorption of remazol blue and remazol yellow in the mixed solution got a significant increase from the 10th minute to the 40th minute. The increase in %removal indicates that the longer the contact time, the more dye that interacts with the adsorbent, the more dye will be adsorbed. At 10 minutes, there was still a lot of active adsorbents that had not been occupied, so the %removal for remazol blue dye was 66.09% and 11.74% for remazol yellow. The vacant active site begins to be filled by the dye molecules as time goes on. The high removal rate at the beginning of the contact time is due to the large surface area available for dye adsorption [17]. Until it reaches the equilibrium point, the surface of the adsorbent is completely covered and filled with dye so that the adsorbent reaches equilibrium, this causes the adsorbent to be unable to absorb the dye anymore [18] so that at the 45th minute and the 50th minute the removal was decreased. Based on Fig. 7, the optimum contact time for the adsorbent to adsorb a mixture of blue and remazol yellow dyes occurred in the 40th minute with an average % removal of each dye (remazol blue and remazol yellow) in the mixture is 92.08% and 20.96%.

The percentage of remazol yellow dye removal is lower than remazol blue because it is related to the porosity characteristics of arabic bidara leaf carbon which determines the accessibility of dye molecules, because remazol blue has a smaller molecular weight than remazol yellow, it will provide a higher capacity for dyeing. The adsorption of the dye also depends on the surface functional groups and the carbon charge of the adsorbent used [19]. The structure possessed by remazol blue is more complex and has many branches compared to the structure of remasol yellow. Adsorbates with branched chains are usually more easily adsorbed [20].

The variation of the adsorbent mass of the carbonated Bidara Arab leaves (*Ziziphus spina-christi*) was carried out to determine the effect of the adsorbent mass required in order to produce an optimum adsorption process for the mixed solution dyes of remazol blue and remazol yellow. The mass variation in the adsorption process is carried out with variations 30; 35; 40; 45; 50; and 55 mg with a contact time of 40 minutes with a volume of 10 ml of mixed solution and a stirring speed of 450 rpm. The results can be seen in Fig. 8.

Fig. 8 shows that the adsorption of remazol blue and remazol yellow in the mixed solution experienced a significant increase in the adsorbent mass of 30 to 40 mg. The increase in %removal with the mass of the adsorbent produced can be related that the more mass of the adsorbent used in the adsorption process, the greater the surface area, so that the availability of active sites on the adsorbent will also increase and so that more dye will be adsorbed [21]. At the adsorbent mass of 40 mg, it was seen that the average value of %removal of each dye (remazol blue and remazol yellow) in the mixture reached its maximum condition, 94.20% for remazol blue and 28.18% for remazol yellow. At the addition of the adsorbent mass of 45, 50, and 55 mg there was a decrease in % removal, this happened because the pores on the adsorbent had experienced saturation as a result of being filled with dye so that the adsorbent was unable to reabsorb, this event can also be called a desorption event. , desorption occurs when the adsorption process has been maximized, and the surface of the adsorbent is saturated so that it is no longer able to adsorp the adsorbate and the equilibrium point has been reached. As the mass of the adsorbent increases, the number of dye molecules available in the solution is not sufficient to completely adsorb all the effective adsorption sites present on the adsorbent, resulting in a state of surface equilibrium and reducing the adsorption capacity per unit mass of the adsorbent [22].

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**FIGURE 8.** Effect of mass adsorbent on adsorption of Mixture Dye (Remazol Blue and Remasol Yellow)

The initial concentration variation in the mixture was carried out to determine the effect of the initial concentration of each dye in the mixture in order to produce optimum %removal in the adsorption process on a mixture of blue and yellow remasol dyes. The effect of initial concentration depends on the relationship between dye concentration and the availability of adsorption capacity on the surface of the adsorbent, generally the percentage of dye removal decreases with increasing initial dye, which occurs due to saturation of the adsorption capacity of the adsorbent. Variations in the initial concentration of each dye in the adsorption process were carried out with variations of 24, 26, 28, 30, 32, and 34 mg/L with an optimum contact time of 40 minutes, an adsorbent mass of 40 mg with a mixed solution volume of 10 ml and stirring speed 450 rpm. The results can be seen in Fig.9.

Fig. 9 shows the percentage of dye removal for different initial dye concentrations, as the results show, the %removal efficiency decreases with increasing initial dye concentration, it can be seen after 40 minutes of the adsorption process, the %removal of each dye decreases. This behavior can be ascribed to the presence of a higher concentration of adsorbate per unit mass of adsorbent, which can limit adsorption [23] this happens because at high concentrations, the amount of dye is also high this is not proportional to the number of adsorbents, resulting in a decrease in adsorption efficciency because the dye can no longer be bound by the adsorbent so that the availability of the adsorbent active group is reduced for the dye at higher concentrations [24]. This may also be due to the increasing concentration causing the dye molecules to tend to form aggregates, so that the diffusion of the dye molecules from the solution to the adsorbent surface is inhibited [25].

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**FIGURE 9.** Effect of initial concentration on adsorption of Mixture Dye (Remazol Blue and Remasol Yellow)

The adsorption of dye on each dye without mixing was also carried out in this study, the results are shown in Fig. 10 (a) and (b). In the image it can be seen that for remazol blue dye there is an optimum point at an initial concentration of 24, and remazol yellow at an initial concentration of 22 and after the optimum point the %removal decreased, this was different from the %removal variation of the initial concentration in the mixture which increased with decreasing initial concentration of each dye. The %removal value for each dye that was not mixed resulted in a higher value than in the mixture, where at a concentration of 30 mg/L %removal in remazol blue was 97.78% and remazol yellow was 68.50% while in a mixture % removal resulted from remazol blue was 96.44% and remazol yellow was 35.4%. This is because if in a mixture of dyes, there is competition in the adsorption of each dye, each dye will compete with each other to occupy the active side of the adsorbent so that the %removal of each dye when in the mixture is smaller when compared to the %removal adsorption of each dye without being mixed.

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| (a) | (b) |

**FIGURE 10.** Effect of Initial Concentration on adsorption Remazol Blue (a) and Remazol Yellow (b)

The effect of the pH of the solution on adsorption was studied with the aim of achieving optimum adsorption and producing high %removal. The variation of pH in the adsorption process was carried out with variations of 3; 4; 6; 8; 10 and 12 with the optimum contact time of 40 minutes, the mass of the adsorbent was 40 mg with the initial concentration of each dye of 30 mg/L, the volume of the mixed solution was 10 ml and stirring speed of 450 rpm. The results can be seen in Fig. 11.

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| (a) |

**FIGURE 11.** Effect pH on adsorption of Mixture Dye (Remazol Blue and Remasol Yellow)

It can be seen in the Fig. 11 that the %removal is high at a strong acid pH state and at a strong base the %removal begins to show an increase. At pH 2 the highest %removal was obtained with a value for remazol blue was 100% and for remazol yellow was 71.49%. The greater the pH value, the %removal of each dye decreased until pH 10, %removal for the remazol blue was 90.10% and 18.03% for remazol yellow. At pH 12, which is a strong alkaline condition, the %removal has increased but the percentage is still lower when compared to acidic conditions, 93.27% for remazol blue and 27.24% for remazol yellow. Each adsorption experiment was conducted three times. The standard deviation calculated for all experiments was less than 2%. This indicates that the experiments were precise.

The protonation and deprotonation reactions of functional groups occur at the pH of the system which results in a change in the charge distribution of the adsorbent and dye. Previous studies have shown that the adsorbent surface is protonated at low pH, and deprotonated at high pH [26]. Adsorption at acidic pH conditions produces higher removal, this is due to increased protonation by neutralizing the negative charge from the surface of the adsorbent so that this the more ease the diffusion process in the adsorbent area. At an acidic pH, the active site of the activated carbon will be protonated, and make its more positively charged and can occur an attraction between a mixture of remazol blue and remazol yellow dyes which are negatively charged and adsorbent which are positively charged. The molecular structure of remazol yellow dye has four sulfite groups, causing this compound to prefer an acidic state than to a base. In addition, the large amount of H+ that can be replaced by hydroxyl radicals makes this compound more acidic [27].

The high percentage of removal under acidic conditions is because the anionic dye contains more H+ ions in solution and protonates the OH- group on the adsorbent, H+ ions in the adsorbent groups will undergo protonation and have a positive charge that is very reactive to speciation in the anion and the presence of OH- ions in the adsorbent groups causes deprotonation and has a negative charge that is reactive to the speciation of anionic dyes in the form of cations [28]. The functional group (-OH) in the carbonated leaves of Bidara Arab is deprotonated and makes the activated carbons negatively charged causing their binding ability to increase. In solution, anionic dyes exist in dissociated form as anionic dye ions in the form of a sulfonate group (-SO3-), this group will bind to H3O+ from the adsorbent, causing the anions of this group to be attracted to the surface of the adsorbent [29].

Compared to other low-cost adsorbents, such as surfactant-modified natural zeolite, which exhibits adsorption capacities of 13.90 mg/g for Remazol Brilliant Blue R and 38.31 mg/g for Remazol Yellow under similar batch conditions [30], and dolomite-modified rice husk biochar, which achieves maximum capacities of 52.00 mg/g for reactive brilliant blue and 35.50 mg/g for RB-5 dyes at elevated temperature and longer contact times [31], the Bidara Arab leaf-based carbon shows strong performance for remazol blue in terms of percent removal but much lower efficiency for remazol yellow. Although the adsorption capacities in this research only 6.60 mg/g, the percentage removals under optimal conditions suggest promise for remazol blue, but indicate significant room for improvement for remazol yellow relative to some other adsorbents like those listed above. These findings suggest that Bidara Arab leaf-derived carbon could serve as a sustainable, locally available alternative for wastewater treatment in dye-laden effluents, provided that its adsorption capacity, especially for yellow dyes, is improved. However, limitations include the lower removal of remazol yellow, the short contact time relative to other studies, and currently modest adsorbent capacity. Future work should focus on quantifying the adsorption capacity in mg/g, surface modification to enhance selectivity for yellow dyes, regeneration/reusability studies, and scale-up under continuous flow conditions.

# CONCLUSION

# Research was carried out using carbon from Bidara Arab leaves (*Ziziphus spina-christi*) as an adsorbent to reduce the concentration of a mixed solution of remazol blue and remazol yellow dyes by the adsorption method. The optimum adsorption conditions were obtained at a contact time of 40 minutes, with removal percentages of 92.08% (remazol blue) and 20.96% (remazol yellow); an adsorbent mass of 40 mg, with removal percentages of 94.20% and 28.18%, respectively; an initial concentration of 24 mg/L, with removal percentages of 97.31% and 36.32%, respectively; and at pH 2, with removal percentages of 100% and 71.50%, respectively. These findings suggest that Bidara Arab leaf–based carbon has potential for integration into wastewater treatment systems, particularly for industries such as textiles and batik that generate dye-rich effluents. However, the relatively lower removal efficiency for remazol yellow highlights a limitation, and further studies on adsorbent modification, regeneration, and scale-up are needed to enhance performance and evaluate practical applications.

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