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Decolourization of textile dyes by using low cost adsorbent: A review

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ABSTRACT

Waste textile effluent containing colour compounds causes serious environmental problems. A large variety of dye stuffs can be found in real effluents such as acid, basic, reactive, direct, etc. The methods used for the removal of textile dyes are flocculation, coagulation, filtration and adsorption etc. Among those methods adsorption is more efficient due to its low cost and higher efficiency. The most frequently applied adsorbent for the removal of dyes and an organic pollutant in wastewaters is activated carbon. Since activated carbon is more expensive, the use of alternative adsorbents is attractive nowadays. Low cost adsorbents such as coconut shell, clay, neem leaf, rise husk, date stones, plantain stalk, mustard stalk, removed dyes from the effluents effectively. The adsorbents selected for this study are palm tree male flower ash, egg shell powder, sugarcane baggase ash, calotropis leaf powder due to its low cost and availability. The effects of different system variables, viz., adsorbent dosage, initial dye concentration and pH are studied.

Keywords: Textile dye, Low cost adsorbents, Adsorption.

1. INTRODUCTION

Industrial developments in recent years have left their impression on the environmental society. Many industries like the textile industry used dyes to color their products and thus produce wastewater containing organics with a strong color, where in the dyeing processes the percentage of dye lost wastewater is 50% of the dye because of the low levels of dye-fiber fixation [1]. Discharge of these dyes in to effluents affects the people who may use these effluents for living purposes such as washing, bathing and drinking [2]. Also dyes may impart toxicity to aquatic life and may be mutagenic, carcinogenic and may cause severe damage to human beings, such as dysfunction of the kidneys, reproductive system, liver, brain and central nervous system [3]. Since the removal of dyes from wastewater is considered an environmental challenge and government legislation requires textile wastewater to be treated, therefore there is a constant need to have an effective process that can efficiently remove these dyes [4]. In spite of the availability of many techniques to remove these pollutants from wastewaters as legal requirements, such as coagulation, chemical oxidation, membrane separation process, electrochemical and aerobic and anaerobic microbial degradation, these methods are not very successfully due to suffering from many restrictions [5]. Adsorption by activated carbon is an important way to clean up effluents and wastewater [6] where it used to polish the influent before it is discharged into the environment [7]. However adsorption by activated carbon has some restrictions such as the cost of the activated carbon, the need for regeneration after exhausting and the loss of adsorption efficiency after regeneration [8-10]. Therefore adsorption by low cost adsorbent used recently as an economical and realistic method for removal of different dyes. In this article, the technical feasibility of various low-cost adsorbents for dye removal from contaminated water has been reviewed. The main goal of this review is to provide a summary of recent information concerning the use of low-cost materials as sorbents.

1.1. Adsorption isotherms

The distribution of dye between liquid phase and adsorbent is a measure of the position of equilibrium in the adsorption process and it can be generally expressed by following adsorption isotherm.

- Langmuir isotherm
- Freundlich isotherm
- Redlich–Peterson isotherm
- Koble–Corrigan model
- Sips isotherm
- Toth isotherm

1.1.1. Langmuir model

The Langmuir model was developed based on the hypothesis of the formation of a monolayer of the sorbate species onto the surface of the particle of the sorbent. It has also been assumed that the surface sites are completely actively homogeneous. But in the true sense, the sorbent surface is energetically heterogeneous. The study of the Langmuir isotherms is essential in assessing the adsorption efficiency of the adsorbent. This study is also useful in optimizing the operating conditions for effective sorption. In this respect, the Langmuir isotherm is important, though the restrictions and the limitations of this model have been well documented. This model is the most widely used two-parameter equation, generally expressed in the form by the following equation.

$$1/q_e=1/Q_e K_L + Ce/Q_0$$

Where,

qe = the amount of dye removed at equilibrium (mg/g).

Ce = the equilibrium concentration of dye (mg/L)

Q_0 = the Langmuir constant, related to the adsorption capacity (mg/g).

b = the Langmuir constant, related to the energy of adsorption (L/mg).

KL = direct measure of the intensity of the sorption (L / mg).

Ce/qe was plotted against Ce using linear regression examination. The constants Q_0 and KL were determined from the intercept and slope of the linear plots, respectively the Qo from the Langmuir isotherm .The essential characteristic of Langmuir equation can be uttered in terms of a dimensionless separation factor RL. The essential characteristics of Langmuir isotherm can be expressed in terms of a dimensionless parameter, RL, which is defined by RL = 1/1+ bC_0, where, C_0 is the initial dye concentration (mg/L) and b is the Langmuir constant (L/mg).

1.1.2. Freundlich model

At Equilibrium conditions, the adsorbed amount, qe can also be predicted by using the Freundlich equation.

$$qe = kf\ Ce^{1/n}$$

Where, qe = dye concentration in solid at equilibrium (mg/g)

Ce = dye concentration in solution at equilibrium (mg/L)

kf = measure of adsorption capacity

n = adsorption intensity

A logarithmic form of the above equation is log

$$qe = \log k_f + (1/n) \log Ce$$

The values of n and k_f were resolute from the plot log Ce vs log qe .Where, k_f is the suggestion of the sorbent capacity and 1/n is a measure of surface heterogeneity, ranging between 0 and 1, becoming more heterogeneous as its value gets closer to zero. The Freundlich equation predicts that the dye concentration on the adsorbent will rise so long as there is an enlarge in the dye concentration in the liquid. The experimental evidence indicates that an isotherm is reached at a limiting value of the solid phase concentration. The equation itself does not have any real physical significance. Freundlich isotherm fitted well to the data with correlation.

1.2. Kinetics of adsorption

Many kinetic models have been proposed to elucidate the mechanism of solute adsorption. These kinetic models are useful for the design and optimization of effluent treatment process. In order to investigate the mechanism of dye adsorption by the following two kinetic models were considered.

1.2.1. Pseudo first order kinetic model

The integrated linear form of pseudo first order kinetic model the model proposed by Lagergren is

$$\log (qe - qt) = \log qe -(k/2.303)x\ t$$

Where,qe is the amount of dye adsorbed at equilibrium (mg/g), qt is the amount of dye adsorbed at time t (mg/g), k_1 is the first order rate constant (min^{-1}) and t is the time (min). Hence, a linear trace is excepted between the two parameters log (q_e - qt) and t, provided the adsorption follows first order kinetics. The values of k1 and q_e can be determined from the slope and intercept. The calculated and experimental qe values shows a reasonable correlation. Even though $q_{e\ cal}$ (calculated value) and $q_{e\ exp}$ (experimental value) are closer, the R2 values suggests that the adsorption data fitted poor to pseudo first order kinetics.

1.2.2. Pseudo second – order kinetics

The adsorption may also be described by a pseudo second order kinetic model .The linearized form of the pseudo second order model is

$$t/q_e=1/k_2q_e^2+1/(q_e)\ t$$

Where, k_2 is the second order rate constant (g/mg min).A plot of t/qt and t should be linear if the adsorption follows second order. q_e and k_2 can be calculated from the slope and intercept of the plot.

1.3. Materials and methods

1.3.1. Materials

Commercially available Reactive Red 35 is selected for this study. Textile dyeing unit effluents were collected from a dyeing unit located at Chennai. Palm tree male flower ash and calotropis leaf powder are collected from rural area. Sugarcane baggase ash is collected from sugar factory. Egg shell is collected from canteen and restaurant etc. All the chemicals and reagents used for the experiments and analyses are purchased from Chennai.

1.3.2. Preparation of solutions

1gm of dye powder can be taken and it can be dissolved in a 1 L of distilled water in a standard measuring flask (SMF), the solution is known as stock solution. Further the other concentrations are prepared from this stock solution.

1.3.3. Preparation of adsorbents

Adsorbents are collected from available area at kanchipuram district. The samples were washed thoroughly with running water. Using sunlight, the excess water from the samples are drained. The drained samples are dried in an hot air oven. The samples are grounded well using ball mill and screened by sieve equipment. The fine particle having average size of is used for the adsorb of dyes. The oversized particle is recycled back into the same ball mill for further reduction.

1.3.4. Structure of RR 35

IUPAC name of Reactive red 35 is disodium (6E)-5-oxo-6-[[3-(2-sulfonatooxyethylsulfonyl) phenyl] hydrazinylidene] naphthalene-1-sulfonate.

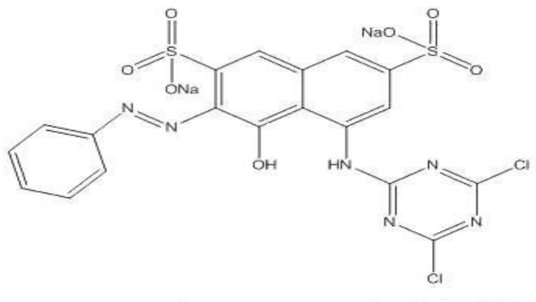

Figure - 1: Structure of Reactive Red 35.

2. CONCLUSION

The characteristic parameters for each isotherm and related correlation coefficients are determined. Adsorbent such as palm tree male flower ash, egg shell powder, sugarcane baggase ash, calotropis leaf powder are used for dye removal Reactive Red 35 and their efficiency in adsorption are found. The concentration of the dyes before and after the adsorption process can be analysed using U V Spectrometer. Sonication process is used to increase the efficiency of adsorption. The equilibrium data are analyzed using Langmuir, Freundlich, isotherms. The characteristic parameters for each isotherm and related correlation coefficients are determined.

3. REFERENCES

1. Mohan N, Balasubramanian N and Basha CA. Electrochemical Oxidation Of Textile Wastewater And Its Reuse. **J. Hazard. Mater,** 2007; 147: 644–651.
2. Sharma MK and Sobti RC. Rec Effect Of Certain Textile Dyes In Bacillus Subtilis. **Mutat. Res. Genet. Toxicol. Environ. Mutagen,** 2000; 465: 27–38.
3. Shen D, Fan J, Zhou W, Gao B, Yue Q and Kang Q. Adsorption Kinetics And Isotherm Of Anionic Dyes Onto Organo-Bentonite From Single And Multisolute Systems. **J. Hazardous Material,** 2009; 172: 99–107.
4. Lee JW, Choi SP, Thiruvenkatachari R, Shim WG and Moon H. 'Evaluation Of The Performance Of Adsorption And Coagulation Processes For The Maximum Removal Of Reactive Dyes. **J. Dyes Pig.,** 2006; 69: 196–203.
5. Sulak MT, Demirbas E and Kobya M. Removal Of Astrazon Yellow 7gl From Aqueous Solutions By Adsorption Onto Wheat Bran. **J. Biores. Technol,** 2007; 98: 2590–2598.
6. Al-Degs Y, Khraisheh MAM, Allen SJ, Ahmad MN and Walker GM. Competitive Adsorption Of Reactive Dyes From Solution: Equilibrium Isotherm Studies In Single And Multi Solute Systems. **Chem. Eng. J,** 2007; 128: 163–167.

7. Yin CY, Aroua MK and Daud WMAW. 'Polyethyleneimine Impregnation On Activated Carbon: Effects Of Impregnation Amount And Molecular Number On Textural Characteristics And Metal Adsorption Capacities. **J. Mater. Chem. Phys,** 2008; 112: 417–422.

8. Srivastava VC, Mall ID and Mishra IM. Adsorption Thermodynamics And Isosteric Heat Of Adsorption Of Toxic Metal Ions Onto Bagasse Fly Ash (Bfa) And Rice Husk Ash (Rha). **Chem. Eng J,** 2007; 132: 267–278.

9. Dinçer AR, Günes Y, Karakaya N and Günes E. Comparison Of Activated Carbon And Bottom Ash For Removal Of Reactive Dye From Aqueous Solution. **J. Biores. Technol.,** 2007; 98: 834–839.

10. Kadirvelu K, Kavipriya M, Karthika C, Radhika M, Vennilamani N and Pattabhi S. Utilization Of Various Agricultural Wastes For Activated Carbon Preparation And Application For The Removal Of Dyes And Metal Ions From Aqueous Solutions. **J. Biores. Technol.,** 2003; 87: 129–132.