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Optimization of Parameters Influencing Adsorption of Brilliant Red Dye on Dried Melon Shell Powder

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Abstract:- **Removal of dyes from waste water discharge of textile Industry is a major issue due to its harmful effect on human life and environment. Based on study of various methods available and considering the aspect of cost effective and efficient technology adsorption is considered to be best approach. In this present work the removal of "brilliant red" dye is carried out by the process of adsorption using raw water melon shell powder. Various batch experiments were performed under different experimental conditions. The effect of parameters such as Initial dye concentration, pH, contact time, adsorbent doses has been investigated. Various isotherm models such as Langmuir, Freundlich and Temkin analyzed the isotherms of adsorption data.**

Index terms- **Adsorption, Brilliant red dye, Freundlich, Langmuir, Temkin, Watermelon shell.**

I. INTRODUCTION

Although the bright colours has changed the world but it creates worldwide problem of environmental water pollution. Treatment of household waste water and industrial discharge is challenging topic in environmental science and technology [1] Colours that are used for dyeing purposes are usually natural or of synthetic origin that binds with surface or fabrics under various possible conditions to beautify the product and providing bright and lasting colour. Colour application is find in various Industries such as textile, food, paper, Rubber, Cosmetics, plastics [2], pharmaceuticals, distilleries and electroplating,tanneries [3] etc. The colourless effluents may be more toxic than colourful but colour is also considered as characteristicks of effluent and moreover the synthetic dyes used to impart the colour is toxic and harmful for our environment [4] hence there is great need to find the best possible alternate to treat the coloured waste water discharge as according to Environmental pollution act ,the discharge of coloured waste water directly is not permitted, it should be treated to a certain permissible limit of toxic then it can be discharge to natural water body sources or to ground. The water if left untreated, it may affect aesthetic sense of nature, alter the process of photosynthesis and disturb transmission of sunlight into streams. In addition to this, dyes are toxic and carcinogenic in nature. They are resistant to light, water and oxidizing agents. Dyes are harmful for human life, aquatic life and biological life. some dyes can cause allergy, dermatitis, skin irritation and mutations in humans [5].

The most commonly used dyes are reactive dyes due to their favourable properties like colour fastness, bright colour, simple application, long lasting, .industrially it has a world market share of 60 to 70% [6] but these dyes are non-biodegradable, thus colour remain in effluent which has to be treated by various methods. Earlier the conventional processes like froth floatation, precipitation, coagulation, sedimentation and various chemical methods are used but they are unsuccessful in colour removal, less efficient ,and less adaptable to a wide range of dye wastewater [7]. Membrane separation technology plays efficient role but it is expensive, specially small scale industries cannot afford this method, hence the need for an effective, simple and low cost method [8] is desired. In this respect, adsorption is a key for attaining the desired prospective. Various potential adsorbents that are available in nature can be used in their natural form or as activated carbon for the removal of colour. Activated carbon is perhabs the most common used adsorbent because of their excellent adsorption capacity. From literature we can find lots of adsorbents such as clay [9] peat, sugarcane baggase ,wheat husk, orange peel,shell of fruits and vegetables, spent tea leaves [10] seeds, soyabean, hen feathers, walnut shell [11] and many others. In this study, feasibility of water melon shell powder as a successful adsorbent is investigated.

II.EXPERIMENTAL

Materials and Methods

A. Preparation of Adsorbent(WMSP)

Water melon is obtained from local market, After it was used as fruit, the shell which is otherwise waste is used for preparing adsorbent .Shell was washed and cut into small pieces then left for sun drying at peak time 11 to 3pm for two days, then these pieces were grinded to powder form and sieved in sieve shaker, particle size of .004mm is used for the experimental purposes.

Characterization of adsorbent-FT-IR spectrum

The FT-IR spectra were obtained to evaluate chemical structures, the fig shows various peaks, the broadband at around 3500cm-1 is attributed to hydroxyl groups,the region of spectrum 1000cm-1 is typically carbonyl group.

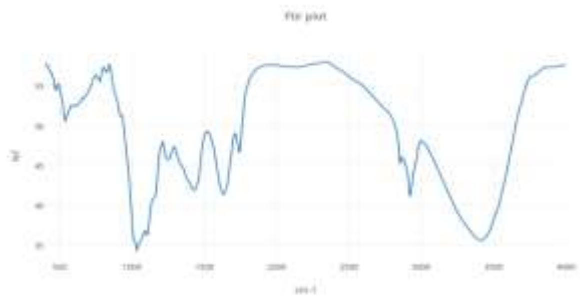

Fig 1- FT-IR Spectrum of WMSP

Adsorbate

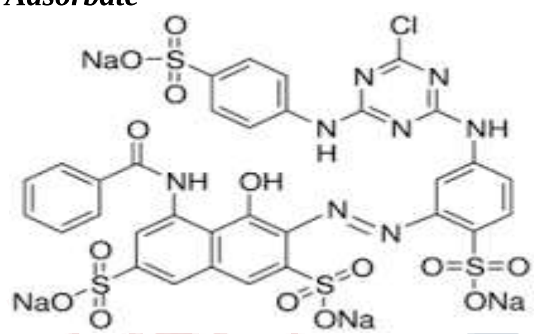

Fig 2- structure of brilliant red dye.

Brilliant red dye is used to determine adsorption performance of the prepared melon shell powder, this dye is used in textile Industries of panipat for imparting colour to fabrics, bedsheets and carpet industry. It is obtained from JAY chemical Industries and used without any further purification.

B. Preparation of Brilliant Red Dye solution

50mg of dye was dissolved in 500ml of distilled water with constant stirring to make a stock solution of 100ppm, Other solutions used for experiment purpose were prepared from the stock solution using the serial dilution.

C. Batch Equilibrium Study

The adsorption experiments were carried out batch-wise at room temperature 30◦C. Five different initial concentration 20,40,60,80,100 mg/l of BR dye samples were chosen for initial dye concentration study taking fixed amount of adsorbent as 10mg.The effect of other parameters like pH is tested taking five samples of fixed 30mg/l BR dye solution ,fixed adsorbent dosage 10mg and varying Ph likewise to study effect of adsorbent dosage,30mg/l of BR dye solutions with varying amount of adsorbent doses. All the prepared samples solution with added adsorbent was kept on rotary shaker at 120rpm for a period of 2hours, then the samples were filtered and final concentration of dye solution were determined by measuring absorbance at a wavelength of 537nm by UV-VIS ultra-3660 spectrophotometer.

III.INFLUENCE OF PARAMETERS

The effect was studied by varying initial dye concentration from 20 to 100mg/l for 10mg/10ml of adsorbent dosage. Results shows that the adsorption intake of BR sample increases with an increase in Initial dye concentration. Initially adsorbate molecules experienced boundary layer effect and then it diffuses onto adsorbent surface and finally to the porous structure of the adsorbent, thus at high initial dye concentration number of molecules competing for available sites was high leading to higher adsorption capacity .Maximum removal is found to be 34%.

A. Initial dye concentration

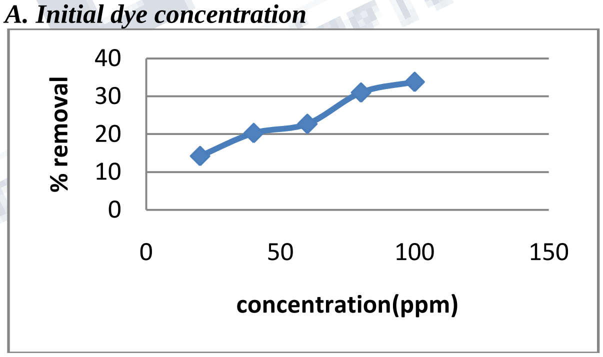

Fig 3: effect of initial dye concentration on adsorption equilibrium.

B. Effect of pH

pH affects the degree of ionization of dye as well as surface properties of adsorbent. To study effect of pH five samples of 2-10 range were taken. pH was adjusted by adding a small amount of 0.1M HCL and 0.1M NaOH. Results shows maximum removal takes place at pH 2 that is 88%.

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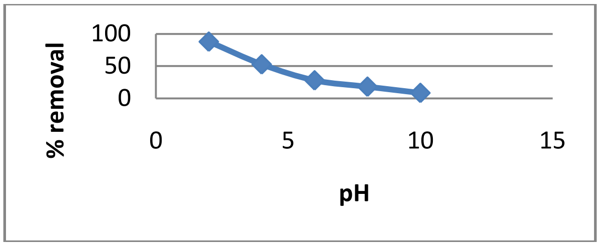

Fig 4: effect of pH on adsorption equilibrium

C.Adsorbent dosages

The adsorbent adsorbate solution with different amount of adsorbent (.01 to .1gm) has been prepared to study the effect of varying adsorbent quantity on BR removal. From experiment, it is found that dye removal increases with increasing doses of adsorbent as a result of more amount of sorption sites available at the surface of adsorbent .Maimum removal takes place at .05 gm of adsorbent. The curve shows decrease in % removal after the optimum amount, this can be explained as now more active sites of adsorbent are present but concentration of dye is fixed.

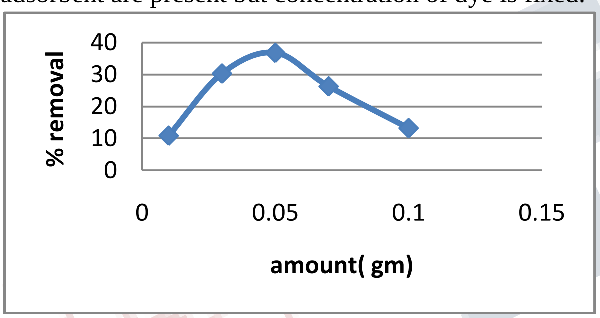

Fig 5: effect of adsorbent doses on adsorption equilibrium

D. Effect of contact time

The effect of contact time was investigated at initial concentration 30 mg/l and it was observed that rate of removal increases initially, maximum removal takes place after 90 min and then it reaches equilibrium. Rate of removal is higher due to large surface area available, maximum removal is 38%.

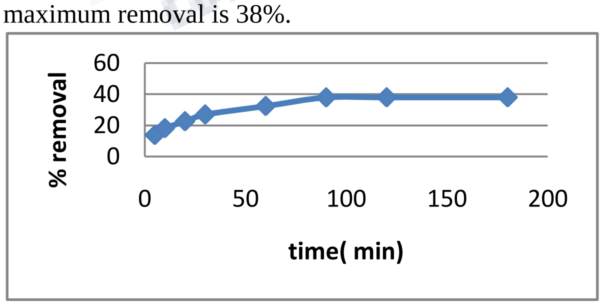

Fig 6: effect of contact time on adsorption equilibrium

IV.ISOTHERMS OF ADSORPTION

For the mathematical equation of the entire curve, various models Langmuir, Freundlich and Temkin can be used.

A.Langmuir isotherm

It is applicable for homogenous surface adsorption, [12] is given as:

$1/qe = 1/qmax + 1/qm KlCe$

Where qe is adsorption capacity (mg of solute/gm of adsorbent)

qmax is maximum adsorption capacity

Ce is equilibrium concentration

Kl is Langmuir adsorption isotherm constant

Langmuir model is based on:

1) Formation of single layer on adsorbent surface.
2) Uniformity of surface
3) Existence of defined sites of adsorption.

By plotting 1/qe versus 1/Ce, the Langmuir constants can be obtained.

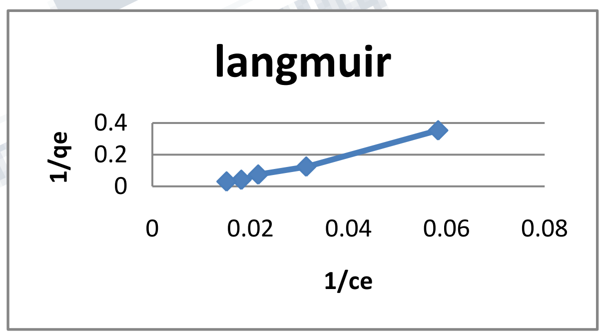

Fig-7- Langmuir isotherm plot.

B. Freundlich Isotherm

The Freundlich model is based on heterogeneity of adsorption sites.

Freundlich adsorption equation(adsorption of heavy metal)

$\text{Log } qe = 1/n \log Ce + \log KF$

Where qe is adsorption capacity (mg of solute/gm of adsorbent)

qmax is maximum adsorption capacity

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Ce is equilibrium concentration

KF and 1/n are freundlich characteristicks constants indicating adsorption intensity and capacity.

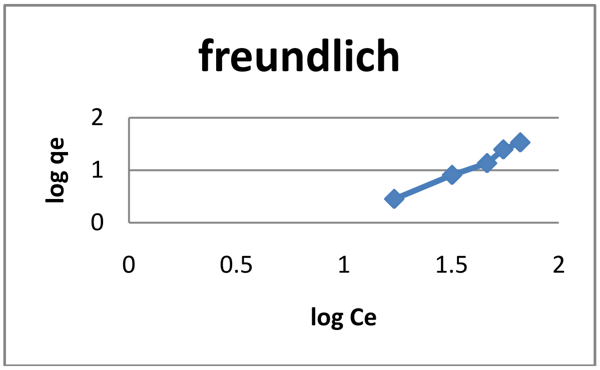

Fig-8- Freundlich isotherm plot.

C. Temkin Isotherm

The temkin Isotherm takes into account adsorbent-adsorbate interaction.

Assumption

Heat of adsorption of all molecules in layer would decrease linearily rather than logarithimic with coverage

Temkin equation is given by

qe = BlnAT +BlnCe B= RT/bT

AT =Temkin isotherm equilibrium binding constant (L/g)

bT = Temkin isotherm constant

R = Universal gas constant (8.314 J/mol/K)

T = Temp at 298K

B = Constant related to heat of sorption (J/mol)

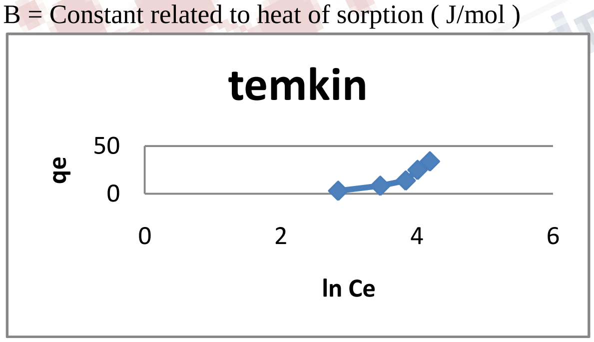

Fig-9- Temkin isotherm plot.

The estimated parameters of all isotherms for the adsorption of BR dye on water melon shell are gathered as

Langmuir			Freundlich			Temkin		
Q_{max} (mg/g)	K_L (L/mg^1)	R^2	n_f	K_F	R^2	B	A_T	R^2
10.63	.012	.992	.55	.05	.986	21.33	.03	.823

Table-1: Estimated parameters

V. CONCLUSION

This study revealed potential of water melon shell powder to be used as an adsorbent for removal of brilliant blue dye but the efficiency is less, it can be enhanced by various modifications like thermal expansion and by its activation. Based on experiments, influence of initial dye concentration, adsorbent dosage, pH, mixing time the optimum range of each variable is determined. Maximum removal is found to be 88% at pH value 2.

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