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Waste Tendu Leaves From Beedi Industry Utilized For Removal of Sulphur Dye From Textile Waste Water

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ABSTRACT

An activated carbon as adsorbent is derived from waste tendu leaves (Diospyros melanoxylon) from local Beedi (Cigarette) industry for removal of sulphur dye from textile waste water. Tendue leaves were chemically treated with sulphuric acid and activated carbon prepared was analyzed by pH, moisture content, ash content, bulk density and BET surface area. The adsorption studies were performed as a function of different concentration of dye solution, contact time, pH and different adsorbent doses. The kinetics of the adsorption process follows the pseudo second-order kinetic model. Equilibrium data was analyzed using Langmuir, Freundlich and Tempkin isotherm models. The suitability of the data in different model of isotherm is determined from correlation coefficient (R^2) value. The results of all isotherms model shows correlation coefficient (R^2) value close to 1 and hence results fit into adsorption data.

The results showed that tendu leaves a solid waste disposal from Beedi industry can be used as effective biosorbent for removal of sulphur dye from textile waste water.

Keywords: Tendue leaves, adsorption, activated carbon, isotherm.

INTRODUCTION

Ecological balance is threaned by increasing environmental pollution due to rapid industrialization in the world and textile industries are one of the sources of the environmental pollution[1]. The textile industries not only causes water pollution by discharging large amount of waste water into various receiving bodies but also air pollution by ejecting different gases into atmosphere[2]. In fact, major pollution due to textile industries are discharging colored effluents containing various types of dyes and most of the dyes used are stable towards photo-degradation and biodegradation due to their complex structure[3] and it is disastrous for the environmental beings. Many of the organic and inorganic dyes are hazardous and may affect aquatic life and the food chain and sulphur dyes are not exception for this. In addition some dyes or their metabolites are toxic, mutagenic or carcinogenic in nature[4]. Thus colored effluents discharged by textile industry are dangerous source of environmental contamination not only from aesthetic point of view but also due to its toxicity to aquatic life.[5]

So it is essential to remove dye from colored effluent for safe discharge in receiving water bodies and prevent water pollution due to textile effluent. Various methods are available for removal of dye like coagulation using alum, flocculation using polyelectrolyte, ozonation, chemical, biological, membrane and adsorption by activated granular carbon but these have significant disadvantage such as high cost, high energy requirement etc. therefore these methods are not suitable for developing country like India. Biosorption using reusable industrial waste offer a reliable alternative to these traditional methods for dye removal in economically and eco-friendly.

Adsorbents prepared from agriculture waste and by product have been widely studied. A number of low cost adsorbents, such as activated carbon prepared from various wastes[6-8,] baggas fly ash[5], Rice Husk[9-13,] coal fly ash[14], Tendue leaves[3, 15]. Trpioca peel activated carbon (TPAC)[16], Granulated carbon, powdered carbon, Aluminum oxide[17], Red ochre[18] and Datura Stramonium[7] have been studied for adsorption of dye.

In the present study Tendue leaves (Diospyros melanoxylon) are used as adsorbents for removal of sulphur dye from textile waste water. Tendue leaves are important material used in (hand rolling) Beedi industries in India. About 7.5 million peoples are engaged in collection of tendu leaves and another 3 million are in beedi preparation by hand rolling process. Estimated revenues from tendu leaves are US$ 200 million per year.[4] Around 300,000 tons of tendu leaf are produced annually across the India, from which 20% waste is remaining during manufacturing of beedi[20.] The purpose of this proposed work is to investigate the adsorption capacity of chemically activated tendu leaves. The effects of various parameters such as agitation time, adsorbent doses, concentration of dye solution and pH have been studied.

MATERIAL AND METHODS

Collection and preparation of biosorbent

Tendu leaves are used as beedi wrapper, beedi is smaller and less expensive than a cigarette and it is poor man's cigarette in India. Small cutting pieces of tendu leaves were remaining during manufacturing of beedi, which itself causes environmental pollution. These waste tendu leaves are reused as adsorbent material for dye removal in the present study. Waste tendu leaves are collected from dumping site of Beedi industries in Solapur city, India. These leaves are cut into small pieces and washed with distilled and then dried at 70^{o}C for 8 hours. The completely dried material was grinded into powder and again stored into air tight oven at room temperature.

Activated carbon from tendu leaves are prepared by treating the material with concentrated sulphuric acid in the ratio of 3:1 proportion and kept in air tight oven at 150^{o}C-180^{o}C for 48 hours. The black colored mass was washed with distilled water until it becomes free from excess of acid and further dried in oven at 105oC for 12 hours. Dried product is called as activated carbon tendu leaf reuse (ACTLR).

Preparation of Dye solution

A stock solution of sulphur black dye was prepared by dissolving 1gm of sulphur dye in 1000ml distilled water to make the concentration of stock solution is 100mg/l. To prepare desired concentration of dye solutions, take 10, 20, 40 and 50mg/l of stock dye solution and diluted to 100ml. For absorbance measurements study before and after treatment of ACTLR a UV-VIS spectrophotometer (SAMAZU, 1202D) IS USED. All absorbance measurements was done at λmax= 620 nm. Concentrations of dye before and after treatment of ACTLR are determined by standard calibration curve.

Adsorption Studies

The batch adsorption was carried out in 250 ml Borosil conical flask by mixing 1gm CATLR and 100 ml aqueous solution of dye at different concentration of (10, 20, 40, and 50). The conical flasks were kept on a magnetic stirrer and agitated for different time interval. The solution was filtered and filtrate was used for measurement of absorbance. Concentration of dye remaining after treatment is determined by standard curve. The adsorption capacity, q_e were calculated from difference between the initial concentration and equilibrium concentration, which can be calculated as : $qe = (Co-Ce)\,V \quad X \quad 1000/M$

qe = adsorption capacity in mg/g, Co and Ct are initial concentration and equilibrium concentration in mg/l, M= adsorbent in gm and V= volume of solution.

The adsorption behaviours of samples were studied by evaluating % removal efficiency of CATLR by relation, % Removal = Co – Ce / Co x 100

RESULTS AND DISCUSSIONS

Characteristics of adsorbent

The physical characteristics of chemically activated tendu leaves prepared are given in table no. 1. Analysis of CATLR are determined by standard methods [21, 22]

The adsorption of sulphur dye in aqueous solution on activated tendu leaves were studied with the help of physico-chemical parameters such as contact time, pH and amount of absorbent, adsorbate and effect of agitation gradually.

Table No. 1 Characteristics of CATLR

Parameters	Characteristics value
pH	8.06
Bulk density(g/ml)	0.5984 g/ml
Moisture content (%)	3.88 %
Ash content (%)	4.47 %
BET Surface Area m^2/g	270 m^2/g

Effect of contact time and Agitation time

The experiment was carried out with different concentrations 10, 20, 40, 50 mg/l of sulphur dye (100ml) and agitated with 1 gm of activated carbon tendu leaves at room temperature .Figure 2 shows the effect of initial concentration of dye and contact time on rate of adsorption. The adsorption at different dye concentration was rapid at initial stages and then decreases with the progress of adsorption. The uptake of sulphur dye on activated carbon nearly reaches equilibrium within four hours. These results are expected because our large numbers of surface active sites are available for adsorption at initial stage and after laps of time, the remaining surface sites are difficult to occupy, because of repulsion between solute molecules of the solid and bulk phase.

Effect of pH

The effect of pH and contact time on adsorption of sulphur dye is shown in figure no.3. It is evident from figure that maximum adsorption of sulphur dye at pH =8.06. The pH of solution is an important parameter for controlling the adsorption process. The nitration between adsorbate and adsorbent is affected by pH of an aqueous medium.

Effect of Adsorbent Dosage

A series of adsorption experiment was carried out with different adsorbent dosages at initial concentration of 20mg/l with constant volume

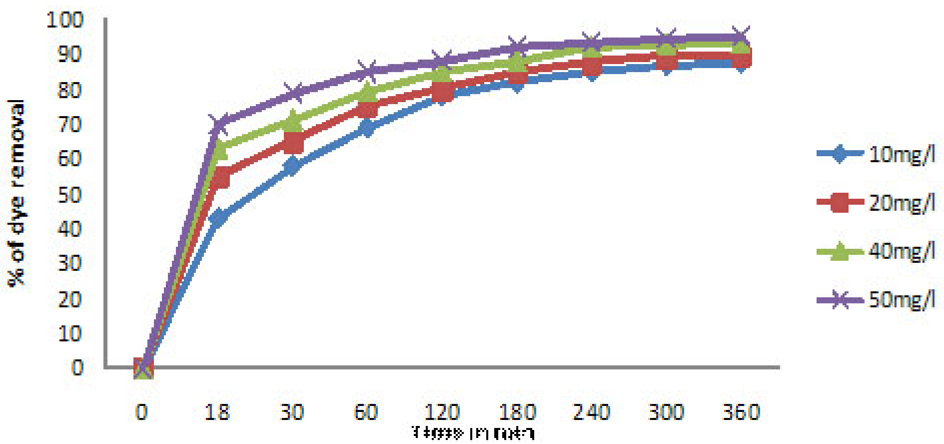

Fig. 1 Treatment of Tendue leaves without stirring

of dye solution (100ml). Figure-4 shows the effect of adsorbent on adsorption process, as increased the dosages of adsorbent the amount of adsorption is also increases. This is due to availability of large number of active sites on adsorbent surface at higher dosages.

Kinetic model

Various adsorption kinetic models have been used to describe the adsorption of dyes. The pseudo first order rate equation[23] and pseudo second-order model[24, 25] have been widely used. From results it is shows that present adsorption process follows pseudo second-order kinetic model, because correlation coefficient shows greater i. e. 0.999 value. Pseudo second-order equation is based on the sorption capacity on the solid phase.

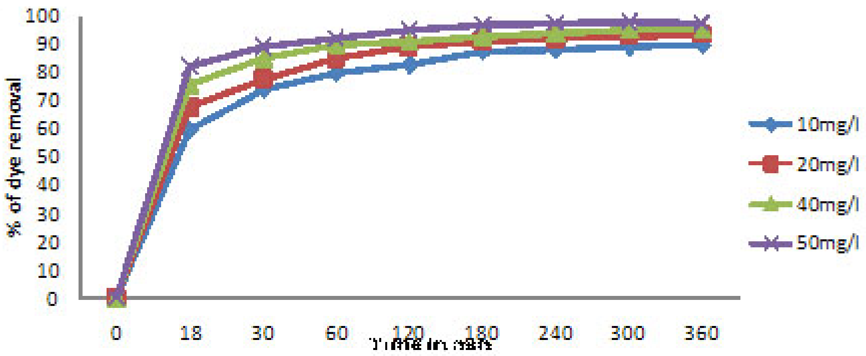

Fig. 2: Effect of stirring treatment of Tendue leaves

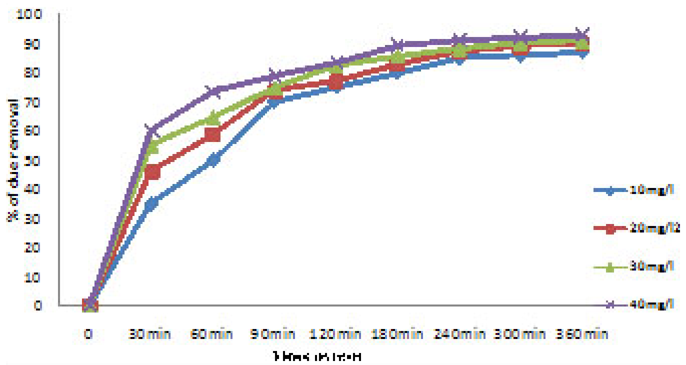

Fig. 3: Effect of Adsorbent dosages

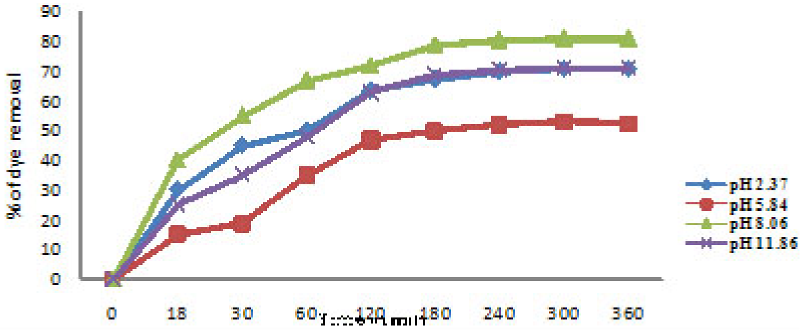

Fig. 4: Effect of pH

Adsorption isotherms

The analysis of isotherm data by fitting them into different model. Here, Langmuir, Freundlich and Tempkin model were used to describe the data derived from the adsorption of sulphur dye by CATLR. The applicability of three isotherms was compared by evaluating the correlation coefficients (R^2) values.

Langmuir isotherm

In order to facilate the estimation of the adsorption capacities at various conditions, the Langmuir adsorption isotherm was applied[24]. The linearised Langmuir model can be given as,

$$1/qe = 1/K_{L +} 1/K_L 1/Ce$$

Where Ce is concentration of dye in mg/l, qe is amount of dye adsorbed at equilibrium in mg/g, K_L (mg/l) and b (mg/g) are Langmuir constant, representing the maximum adsorption capacity for the solid phase and energy constant related to heat of adsorption. The constant b and K_L can be evaluated from the intercept and slope of linear plot of the experimental data of 1/ qe vs 1/Ce respectively. The plot of of 1/ qe vs 1/Ce is shown in fig no.6.

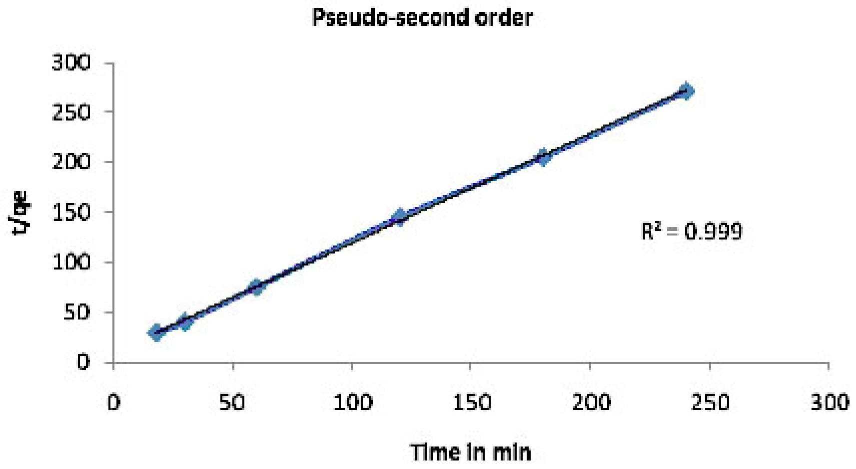

Fig. 5: Pseudo second-order plot

Freundlich isotherm

Freundlich isotherm has been widely adopted to characterize the adsorption capacity of organic pollutants using different adsorbents by fitting the adsorption data. The Freundlich isotherm in its linearised form can be written as,

$$\log qe = \log K_{f -} 1/n \times \log Ce$$

K_f is a Freundlich constant related to the adsorption capacity (mg/g) and 1/n is the intensity of adsorption. The values of K_f and 1/n are determined from intercept and slope respectively from linear plot of ln qe v/s ln Ce. The 1/n values indicate the type of isotherm to be reversible (1/n=0), (0<1/n<1), unfavorable (1/n>).[26] The plot of ln qe v/s ln Ce is shown in figure no.7. The values of K_f and 1/n are calculated from graph shown in table no. 2. From experimental data the value of 1/n is less than one indicating the given adsorption process is favorable.

Tempkin isotherm

The linear form of Tempkin isotherm[27] is expressed as,

$$qe = B \ln A + B \ln Ce$$

B is constant related to the heat of adsorption (J/mol) and A is Tempkin isotherm constant (L/mg). The constant A and B are calculated from slope and intercept of qe v/s ln Ce. The plot of of qe v/s ln Ce is shown in figure no.8. The parameters calculated from graph are shown in table no. 2. Based on correlation coefficient from all the three isotherm models, Langmuir model gave highest R^2 value showing that the adsorption of sulphur dye on CATLR was best described by this model.

Table No. 2: Adsorption isotherm parameters for adsorption of sulphur dye

Langmuir Isotherm			Freundlich Isotherm			Tempkin Isotherm		
K_L(mg/l)	b(mg/g)	R^2	K_F	$_{1/}$n	R^2	A(l/mg)	B(J/mol)	R^2
0.566	11.47	0.996	0.130	0.5	0.993	4.107	0.596	0.933

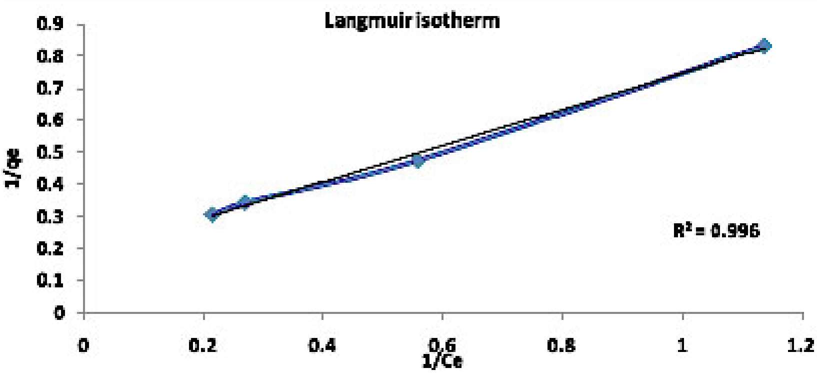

Fig. 6 Langmuir plot for removal of sulphur on tendu leaves.

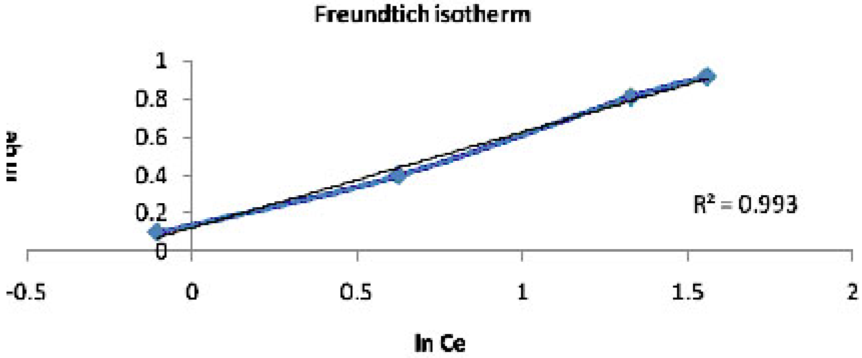

Fig. 7 Freundlich plot for removal of sulphur on tendu leaves

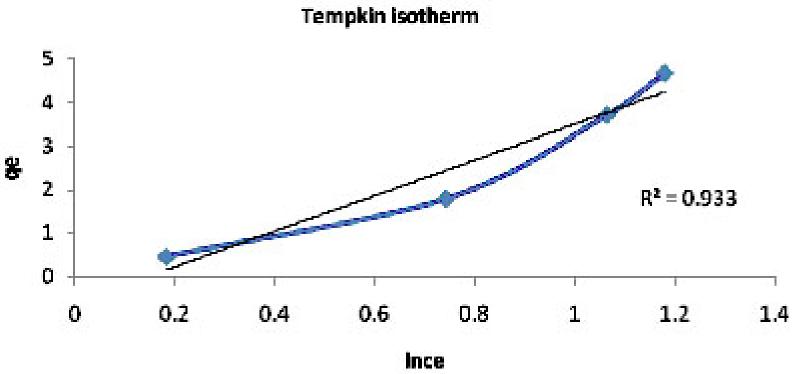

Fig. 8 Tempkin plot for removal of sulphur on tendu leaves

CONCLUSION

In the present study was carried out to examine reuse of tendu leaves waste from Bidi industry as a bio-sorbent material and results shown that it is used successfully for removal of sulphur dye from textile waste water. After adsorption pseudo second-order kinetics, Langmuir, Freundlich and Tempkin isotherm model is studied.

Activated carbon prepared from waste tendu leaves from local Bidi industries in Solapur city, India. Developing countries like India, industries cannot afford to use conventional waste water treatment like polyelectrolyte, hydrogen peroxide, activated carbon etc because these are economical. Therefore, preparation of biosorbent from zero cost tendu leaves waste is best alternative way of commercially available adsorbent for removal of dye from the textile waste water to prevent the environmental pollution.

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