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Biodecolorization of Remazol Black B using biochar produced from coconut shell: batch, desorption, isotherm and kinetic studies

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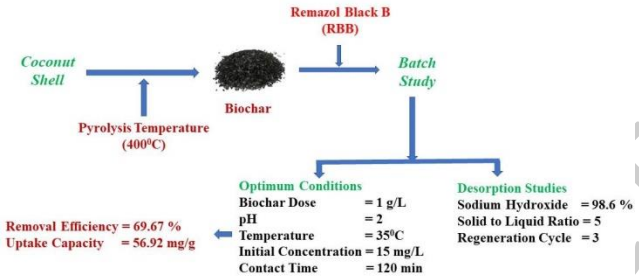
Graphical abstract



Abstract

The coconut shell-derived biochar was employed in this study to remediate Remazol Black B from aqueous solutions. For efficient dye remediation, preliminary batch investigations focused on adjusting temperature, biochar dosage, initial dye concentration, and pH. The results shown that dosage of biochar had a considerable effect on the potential of dye absorption, with 1 g/L performing well. In addition, the data revealed that a pH of 2.0 was employed to attain equilibrium. Different temperature ranges from 30°C to 45°C were used to explore the influence of temperature, with 35°C being found to be the optimal value. The characteristics of biochar were investigated using Fourier Transform Infrared Spectroscopy, thermogravimetric analysis, and a Scanning Electron Microscope. In addition, the potential of biochar desorption was investigated by varying the solid to liquid ratio for different elutants. Adsorption and kinetic study revealed that the adsorption was favoured by physical adsorption. According to the findings, it was found coconut shell-derived biochar can treat dye-bearing aqueous solutions with a removal efficiency of 69.67%.

Keywords: Remazol Black B, biochar, decolorization, desorption, characterization

1. Introduction

In both developing and developed nations, growth of population and industrial expansion has led to a significant increase in water consumption. Several toxins are emitted in large quantities by industries into nearby water bodies, degrading water quality and disturbing the aquatic ecology (Abdin *et al.*, 2020). Colouring is one of the major primary pollutants which is highly responsible for surface pollution of water bodies. This is primarily attributable to the extensive use of dyes in various industrial settings. There are two distinct types of dyes, namely synthetic dyes and natural dyes (Deb *et al.*, 2020). Synthetic dyes are created through the use of various chemical processes. Dyes, which are frequently emitted by industries, had a significant effect in water quality degradation (Fegousse *et al.*, 2019). The methods and technology that are available right now are not sufficient to deal with these enormous amounts of effluent that contain dye (Franca *et al.*, 2019). India's major cities produce such a large amount of wastewater that the country's sewage treatment plants are unable to adequately process all of it (Yan *et al.*, 2019). Dye-bearing wastewater is released untreated by surrounding industries into nearby streams and rivers. Huge Volume of dye wastes are produces due to excessive usage of dyes. Effluents that are contaminated by dyes are mostly cancer-causing and non-biodegradable (Mohammad *et al.*, 2018). When wastewater containing dyes is released into freshwater bodies, it results in severe health consequences.

Dyes exposure can be harmful to one's health, which may cause kidney and liver cancer, respiratory problems, and allergies (Thoren *et al.*, 1980). As a result, these potentially harmful substances have got to be removed from the wastewater. Ion exchange, electro coagulation, adsorption, sedimentation, oxidation, advanced oxidation process, ozonation, photocatylatic degradation and

membrane filtering are some of the techniques that can be utilised in the process of removing colours from wastewaters (Morikawa *et al.*, 1997). Aside from that, bioremediation is a biological process that involves using biological components to clean up dye. This process is known as bioremediation (Nilsson *et al.*, 1993). The thermal degradation of biomass results in the production of biochar, which is a substance that is rich in carbon (absence of oxygen). It is highly effective at treating effluent containing dyes. Due to its environmental friendliness, this approach has proven to be quite useful in remediation of industrial wastewater (Hao *et al.*,2000). Biochar contains a diverse set of features, including many functional groups, pores, and pore size. Because of these characteristics, biochar is a good substance for removing hazardous contaminants from wastewater. Azo-based chromophores combine azo-based dyes with various reactive groups (Yagub *et al.*,2014). The water used for washing during fibre dyeing may lose up to 50% of Remazol dyes (Safa *et al.*,2011). Only 10% of total Remazol colours can be removed from wastewater using standard activated sludge treatment method (Kaushik and Malik, 2009). As a consequence of this, innovative and workable strategies are required for the removal of dye from effluents. The major goal of this study was to see if coconut shell could be used to remove Remazol Black B from aqueous solutions. India is one of the world's top three coconut-producing countries. In India 90 % of the coconut contribution wa from South Indian stses namely Tamil Nadu, Kerala, Andhra Pradesh and Karanataka. As a result, massive amounts of solid trash were generated during processing. Even though coconut trash is employed in a variety of industries, coconut shell is becoming a difficult problem. The use of coconut shells in the creation of biochar will result in a waste management solution. The coconut shell has high carbon content and will work as an adsorbent for harmful pollutant removal.

2. Materials and methods

2.1. Chemicals and dyes

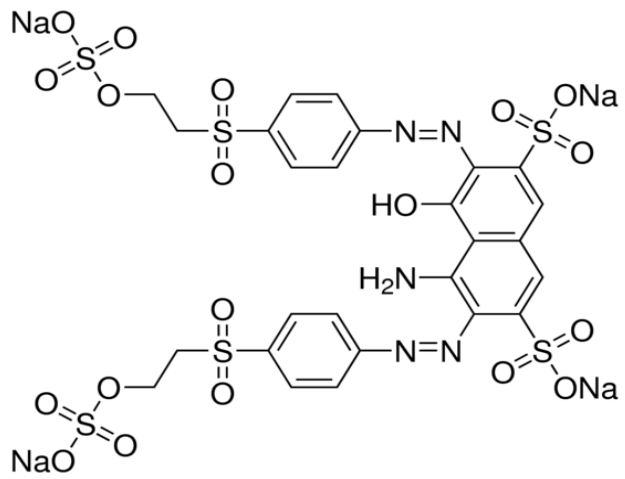


Figure 1. Remazol Black B dye structure

Remazol Black B (RBB), which has an empirical formula of C26H21N5Na4O19S6, a colour index of 20202, a molecular weight of 991.82 g/mol, and a wavelength of 597 nm, was utilised in this investigation. Its characteristics include: a colour index of 20202; a molecular weight of 991.82 g/mol; Remazol Black B's three-dimensional structure is depicted in Figure 1 (RBB). All of the chemicals and colours that were utilised in this experiment were supplied by Sigma-Aldrich (India).

2.2. Raw material and biochar preparation

This investigation made use of coconut shells that had been gathered from the local area as a source of raw material. After obtaining the raw material, it was cleaned with distilled water and allowed to dry in the open air for a period of twenty-four hours. This raw material had been sun-dried before being pulverised and then sieved to produce particles of a consistent size of 75 mm. After placing a specific quantity of dry material in a crucible, the crucible was wrapped in aluminium foil and placed in an electrical muffle furnace, where it was heated to a temperature of 400 degrees Celsius for two hours. Pyrolysis is the process that turns the sample into biochar. Because oxygen is not present in the muffle furnace, this process can take place. After the pyrolysis process was finished, the crucible allowed to cool to its normal room temperature. (Vijayaraghavan and Malik, 2008).

2.3. Batch experiments

Batch Trails were carried out with the goals of perfecting the fundamental parameters and increasing the biochar's dye-absorption capacity as much as possible. A conical flask with a capacity of 250 millilitres and containing 100 millilitres of known dye concentration of 5 mg / L had a defined quantity of biochar (1 g/L as the control) added to it. After that, the samples are put into an orbital shaker, which rotates at a rate of two hundred revolutions per minute for a period of six hours. After that, the suspension was poured into vials and placed in a centrifuge that was set to rotate at 2600 revolutions per minute for a period of 25 minutes. After the centrifuge had completed its cycle, the samples were extracted very carefully so as to cause as little disturbance as possible. In order to take readings with a spectrometer, the uppermost layer of liquid is skilfully extracted and placed in vials containing 10 millilitres. The final concentration in the supernatant was determined with the assistance of a spectrophotometer that had its wavelength adjusted to 597 nm (Dönmez and Aksu, 1999) The batch trails were conducted by varying the parameter of biochar from 0.5 to 10 g/L, pH of 2 to 5, dye concentration of 5 to 100 mg/L and temperature of 30 to 45 ℃ respectively. Constant values of biochar of 1 g/L, pH of 2, Initial dye concentration of 15 mg/L and temperature of 35 ℃ were maintained. The removal efficiency (%) and biochar uptake capacity of the biochar was calculated by equation 1 & 2

$$Q = V(C_0 - C_e)/W \quad (1)$$

$$\text{Removal efficiency} = \frac{(C_0 - C_e)}{C_0} \times 100 \quad (2)$$

Where, V- RBB volume (L); C_o- Initial RBB concnetration (mg/L); C_e- Final RBB concentration (mg/L); W- Quantity of biochar (g).

2.4. Biochar characterization

In order to gain a deeper comprehension of the attributes of biochar, some analytical techniques were utilized in the research process. An apparatus known as a thermogravimetric analyzer was utilized so that the thermal solidity of the material could be determined. Analyzing the surface properties of the biochar, which were essential in the process of the molecular adsorption of dye using the pores that were present on the surface, required the use of a scanning electron microscope. The application of Fourier Transform Infrared Spectroscopy allowed for the investigation of the functional groups in biochar, which play a significant role entire adsorption.

2.5. Desorption studies

In order to investigate the utility of biochar in subsequent adsorption and desorption processes, desorption experiments were carried out. Elutants included sodium hydroxide (NaOH), sodium carbonate ($NaCO_3$), ammonium hydroxide (NH_4OH), hydrochloric acid (HCL), methanol (CH_3OH), and EDTA. A ratio of solid to liquid, denoted by the notation S/L, was also investigated as part of the process of determining the best way to use elutants. Experiments on sorbent regeneration were also conducted in order to determine the maximum number of times a sorbent could be used for adsorption before needing to be replaced (Warnock *et al.,* 2007).

2.6. Isotherm and kinetic studies

Adsorption isotherms, including two parameter models (Langmuir and Freundlich) and three parameter isotherm models (Redlich- Peterson, Khan, Vieth-Sladek, Unilin, Radke- Prausnita and Fritz-Schlunder – III), were investigated in order to gain a better understanding of the adsorption mechanism. This was done in addition to the study of the sorption of RBB dye molecules onto the surface of the biochar. The kinetic study was looked at further in order to measure the amount of adsorbate that was contained within the pores of the sorbent. A kinetic study was performed with varying concentrations, and the results were examined at varying time intervals while the pressure was held constant. Both the Pseudo First order Kinetic model and the Pseudo Second Order Kinetic model were investigated for this project.

Table 1. Raw coconut shell biochar FTIR spectra and dye adsorbed biochar FTIR spectra

Type of Vibration	Wavenumber (cm^{-1})	
	Coconut shell biochar	RBB adsorbed biochar
=C–H bend	750	746
C–O stretch	1182	1179
C=C stretch, N-H bend	1589	1568
O–H stretch	2318	2305
C-H bend	2648	2627

3. Results and discussion

3.1. Biochar characterization

In order to investigate the impact that temperature has on the thermal stability of the materials, a thermogravimetric analysis was carried out. When making biochar, the ability of a material to withstand heat is absolutely necessary (Atkinson *et al.,* 2010). According to the findings, elevating the temperature led to a reduction in the amount of mass possessed by the biomaterials. At a temperature of 700 degrees Celsius, an over-all weight loss of approximately 94.98 percent had occurred. The presence of moisture caused the first stage of degradation to take place between 0 and 100 degrees Celsius, which resulted in a weight loss of 8.8 percent. The second stage of active disintegration took place at temperatures between 100 and 350 degrees Celsius, which led to a weight reduction of 49.50 percent overall. The most degradation transpired in the subsequent stage due to the limited disintegration of the content of the coconut shell's cellulose, lignin, and hemicellulose, as well as due to the release of the entire moisture content (Tan *et al.,* 2015) This led to the most significant surge in the rate of degradation. The final stage of the disintegration process took place at temperatures between 350 and 500 °C. This led to the release of the sample content of the mass, a reduction in weight of 35.02%, and an additional rise in temperature. The findings also show that a peak curve was obtained at 470 °C. The scanning electron micrographs (SEM) are depicted in Figure 2 come from both before and after the process of reactive dye adsorption. As can be seen from the observations, the raw biochar had a significant increase in the number of binding sites as well as the number of pores. Because of its properties, biochar might be able to encourage the binding of dye molecules to its surface (Ahmad *et al.,* 2014) Because of the adsorption process, the surface of the biochar becomes smooth, as shown in Figure 2.

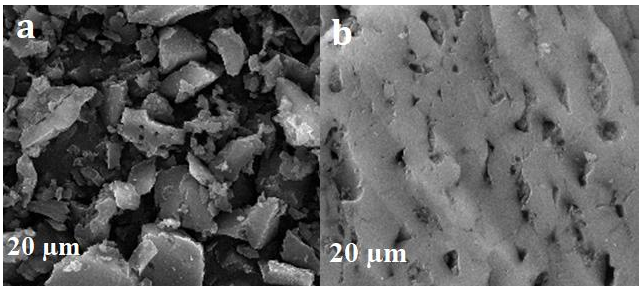


Figure 2. SEM images of raw coconut shell biochar (a) and dye RBB dye adsorbed biochar (b)

Table 1 displays the FTIR spectra of both raw biochar and biochar that has had dye adsorbed to it. From table 1, it was possible to infer that the characteristics of biochar were quite complicated. The intricate structure of the dye molecules facilitated improved binding between a wide

variety of functional groups (Takaya *et al.,* 2016) The research concluded that primary alcohols, alkanes, and alkyl groups are the components that make up biochar.

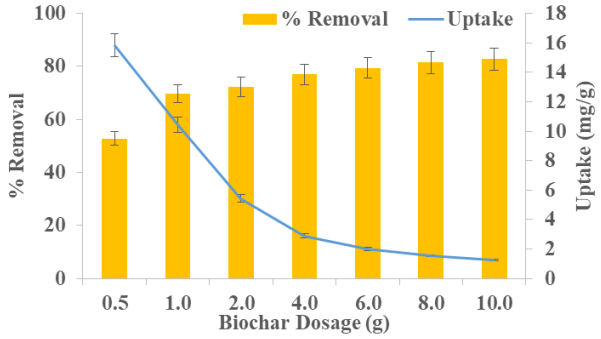


Figure 3. The influence of biochar dose on the removal of RBB using Coconut Shell derived Biochar (Process conditions: pH= 2; Temperature = 35°C; Initial RBB Concentration = 15 mg/L)

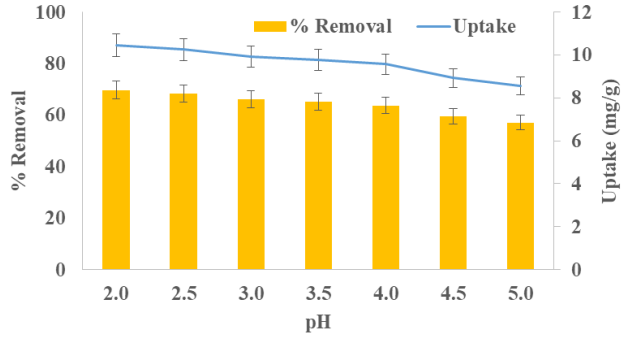


Figure 4. Influence of pH on the removal of RBB using Coconut Shell derived Biochar (Process conditions: Biochar Dose= 1 g/L; Temperature = 35°C; Initial RBB Concentration = 15 mg/L)

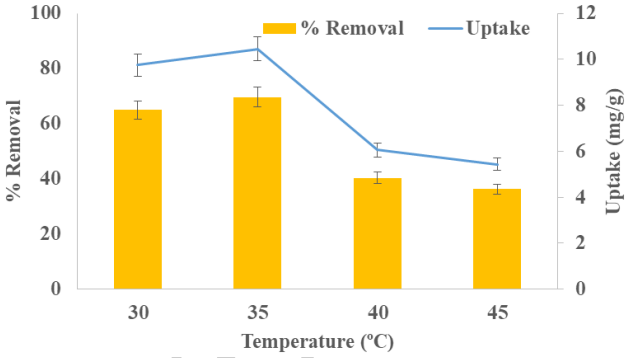


Figure 5. Effect of Temperature on the removal of RBB using Coconut Shell derived Biochar (Process conditions: Biochar Dose= 1 g/L; pH= 2; Initial RBB Concentration = 15 mg/L)

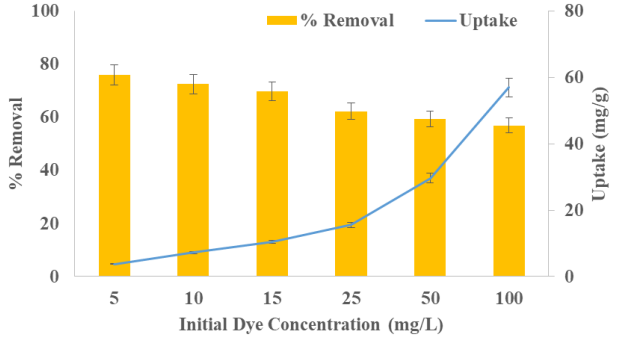


Figure 6. Influence of Initial RBB Concentration on the removal of RBB using Coconut Shell derived Biochar (Process conditions: Biochar Dose= 1 g/L; pH= 2 Temperature = 35°C)

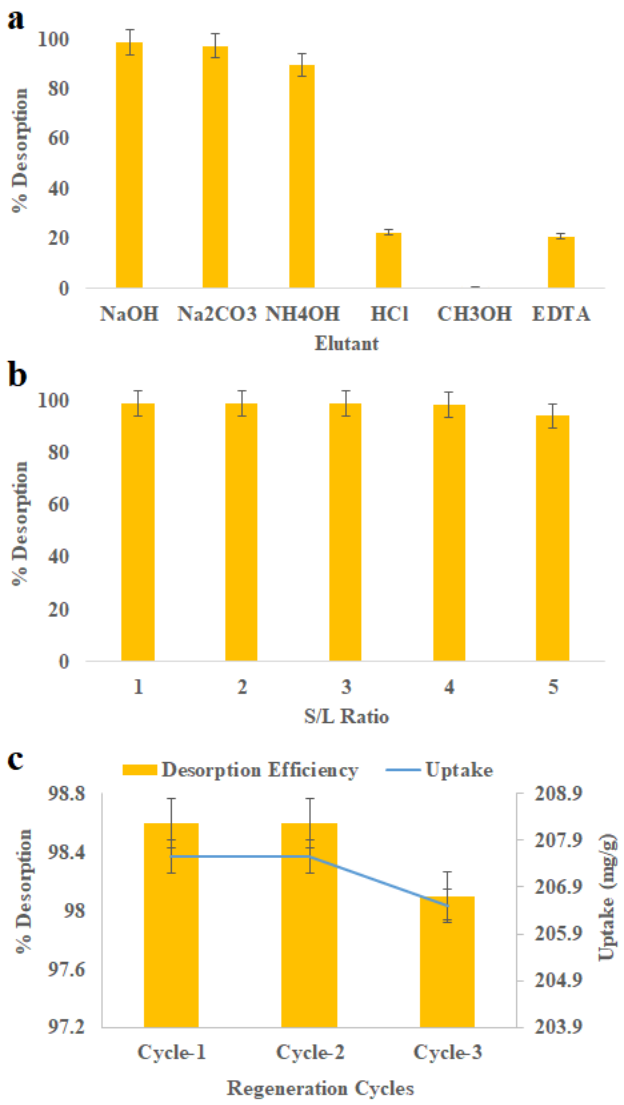


Figure 7. Desorption Efficiency (a) Elutants; (b) S/L Ratio; (C) Regeneration Cycles

3.2. Effect of biochar dosage

The effect of a biochar dosage that was made from coconut shell on the remediation of Remazol Black B was studied. The amount of biochar that was added to the solution was varied between 0.5 and 10 g/L while the temperature remained at 35 degrees Celsius, the pH remained at 2.0, and the initial dye concentration remained at 15 ppm. Figure 3 illustrates the sorption and absorption processes that take place between biochar and RBB. It was discovered that increasing the dosage of biochar resulted in a decrease in the capacity of biochar for absorption. As the amount of biochar in the solution increased from 0.5 to 10 g/L, the amount of RBB that could be absorbed by biochar decreased from 15.84 mg/g to 1.24 mg/g. Because there are fewer binding sites present in proportion to the excess dye concentration, a high absorption capacity can be obtained at a low dosage despite the fact that the dye is present (Parka et al., 2019) As revealed in Figure 3, the percentage of dye that biochar is able to remove from a solution rises in proportion to the amount of biochar present in the solution. The effectiveness of biochar in removing RBB increased from 52.80% to 82.80% during this study. The increased surface

area of the biochar was thought to be responsible for the increased sorption absorption that occurred as a result of higher dosages (Vijayaraghavan and Ashokkumar, 2019).

3.3. Effect of equilibrium pH

Researchers looked into how pH affected the amount of Remazol Black B that was adsorbed onto biochar made from coconut shells. It was varied to be 2.0, 2.5, 3, 3.5, 4, 4.5, and 5.0 with the dosage being 1 mg/L, initial dye concentration being 15 ppm, and temperature being 35°C, respectively. Figure 4 illustrates how the value of pH influences the rate of RBB elimination. When it comes to sorption, the pH is an extremely important factor in figuring out how well a sorbent will do its job (Aravindhan *et al.,* 2007) It was found that as the pH of the solution increased, the removal efficiency as a percentage and the absorption capacity both decreased. The uptake capacity was found to be 10.45 mg/g at pH 2.0 and 8.55 mg/g at pH 5.0, while the elimination efficiency was found to be 69.67% and 57%, respectively, at these two different pH levels. At low pH levels, it was found that dye sorption was at its highest possible value. This was due to the electrostatic interactions that take place between biochar anions and the dye. When the pH of the environment is low, the surface of the biochar should have a positive charge, and the functional groups of the biochar should include H+ ions (Mahdi *et al.,* 2017). There is a reaction that takes place between negatively charged dye molecules and the positively charged surface of the sorbent (Becidan *et al.,* 2007) All of the batch tests were performed with the pH at 2.0, and all of the other parameters were taken into consideration.

3.4. Effect of temperature

Research was conducted to investigate how temperature affected the sorption of RBB onto biochar made from coconut shells. Figure 5 demonstrates that as temperature rises, biochar uptake increases but then gradually decreases. The amount of RBB that biochar is able to absorb increases from 9.75 mg/g at 300°C to 10.45 mg/g at 350°C, but then it drops back down to 5.44 mg/g at 450°C. As can be seen in Figure 5, the biochar uptake increases along with the temperature before beginning a downward trend. The efficiency of RBB as a biochar source that was derived from coconut shell increased from 65.03% at 30°C to 69.67% at 35°C, but then it reduced to 36.25% at 45°C. After taking all of the factors into consideration, the optimal temperature for all of the batch tests was determined to be 35 degrees Celsius (Saha *et al.,* 2011) It was determined whether the adsorption performance was spontaneous or non-spontaneous through the use of thermodynamic parameters, namely G°, H°, and entropy S°. Additionally, it was determined whether the reactions were exothermic or endothermic through the use of these thermodynamic parameters. According to the findings of the thermodynamic study, the reactions are endothermic and spontaneous. This was determined by the fact that the values for (G°) were calculated to be -5.21 (293 k), -6.50 (303 k), and -6.82 KJ/mol (313 k), respectively. In a similar manner, the values for H° and S° that were obtained were respectively 16.86 KJ/mol and 27.09 J/mol/K. The positive values of enthalpy change (H°) are evidence that the reactions produce endothermic heat.

Table 2. Adsorption isotherm model constants

Model	Parameter	Values	Model	Parameter	Values
Two Parameter Model					
Freundlich	K_F	3.27394	Langmuir	Q_0	100.80
	$1/n_F$	0.72652		b	0.02482
	R^2	0.9739		R^2	0.9936
Three Parameter Model					
Redlich-Peterson	K_{RP}	27.1162	Vieth-Sladek	Q_{MVS}	2.26475
	α_{RP}	9.0806		B_{VS}	1.31433
	β_{RP}	0.2063		N_{VS}	0.20343
	R^2	0.9973		R^2	0.9964
Khan	Q_{max}	1.2233	Radke- Prausnitz	Q_{MRP}	2.042307
	b_k	7.6439		K_{RP}	1.459812
	a_k	0.3386		n_{RP}	0.198535
	R^2	0.9922		R^2	0.9971
Unilin	Q_{MU}	499.552	Fritz-Schlunder - III	Q_{MFS}	5.40421
	A_U	3.28175		K_{FS}	3.12893
	B_U	0.27409		N_{FS}	0.21084
	R^2	0.9939		R^2	0.9967

3.5. The influence of the initial concentration

The dye concentration ranged anywhere from 5 to 100 mg/L throughout the experiment. In these experiments, the pH was held at a constant value of 2.0, and the temperature was held at a constant value of 35 degrees Celsius. The dye sorption potential of the biochar that was generated from coconut shells is shown to increase as the dye concentration increases in Figure 6. The uptake capacity became saturated as a result of the higher concentration of the dye, which led to the observation that there was no further change in the uptake capacity. For instance, it was discovered that the uptake capacity was 3.40 mg/g when the initial RBB concentration was 5 mg/L. It was discovered that the sample had an uptake

capacity of 51.92 mg/g, despite the fact that the initial RBB concentration was 100 mg/L. When the initial concentration of RBB was increased from 5 to 100 mg/L, the percentage removal effectiveness of RBB dropped from 68 to 51.92%. This was a significant drop. When the initial concentration of RBB was higher, the removal effectiveness was lower; this was possibly because there were fewer binding sites available for the additional dye molecules (Chen *et al.*, 2018) According to the findings, the level of removal effectiveness that was optimal was attained when the initial concentration of RBB was 5 mg/L.

3.6. Desorption studies

The effectiveness of the desorption of a number of different elutants is illustrated in Figure 7. As can be seen in Figure 7, the maximum amount of desorption efficiency that sodium hydroxide can achieve is 98.6%. It's possible that this is due to the fact that reactive dyes contain more positive ions, which causes higher OH- ions to speed up the removal of dye molecules from biochar. In order to find the optimal volume of elutant to use in the desorption tests, it is necessary to conduct a solid to liquid (S/L) ratio experiment. Figure 7b demonstrates that the ideal S/L ratio is 5. This ratio is shown to be most effective. Using regeneration tests, we evaluated not only the capacity of biochar for simultaneous adsorption and desorption, but also for regeneration. Following the completion of three in a row of sorption-elution cycles, the desorption efficiency of 98.1% was accomplished, as shown in Figure 7c. According to the results of the desorption experiments, sodium hydroxide containing an S/L ratio of 5 was utilized for three cycles.

Table 3. PFO and PSO Kinetic Reactions Model Constants

Kinetic Model	Constant	5 mg/L	15 mg/L	25 mg/L	50 mg/L	100 mg/L
Pseudo First Order Kinetics	Q_e	1.87	5.17	7.74	14.70	28.31
	k_1	0.0458	0.0413	0.0361	0.0349	0.0333
	R^2	0.9957	0.9973	0.9962	0.9970	0.9961
Pseudo Second Order Kinetics	Q_e	2.05	5.68	8.60	16.35	31.64
	k_1	0.0340	0.0107	0.0058	0.0029	0.0014
	R^2	0.9907	0.9864	0.9779	0.9823	0.9788

Table 4. Comparison of Remazol Black B removal with related research

S.No	Adsorbent	Removal Efficiency (%)	Uptake Capacity	Reference
1	*Aspergillus* Flavus	91	-	28
2	Magnetoconductive Poly (3,4-Ethylenedioxythiophene) / Maghemite	95	-	29
3	Ferric Chloride	98	-	30
4	Brown-Rot Fungus Gloeophyllum Trabeum Biocomposite	72.55	-	31
5	Lotus Pollen-Derived Hierarchically Porous Carbons	-	615.6 Mg/G	32
6	Brown-Rot Fungus Gloeophyllum Trabeum	-	53.08	33
7	Bacillus Albus Dd1	98	-	34
8	Peroxymonosulphate With Manganese And Cobalt Coated Micro Sand Particles	97.8	-	35
9	Green Synthesized Cui		176.42 Mg/G	36
10	Peroxymonosulfate With Fe3o4 Magnetic Nanoparticles	50	-	37
11	Ochrobactrum Anthropi	80	-	38
12	Coconut Shell	82	56.92 mg/g	-

3.7. Isotherm studies

Tabular representation of the adsorption isotherm model constant can be found in Table 2. Isotherm models with two and three parameters were investigated in order to gain a deeper comprehension of the adsorption mechanism. An adsorption isotherm is a diagram that depicts the relationship between the amount of adsorbate that is adsorbed on the surface of the sorbent and the temperature or pressure that is present. In most cases, the surface of the sorbent will have a heterogeneous composition, characterised by a range of temperatures and binding affinities. The freundlich isotherm model will be used to make predictions regarding the possibility of adsorption occurring as a result of multi-layer sorption. Due to the heterogeneous nature of the sorbent, adsorption was able to take place as demonstrated by the fact that the obtained value for 1/nF is 0.7226. This value falls within the range of 0 to 1, indicating that adsorption did take place. There is a possibility that dye molecules will sorb due to the monolayer's homogeneous nature. According to the predictions made by the Langmuir model, the maximum uptake capacity is 100.80 mg/g. Calculation of the separation factor RL required changing the initial dye concentration from 50 mg/L all the way up to 500 mg/L. It was found that the RL values were less than 1, with values ranging from 0.011 to 0.0102. The separation factors that were found were found under the favourable conditions of 0 RL 1, which led to their discovery. The correlation coefficient was used to develop the khan adsorption isotherm, which was then used to determine the maximum monolayer adsorption capacity. This capacity was found to be 1.22 mg/L. The best fit model was Redlich-Peterson (0.9973), followed by Radke-Prausnitz (0.9971), Fritz-Schlunder - III (0.9967), Vieth-

Sladek (0.9964), Unilin (0.9939), Langmuir (0.9936), Khan (0.9922), and Freundlich (0.9739). Adsorption isotherm models' predicted and experimental uptakes are depicted in Figure 8.

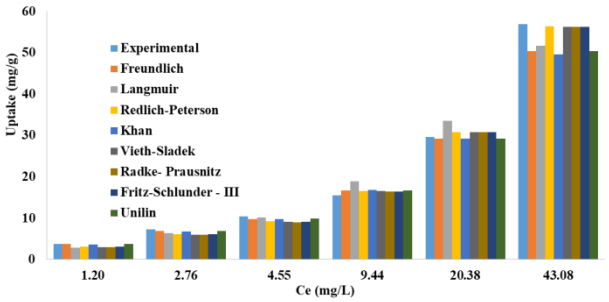


Figure 8. Adsorption Isotherm- Comparison of Experimental and Predicted Uptakes

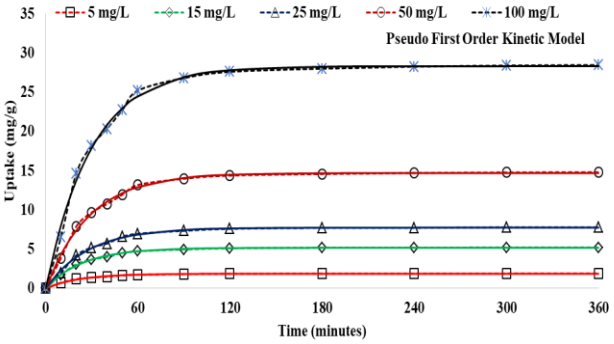


Figure 9. Pseudos First order Kinetic reaction- Experimental and Predicted Uptakes

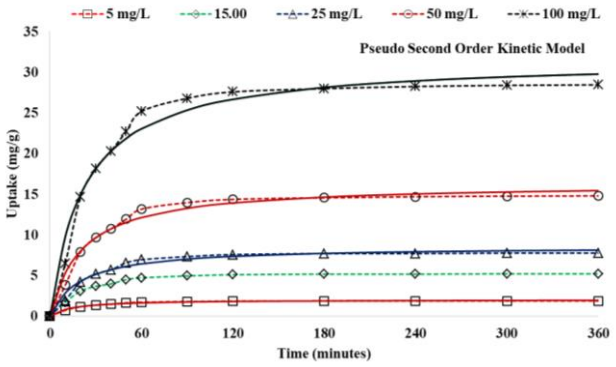


Figure 10. Pseudos Second order Kinetic reaction- Experimental and Predicted Uptakes

3.8. Kinetic studies

The PFO and PSO kinetic model parameters were outlined in Table 3, which was a summary table. The experimental and predicted uptake of biochar is depicted in Figures 9 and 10, respectively, at a variety of initial dye concentration levels. According to the kinetic study, the removal efficiency was at its highest during the first 120 minutes. After that point, there was very little increase in removal efficiency despite the passage of more time. For instance, after 120 minutes, a removal efficiency of 74.5% was obtained at an initial dye concentration of 5 mg/L, while after 360 minutes, a removal efficiency of 76% was obtained. Both of these results were obtained with the same conditions. After the allotted time of 120 minutes, the removal efficiency had only increased by 1.5%. In the beginning, the removal efficiency was quite high, which suggests that the biochar has a strong affinity for the dye molecules. Once all of the advantageous binding sites and surface functional groups in the biochar were occupied to their maximum capacity, the removal efficiency began to decline. Both the rate of reaction k_1 and the rate of reaction k_2 were found to be much too quick for the initial concentration to be so low. The initial dye concentration had an effect on the rate constant; it decreased as the concentration of the dye increased. It would appear from this that biochar has a higher affinity for dye molecules when they are present in lower concentrations rather than when they are present in higher concentrations. As a result of the kinetic study, it was determined that the most effective amount of time for the removal of dye molecules was one hundred twenty minutes. Table 4 summarized the removal efficiency of different adsorbent in the removal of RBB.

4. Conclusion

According to the findings of this research, biochar has the potential to be utilised in an effective manner for the remediation of Remazol Black B (RBB) from dye containing effluents. Experiments conducted in batches demonstrated that the optimal dosage of sorbent, pH, and temperature are respectively 1 g/L, 2.0, and 35 degrees Celsius. The biochar produced from coconut shells had the highest possible RBB absorption, measuring in at 56.92 mg/g. As a direct result of this research, highly efficient sorbents for the removal of a wide variety of Remazol dyes from aqueous and wastewater solutions have been developed. Because it is a product that is both inexpensive and friendly to the environment, biochar has the potential to take the place of the more expensive activated carbon in the process of treating wastewaters that contain dyes.

Conflict of Interest

The Authors declare no conflict of Interest

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