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Studies on Removal of Rhodamine-B Dye by Using Bark of Vachellia Nilotica Tree

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Abstract- Rhodamine-B was removed from prepared synthetic aqueous dye solution by activated carbon prepared from bark of Vachellia Nilotica. The influence of process parameters such as interaction time, dose, pH and initial concentration are investigated and presented. The adsorption equilibrium values analysis was performed with different isotherm models such as Freundlich, Langmuir Isotherm, Toth, R-P, and Fritz-Schulender isotherm model is best fitted for Rhodamine –B dye removal. Present study shows that bark of Babul Tree [BBT] is efficient for removal of Rhodamine-B dye.

IndexTerms: Bark of Vachellia Nilotica Tree, Isotherm Study, Rhodamine-B Dye, Kinetic Study and Activated Carbon.

I. INTRODUCTION

The occurrences of dyes in waste water are created a very serious environmental problem, when it discharges in to hydrosphere such as river, pond, Lake Etc. Dyes are commonly utilized in several sectors such as cosmetics industry, rubber industry, printing industry, leather industry, food industry, textile industry, tanning industry and dye production industries [3]. Dyeing industries will give as adverse colors to the hydrosphere they will be reduce the sunlight penetration in water body and resist the photosynthetic reaction due to this reason aquatic life system and biodiversity are affected [1].

World health organization and Indian government have responsibilities to increase health and environmental awareness. There are three methods used for dye removal physical, chemical, biological and combined methods [4]. The adsorption process is best process compare than other removal process due to it has low cost, simple methods, sludge free clean operation and complete removal of dyes [7],[8]. Activated carbon are widely used as adsorbent due to it consist several properties such as it extended surface area, high degree of surface reactivity, micro porous structure and high adsorption capacity [5]. Cost of commercially used activated carbons is very high. In these study various active carbon use as adsorbent, these are include such as coconut husk, soybean husk, peanut shell, saw dust and bark of Vachellia-Nilotica tree. This adsorbent is more effective due to low cost [6],[10].

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The purpose of present studies is; (i) To find the optimal process parameters such as adsorbent dose, pH, initial dye concentration and contact time for efficient adsorption by using bark of babul tree are found and presented. (ii) To find the applicability of mono component equilibrium models; viz., Langmuir, Freundlich, R-P, Toth and Fritz-Schulender isotherm models; (iii) To find the kinetics study.

II. MATERIALS

Chemicals used in this experimental work are arranged from chemical engineering department of UEC Ujjain (M.P) and Malic chemical suppliers. 100 mg/l of Rhodamine-B stock solution was prepared by using 0.1g of Rhodamine –B mixed in 1L of distilled water. Dilute dye solutions are used for calibration curve and pH was used adjusted to using 1N-NaOH and Hcl prepared solution.

III. Experimental Process

Batch experiments for optimization of process parameters were carried out by taking 100 ml sample in conical flask mixed with 1-5 gm. adsorbent by using 120 rpm in an incubator cum orbital shaker (Rimi Instrument Model No. CIS24-9/99) for 2hrs. The optimum pH (pH 4-12) and temperature (31±1°C) was used in present experimental work. Different dose of activated carbons are used in range of 1 to 5 gram mixed with 100 ml of dye solution having concentration in range of 100 to 600 mg/l. After that solution mixer was removed from shaker at predetermined time duration. Adsorbent was separated by filter paper from the dye aqueous solution. There after residual dye concentration was measuring by UV 1800 spectrophotometer at 554 nm (λ). The adsorption equilibrium amount of activated carbon is found by using of eq. 1 [5].

$$qe = (Ci - Co)\frac{V}{M} \ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where, qe= amount of adsorbate adsorbed at equilibrium (mg/g), C_i & C_o (mg/g) one the initial and final concentration of dye solution, V (L) the volume of dye solution and M (g) the weight of the adsorbent used in the present study.

Preparation of adsorbent:

In present work, biodegradable solid waste are collected from local area of Ujjain city. Firstly, washed with tap water and distilled water for 3-4 times for elimination of debris, dust and mud. Sample was dried for 3-4 days in sun light. After that samples are dried in oven at 60±5°C for 3 to 4 hr. Carbonization process is done at 300°C for 2 hour is Muffle Furnace- (Tempo Instruments pvt. Ltd 230v/14AMPS, S.NO-SM-1033). After that chemical activation of samples are done with using of 2N-H_2SO_4 for 24 hrs. After the completion of chemical activation process samples are

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washed with distilled water 3 to 4 times. For removing extra moisture samples are dried using oven.

IV. CHARACTERIZATION ANALYSIS

Scanning Electron Microscopy (SEM) Analysis

SEM is used to verify the external morphology of the material [2][6]. Fig.-1 shows SEM image of the activated carbon it is clearly seen that the pore formed in different shapes and sizes and Fig.-2. show SEM image, after adsorption of dye.

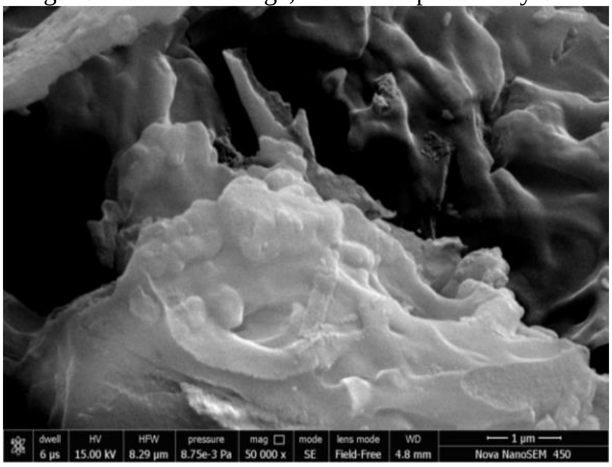

Figure 1. SEM image of activated carbon of bark of Vachellia Nilotica Tree.

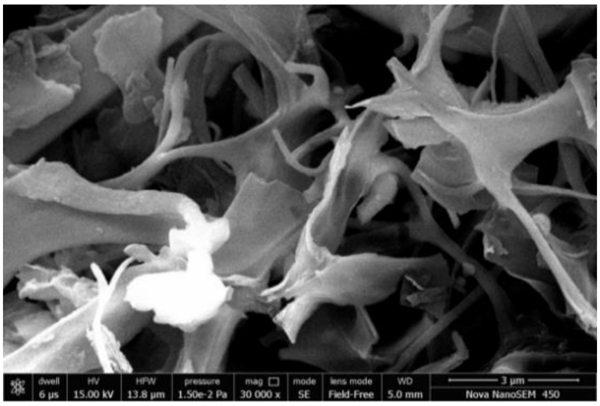

Figure 2. Show SEM image after adsorption of dye.

FTIR Spectroscopy Analysis

FTIR provide specific information about the shaking and revolution of the chemical bonding and molecular structure, organic material and fixed inorganic material [5]. FTIR were recorded by a Perkin Elmer Spectra version 10.4.00 MANIT JAPURE (R.J).The samples were existing into the measured in the range 4000- 400cm^{-1}. The FTIR spectrum of activated carbon of bark of Vachellia Nilotica tree shown in Fig.-3 The FTIR spectrum shows a broad adsorption bond at around 3420.57 cm^{-1} similar to the vibrational of hydrogen bond between N-H and O-H groups, the region between 1711.1-1621.78 cm^{-1} is assigned to the C=C stretch of Alkynes.1384.13-1316.21 cm^{-1} is assigned to C-H Alkanes groups, 1146.55-780.07 cm^{-1} is C-O is assigned to Alcohols and Ester group and 665.50-601.05 is indicating the presence of C-H Alkynes. The strong bond at 515.49 cm.$^{-1}$

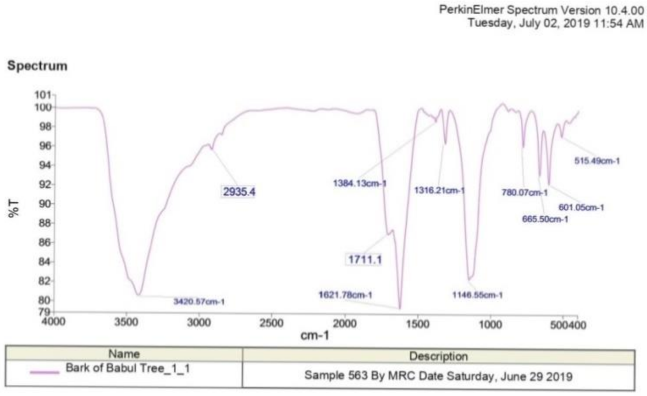

Figure 3. FTIR spectra graph for bark of Babul tree.

V. RESULTS AND DISCUSSION

Influence of PH

The pH is an essential factor for affecting the elimination of dye from waste water due to dissimilarity of H^+ and OH^+ of the. The adsorption influence of Rhodamine-B dye over a pH range of 4-12.The obtained results shows that adsorption process of Rhodamine –B was favorable in basic media in Fig.-4. increasing pH of solution helps to increase the adsorption capability. The pH progressively increased the adsorption capacity due to decreased protonation of the (ACBBT) surface charge.

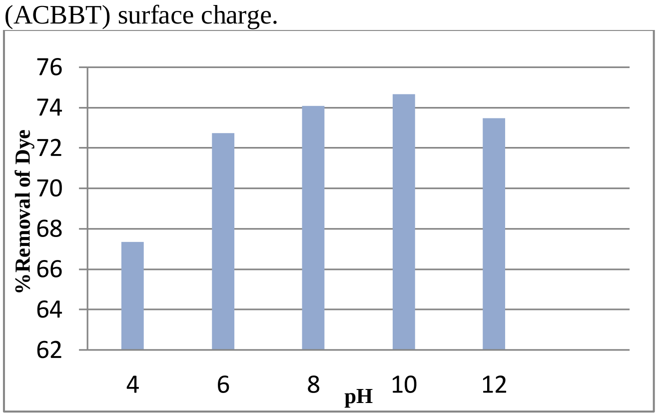

Figure 4. Influence of pH on dye removal of dye.

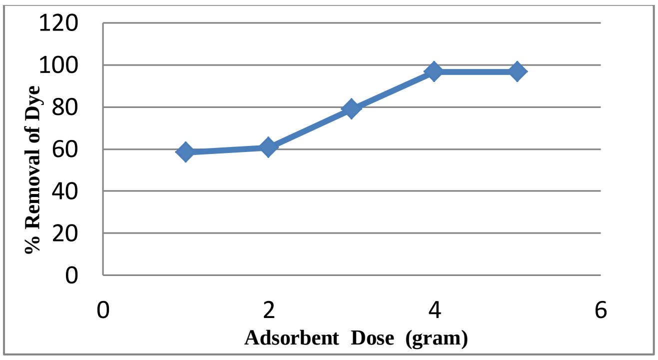

Figure 5. Influence of adsorbent dose on removal of dye.

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Influence of Adsorbent Dose

The influence of adsorbent dose on the elimination of dye was studied for 1-5 gram of ACBBT doses. It is found that Percent's elimination of Rhodamine-B dye was increased due to rise in surface area, high porosity and pores volume. The increase in percentage elimination of dye is clarified due to increase in dynamic places with increase in adsorbent dose. On further elimination of dye percentage was found constant. These happen due to fact that overlapping of activation at high dose which decreased the surface area. It was found that at optimum condition 96.75 % of dye removed at 4 g/l dye concentration show in fig.-5.

Influence of Contact Time

The adsorbent concentration and interaction time between adsorbent species play a major role in the process of elimination of Rhodamine–B dye from synthetic waste water. Result of these is presented in Fig.No.-6. It is observe from that during the initial stage adsorbent process, percentage elimination of Rhodamine –B. Initially adsorption was very fast these happen due to fact that high concentration gradient present between the dye concentration and adsorbents surface. Maximum removal done after3 hr. where it shows the maximum removal of dye and after that removal becomes constant. At initial stage of process, adsorption done very fast, these happens due to fact that weak Vander wall force present between molecules. On further increasing the reaction time strong bond formed between adsorbate and adsorbent which slow down the removal process.

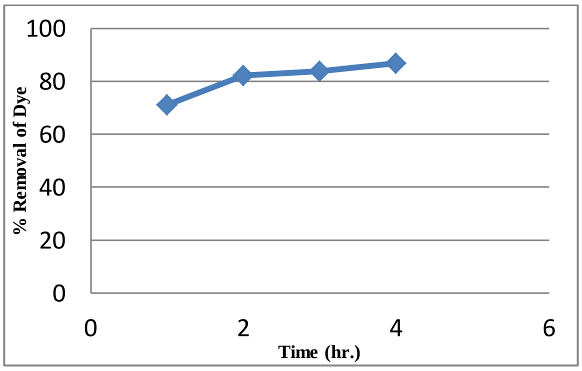

Figure 6. Influence of contact time.

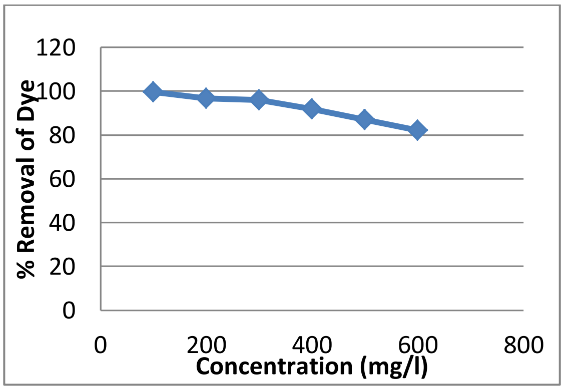

Figure 7. Influence of initial concentration of dye [con. 100-600mg/l, dose 4g/l, contact time 4 hr., pH -8, Agitation speed 120 rpm and temperature 31±1°C.

Influence of Initial Dye Concentration

The initial concentration provides a driving force for concentration gradiant of adsorbate and adsobent. Show in Fig.-7 removal of dye about 99.68 % was carrid out at an initial concentration of 100mg/l. On further increasing the concentration in range of 200-600 mg/l the removal percentage decreases but adsorbent equilibrium ammount increase. This happen due to fact that at low concentration the active sites are easily engaged with absorbent molecules, which indicated a high percentage removal. After that inceasing ammount of initial concentration of dye and adsorbent quantity is constant these shows that high ammount of dye leads to saturation of binding capacity of adsorbents which decreases removal of dye.

VI. ADSORPTION EQUILIBRIUM ISOTHERM MODEL

Results for removal of dye on ACBBT was analyzed using solver function of Microsoft excel 2010. The data mono component adsorption of dye onto ACBBT was fitted to various isotherm models i.e Freundlich, R-P, Fritz- Schlunde, Langmuir and Toth models [9]. From Table -1 and Figure-8 it could be observed that Langmuir model are not suitable due to high MPSD. Freundlich, R-P.Toth, Fritz-Schluder proved better result lowest MPSD. The maximum adsorption capacity of dye was found 7.759 mg/g for dye removal.

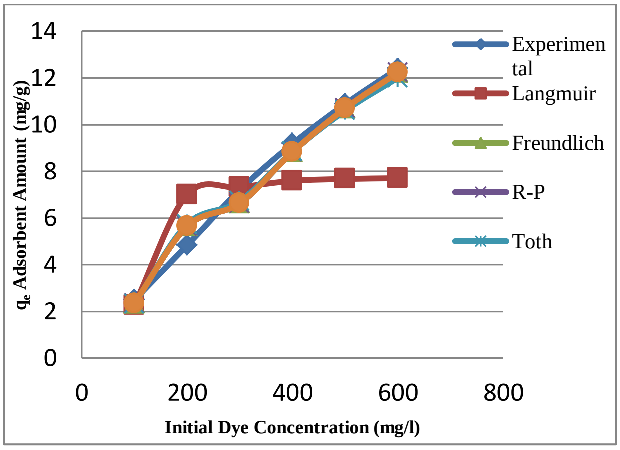

Figure 8. Comparisons of Isotherm Model.

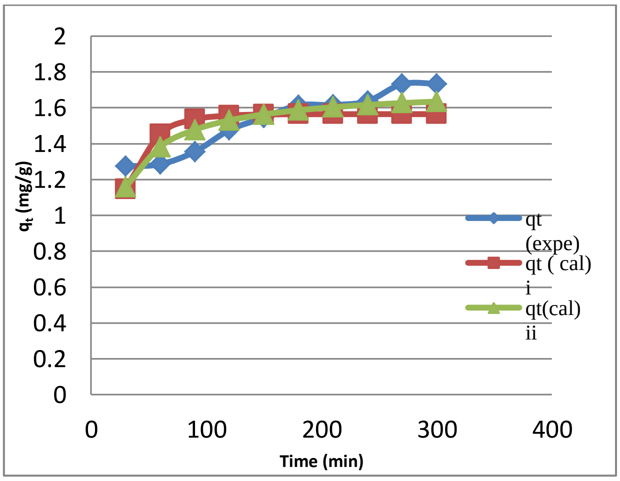

Figure 9. Kinetic study of adsorption of dye

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Table 1: Equilibrium Isotherm Constants of Rhodamine-B Dey Removal on ACBBT

Isotherm Model	Various Parameter				MPSD
Freundlich $qe = KfCe^{1/n}$	**K_f**	**1/n**	**N**		8.91
	3.29	0.28	3.54		
Langmuir $qe = qmKlCe/(1 + KlCe)$	K_L	q_m	----------		30.67
	1.3790	7.76	…….		
Toth $qe = \frac{qe''Ce}{(a + Ce^{th})1/th}$	q''_e	a	th		9.68
	54	0.42	0.036		
Frith-Schlunder $qe = \frac{\alpha 1Ce^{\beta 1}}{(1 + \alpha 2Ce^{\beta 2})}$	β1	β2	α_1	α_2	8.92
	0.28	0	3.3	5.71 E-05	
Redlich –petertion $qe = K1Ce/(1 + K2Ce^b)$	K_1	K_2	---	B	8.922
	62972.83	1911.84	----	0.72	

VII. Kinetic studies

For finding of kinetic study adsorption of Rhodamine-B dye occurs through physisorption and chemisorption. Pseudo-first order and Pseudo-second order kinetic models were applied respectively. Result of these is presented in Table -2 and Fig.-9. In case of Rhodamine-B kinetic data is well fitted by pseudo-second order, ARE value (1.71) is lower then, pseudo-first order ARE value (2.6565). ARE value lowest is best for kinetic study. Hence dye are adsorbent by chemisorption.

Table 2: Kinetc Studies of Adsorption of Rhodamine-B Dye on Bark of Babul Tree

Kinetic Study	Rhodamine-B Dye
Pseudo- First order	**Value**
q_1 (mg/g)	1.564789
K_1 (min^{-1})	0.044026
ARE (%)	2.656562
Pseudo-Second order	**Value**
q_2 (mg/g)	1.71
K_2 (g/mg-min)	0.040646
ARE (%)	1.76156

VIII. Conclusion

Results of adsorption of dyes are fond and presented in this paper at different process parameter such as pH, temperature, size and amounts of adsorbent. Dye 100mg/l was attained at pH-8, temperature 31°C, dose concentration 4g/L., contact time 2hrs., and agitation speed 120rpm. are optimum parameters. It is found that at optimum conditions 99.686% dye removed from aqueous solution. Containing Moreover equilibrium and kinetic studies were also carried out at optimized parameters. Dye adsorption was found to be expressed by Toth model. Kinetic studies relating to adsorption of dye revealed that chemisorption to be the mechanisms of adsorption. ACBBT are a cheap and easily available material which are act better substitute of activated carbon.

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