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ADSORPTION OF BRILLIANT BLUE DYE USING ACTIVATED WALNUT SHELL POWDER

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ABSTRACT

Textile dyeing contributes to worldwide wastewater problem as it is one of the large water consuming industries. Various physical and chemical treatment methods have been used for removal of dyes. Adsorption is most effective and economical method for dyes removal. Batch experiments were performed to study the effect of various parameters such as solution pH, initial dye concentration, adsorbent dosage, temperature etc. on adsorption of brilliant blue dye using walnut shell in powdered form as an adsorbent. Kinetic study was explained by pseudo second order reaction, natranjan and khalaf model and Elovich kinetic equation.

Keywords: Adsorption, Kinetics, Brilliant Blue Dye, Walnut.

I. INTRODUCTION

Technological advancements and changing trends in industries contributes to growth and betterment of society but it also creates worldwide problem of environment contamination. Water is very necessary element for supporting our life, 97.5% of available water is salt water which is not suitable for human consumption, out of this 2.5% only 0.27% of fresh water is accessible and rest is distributed in aquifiers, frozen polar ice cap. Rapid increase in industrial activities and population causes great demand for water and also generation of waste water from various sources like agriculture, industries, municipality is also increased. Among all industrial sector, textile industries are rated as high polluters, taking into consideration volume of discharge and effluent composition [1, 2], Therefore it is very important to treat waste water in order to save public health and environment.

During the dying process, thousands of dye stuff are released into the environment in form of effluents. Dyes usually have synthetic origin and complex aromatic molecular structure which make them stable and difficult to biodegrade

[3]. Over 7×10^5 tones and 10,000 different types of dyes and pigments are produced worldwide annually . If the dying waste water is left untreated, it may cause human health problems and harm to animals and aquatic life due to its toxic and carcinogenic, mutagenic and genotoxic effects, hence it is very important to remove the synthetic dyestuff from waste water before it get discharge into any natural receptor water. Conventional methods such as flocculation, coagulation, precipitation are nowadays replaced by techniques like ion-exchange, adsorption, ozonation, Irradiation. Adsorption is effective technique in comparison to other techniques due to its low cost, easy handling and simple design [4, 5]. Adsorption plays key role in modern industries, Over last few years, large number of low cost and biodegrable adsorbents are exploited by researchers, Regeneration of adsorbent is difficult in many cases, thus it is necessary to produce relatively inexpensive adsorbent for the treatment of waste water . Wide variety of low cost materials such as natural clay [6],oil shale ash [7], bagasse fly ash [8, 9], orange peel [10], wheat bran [11] biomass [12] etc. has been successfully used for dyes removal.

In this work, study of adsorption of brilliant blue dye on activated walnut shell powder is carried out. Various experimental parameters were analyzed : dye concentration, contact time, adsorbent amount and study of various kinetics model is carried out.

II. EXPERIMENTAL

Materials

Adsorbent

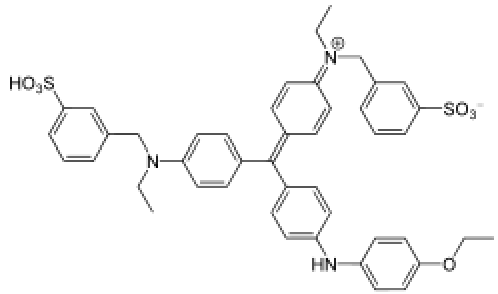
Walnut is used as adsorbent for adsorption of brilliant blue dye. Walnut is procured from local market. It's shell was washed with distilled water to remove dust or particles and left for sun dried for 2hours then it is crushed using Jaw crusher and sieved by sieve shaker at mesh size of 0.004mm.

Activation of walnut powder:

Activation is done by treating walnut powder with concentrated sulphuric acid for 12 hr and then washed with double distilled water until pH is neutralized and then filtered with filter paper and activated at 300°C in muffle furnace for a period of 2hrs.Activated walnut powder is then used for further experiment.

Adsorbate

Brilliant blue dye used in this study was received from JAY chemical Industries ltd without any further purification, this reactive dye is used in the textile industries of panipat.500ml of dye solution of 100ppm concentration is prepared as stock solution.



Adsorption studies

Batch-wise adsorption experiments were carried out at room temperature 20°C by varying parameters like initial dye concentration, adsorbent dosage, pH and mixing time on a magnetic stirrer using 50 ml beaker containing 40 ml of dye solution and agitation speed is 120 rpm. Final concentration of supernatant collected after filtration, was measured by using UV-VIS spectrophotometer (ultra-3660) at 587nm.

III. RESULTS AND DISCUSSION

3.1 Effect of initial dye concentration on adsorption equilibrium.

Five samples of varying concentration from 20 to 100 ppm of dye solution by adding 0.1g of adsorbent per 20ml of the solution is prepared. After 2 hr stirring at room temperature on rotary shaker, sample is analyzed by UV Vis spectrophotometer The percentage removal of dye enhanced with increase in initial dye concentration as presented in Fig. 1. Percentage removal of dye was found to increase from 96 to 98% as the concentration of dye increases from 20 to 100 ppm [13].

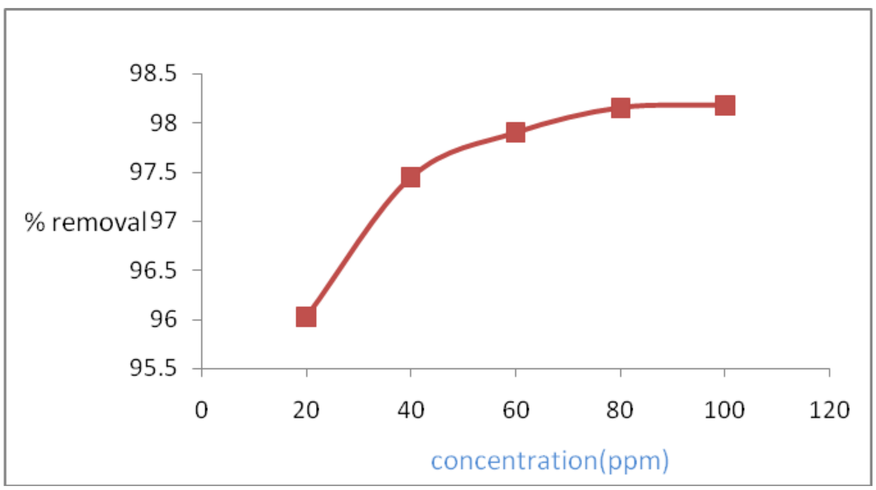


Figure1. Effect of initial dye concentration on adsorption equilibrium

3.2 Effect of pH

Effect of pH is studied by varying pH from 2 to 10 by using N/10 HCl and N/10 NaOH.solution.0.1gm of adsorbent is added and after continuous stirring of 2hr analysis is done. From fig 2, Increase in pH from 2 to 10 shows continuous decrease in adsorption of dye from 98 to 95%. Further, maximum removal of 98% was found at pH 2 [14].

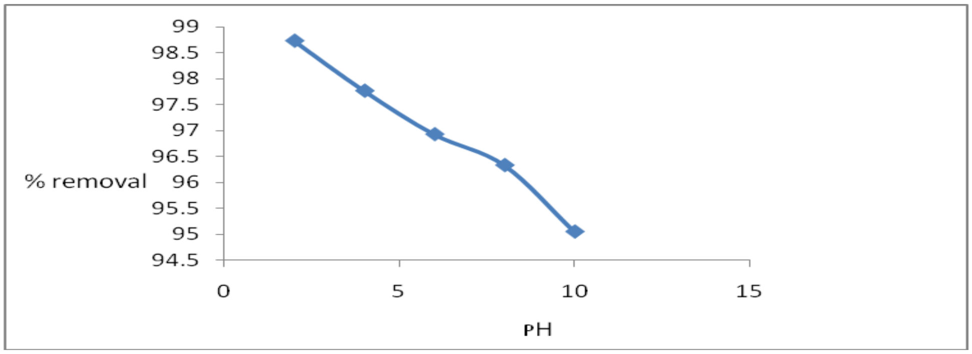


Figure 2. Effect of pH on adsorption equilibrium

3.3 Effect of adsorbent dose

Adsorbent dosage plays a key role in adsorption of dyes. Adsorbent dose decide the optimum quanity of adsorbent required for efficient adsorption. five samples of fixed 40ppm concentration with different doses (0.5gm. 0.1gm 0.15gm 0.2gm 0.25gm) were analysed. From the experimental run, it was observed that increase in dosage from 0.5 gm to 0.25gm resulted in an increase in percent removal of dye from 91 to 97% as presented in Fig. 3. This can be explained as due to more adsorbent particles, more surface area was available for the uptake of dye molecules

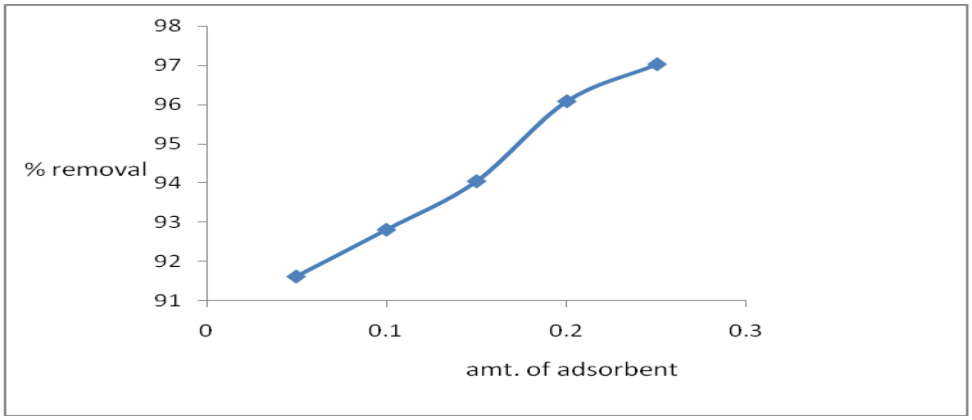


Figure 3. Effect of adsorbent dose on adsorption of dye

Kinetic study

3.4 Effect of Contact Time

The role of contact time was studied using 40 mg/l dye concentration by adding adsorbent dose. At different time intervals samples were collected and analysed. Contact time basically decides the order of reaction and time variation adsorption shows. Results revealed that as the residence time increased adsorption capacity also increased. From initial, rapid adsorption takes place then after 120 min adsorption attained equilibrium. This is all because of all surface reaction changes occurs and time variation and residence time [15].

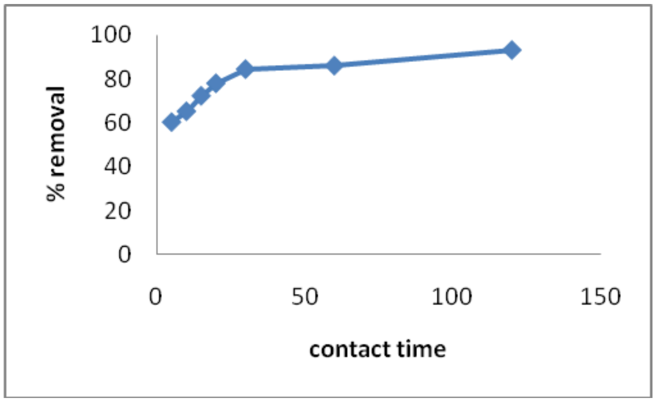


Figure 4. Effect of contact time on adsorption of dye

Pseudo Second order reaction

Langergen pseudo second order kinetic model is given by equation

$t/q_t = 1/(K_2q_e^2) + t/q_e$

Where K_2 is second order rate constant (g mg^{-1} min^{-1}).slopes and intercepts of plot of t/qt vs t, is used to find out q_e and k_2. Pseudo second order plot linear straight lines with respect to R^2 gives value near to 1 which indicates its fitness. Second order behavior is followed by chemisorptions process.. Linearity gives that adsorption of dye by walnut followed second order reaction.

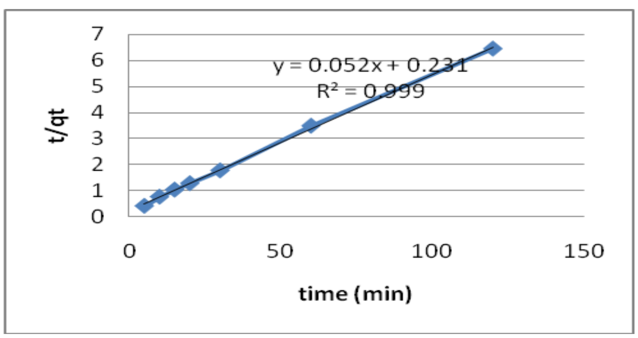


Figure 5. Pseudo second order behavior of dye

Natranjan model

Natarajan and khalaf first order kinetic equation is given by [16]:

$\text{Log}\ (C_0 - C_t) = (K/2.303)t$

C_0 and C_t are concentrations (mg/l), K is first order adsorption rate constant(min^{-1}).

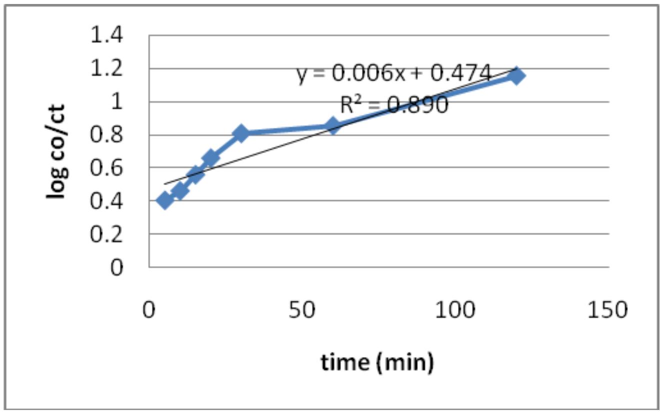


Figure 6. Natrajan and khalaf first order plot of effect of contact time on adsorption of dye.

Elovich Kinetic Equation

Elovich kinetic equation is given by:

$q_t = 1/\beta\ [\ \ln(\alpha\beta)] + \ln t/\beta$

α and β are constants and evaluated by slope and intercept values. Linear relation between q_t and ln t indicates that this model can be used to describe second order kinetic. α is initial rate of adsorption and β is desorption constant.

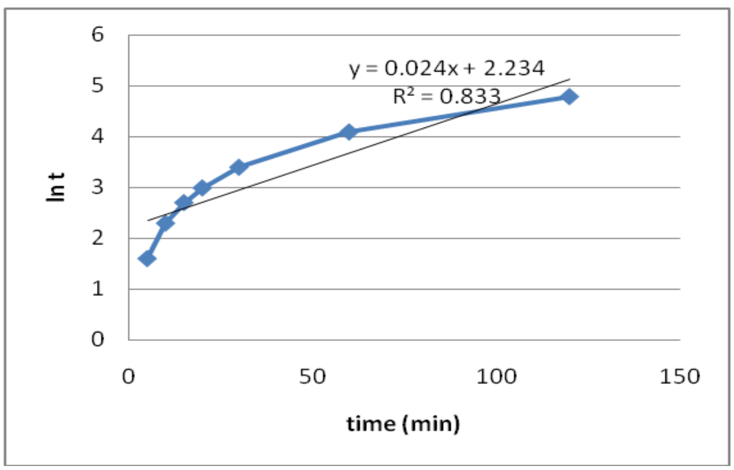


Figure 7. Elovich plot of contact time on adsorption

IV. CONCLUSION

This study revealed potential of activated walnut shell powder to use as successful adsorbent for removal of brilliant blue dye. Based on experiments, influence of initial dye concentration, adsorbent dosage, pH mixing time decides the optimum range of each variable. Kinetic behavior is well explained by pseudo second order model, natranjan and khalaf first order and Elovich equation.

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