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Study of the removal of methylene blue from aqueous solution by using coir pith

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Abstract

The use of reasonable and eco friendly adsorbents studied as an alternative substitution of activated carbon for removal of dyes from wastewater. Adsorbents prepared from coconut coir pith, which is a domestic waste, prosperously used to remove the methylene blue from an aqueous solution in a batch wise column. This study explores the potential use of coconut coir pith, pretreated with perfunctory treatment method, for removal of methylene blue from dye house wastewater. Treated coconut coir pith used to adsorb methylene blue at changing dye concentration, adsorbent dosage, pH and contact time. The sorption data were then correlated with the Freundlich and the langmuir adsorption isotherm models. In both isotherms exhibited a maximum K value in which indicates that the coir pith has greater affinity for methylene blue.

Keywords: Biosorption, coir pith, Langmuir's .Freundlich's isotherms

INTRODUCTION

The purpose of dyes by many industries, like textile, paper and plastics to color their products is a common activity. Ever since these industries also use a substantial amount of water in their techniques, this results in highly colored effluent of these industries which are generally colored due to the bearing of these organic chemicals. Color in water is not only the first noticeable contaminant in water; it also blocks sunlight, which is necessary for many photo-initiated chemical reactions, which are necessary for aquatic life (Robinson. *et al,* 2004, Banat *et al* 1996,Pearce *et al*. 2003). Since synthetic dyes to have good solubility in water, they may frequently be found in trace quantities in industrial wastewater. Water contamination becomes a serious issue due to the fact that two per cent of dyes that are produced are discharged directly in aqueous effluent (Boeningo. *et al* 1994,Theivarasu *et al*, 2010 Namasivayam *et al*. 2002)Increased environmental awareness and the relevant EPA restrictions on the organic content of industrial discharges makes it necessary to eliminate dyes from wastewater before it is discharged in the mainstreams. Aquatic living organisms model a serious threat due to the toxicity and even carcinogenic properties of these organic chemicals(Ghosh *et al*.2002,Avom *et al* 1997,Ayoub *et al* 2001,Bose *et al* 2002)

The liberation of dyes into waste waters from textile, cosmetic, paper and coloring industries places solemn environmental inconveniences. The coloration of the water by the dyes causes inhibitory effect on photosynthesis affecting aquatic ecosystems(Chantawong *et al* 2001 ,Edith Leuf, *et al* 199.,Gupta, *et al* 1985 ,Ho, 2003,Inbaraj *et al* 2002, Kawamura *et al* 1993) Adsorption of methylene blue from the aqueous phase is a useful toll for product control of adsorbents. Adsorption using activated carbon is mostly widely used method to remove dyes from aqueous solution because of its low cost, ease of operation. However, its use is express because of high cost and related problems of regeneration, there is a constant search for cheaper substitutes. Many efforts have been made to use low cost agro waste materials in substitute for commercial activated carbon. Some agro waste materials calculated for their capacity to remove dyes from aqueous solutions are coir pith (Khan, *et al* 1995 ,Lo 1999 ,Louise *et al* 1987 ,McKay *et al* 1989,Mellah *et al* 1997)

Methylene blue (MB) dye had also been adsorbed using kaolinite and activated carbon produced from palm tree cobs (Srivastava *et al* 1989,Undaybeytia *et al* 1996,Mangale *et al* 2012,Vaishnav *et al* 2012). The removal of methylene blue from wastewater needs great attention. In this present study, treated sawdust has been utilized as an adsorbent for the removal of methylene blue from aqueous solutions. The sorption data have also been correlated with adsorption isotherms and kinetics of adsorption has been studied to determine the efficiency of an adsorption process.

The present research is to remove methylene blue from aqueous solution using activated carbon prepared from coir pith. Adsorption isotherm which include Langmuir, Freundlich, Temkin was used to correlate the adsorption data.

MATERIALS AND METHODS

Dye solution preparation

The attributes of the Methylene blue used for the current work is given in Table 1. An exactly weighed quantity of the dyes dissolved in double distilled water to prepared stock solution (1000 ppm). Solution used in the experiment for the desired concentration acquired by successive dilutions. Dye concentration was determined by using absorbance values measured before and after the treatment, heterocyclic aromatic chemical compound with a molecular formula: $C_{16}H_{18}N_3SCl$, Molecular Weight=319.85. λmax = 663nm with Shimadzu UV Visible Spectrometer(Model: UV mini 1240).

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Table 1: Properties of Methylene Blue

Chemical formula	$C_{14}H_{18}N_3SCl$
Molecular weight	319.85 g/mol
Melting point	100 – 110 °C
Type of dye	Basic blue
Boiling point	Decomposes
lmax	665 mm

Biomass preparation:

Coir pith was collected from domestic waste. Coir pith carbon was prepared by thermal pyrolysis of coir pith the materials were sun-dried for 5 h., ground and carbonized. Coir pith material was packed in a steel container which is packed with sand in another concentric steel container. The whole set up was placed in a muffle furnace at 500oC & 600oC, and carbonization was done for 1 hour and 30 minutes respectively. physical characteristics of various adsorbents given in Table 2.

Table 2: Various activated carbons obtained from alternative sources and comparison of their surface areas

Carbon source	Activation method	Tested to remove	BET surface area/m^2 / g
Pecan shell	Steam & phosphoric acid activation	Organic compounds related to COD[a]	900
Fertilizer waste	HCl treatment	Bromophenols	380
Pecan shell	Phosphoric acid activation	—	861
Sawdust & tyres	CO_2 activation	Chromium	320 (S) 832 (T)
Tyres	CO_2 activation	Herbicides	832
Rice husk	Phosphoric acid activation	Phenolic & polyphenolic	420
Petroleum coke	KOH activation and H_2O_2 oxidation	—	2744
Coconut shell & fibers	Sulfuric acid activation	Pyridine	1565
Fuel, tyres, municipal waste	HCl activation	Phenol & dyes	1200
Coffee grounds	Phosphoric acid & ZnCl2 activation	Phenol, dye	640
Coconut fibers & jute	Phosphoric acid activation	Phenol, Cu, dye	1300–1500
Coir pith	CO2 activation	Dyes	550–600
Pitch	Steam act. with HNO3 & NaOH modification	Cu, Ni	1226 (NaOH) 976 (HNO_3)
Rice bran	Sulfuric acid and CO2 activation	Iodine	652
Tyres	HCl treatment, steam activation	Phenol & dyes	985

RESULT AND DISCUSSION

Effect of time on removal of colour

In each adsorption test, 20 ml of dye solution of known concentration and pH was added to 1g of adsorbents in 250 ml round bottom flask at room temperature, and the mixture was mixed on a rotary orbital shaker at 200 rpm. The sample withdrawn from the shaker at the pre determined time intervals for 10 minutes each. At the end of 10 minimums, the agitated sample taken from the shaker and tested for its optical density using the UV Visible Spectrophotometer. The similar Optical Density interpolated with the initial calibration values in order to find out color removal efficiency. All the adsorbents are quite effective, but coir pith found to be very effective next to activated Carbon. The color removal efficiencies of the adsorbents have a breakthrough at 60-minute duration, in which there is no further color removal takes place. Coir pith found to be very effective with color removing efficiency of 90%. Fig 1 shows the effect of contact time on colour removal .

The colour removal efficiency of dried biomass was calculated using the following equation:

$$Q = ((C_0 - C)/m)V \quad \text{--------} \quad (1)$$

Q = mg of metal ion biosorbed per gram of biomass; C_0= initial metal ion concentration, mg/L;

C = final metal ion concentration, mg/L;m = dry weight of biomass in the reaction mixture,g;V = volume of the reaction mixture, L.

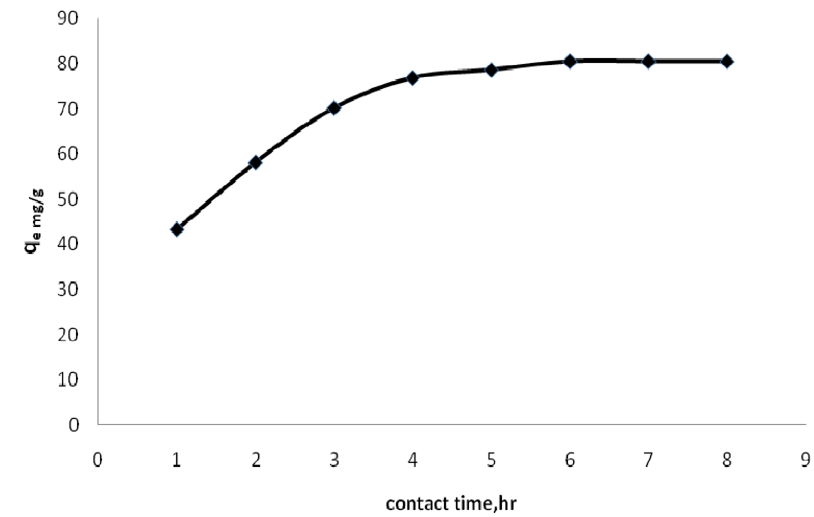

Fig: 1 Effect of contact time on colour removal coir pith

Effect of Solution pH

The pH of dye mixture takes up an important role in the adsorption process, especially on adsorption function. The qe was found to be a maximum at the natural pH of the dye solution (pH = 5). The adsorption amount was less in acidic media but stayed almost constant in basic environment as shown in Fig.2. The observed rate of adsorption is low at lower pH, because the surface charge becomes positively charged, thus making (H+) ions compete effectively with dye cations causing a decrease in the amount of dye adsorbed.

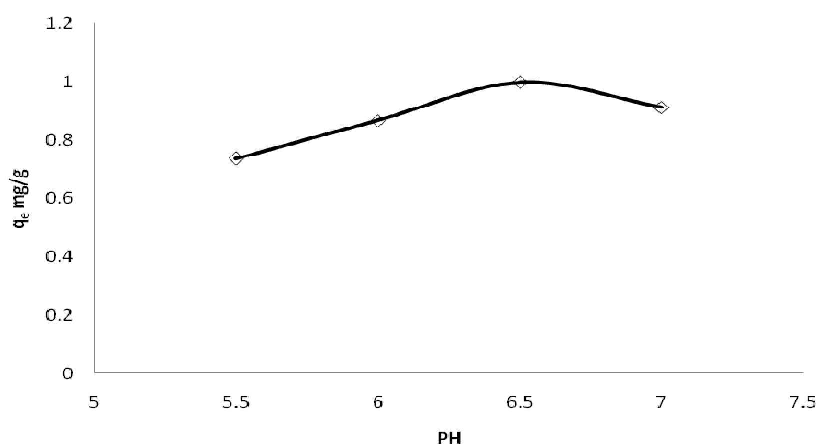

Fig: 2 Effect of pH on colour removal coir pith

Effect of adsorbent dosage

250 ml of the stock solution of 1000 ppm taken and with a varied amount (10,20,30,40,50,60 g) of adsorbent fed into the 500ml flask and kept for agitation at 150 rpm using rotary orbital shakers for the regular interval of 45 minutes. At the end, the agitated sample taken from the shaker and experimented for its optical density using the UV visible Spectrophotometer. The comparable Optical Density interpolated with the initial calibration values in order to find out color removal efficiency of the adsorbent.

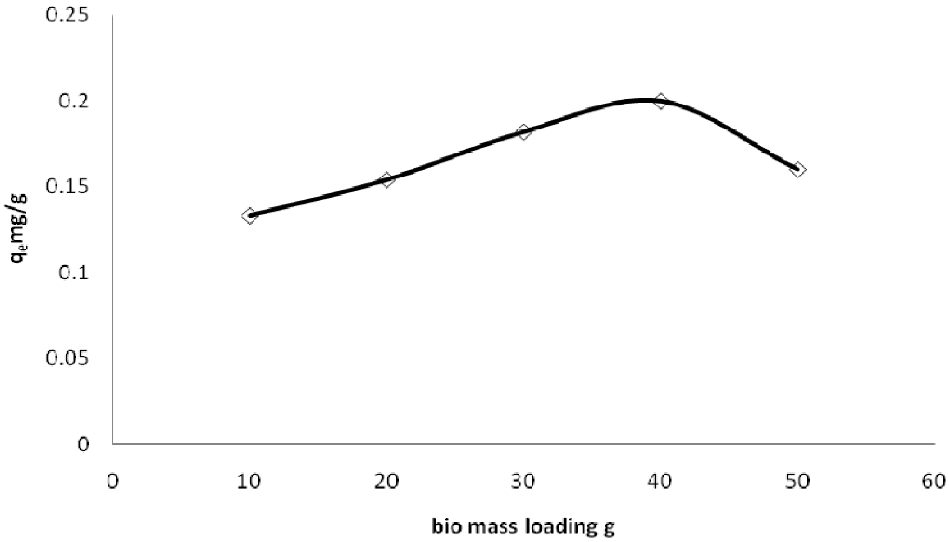

Fig: 3 Effect of bio mass loading on colour removal coir pith

Sorption Isotherm Models:

Models have an important role in technology transfer from laboratory to pilot plant scale. An appropriate model can help in understanding the process mechanism, analyze experimental data, answer to operational conditions and optimize process. Langmuir, Freundlich, Dubinin Radushkevich and Temkin models are used in the present work. These models are simple, well established, having physical meaning and are easily predictable (table-3)

Table-3 Adsorption isotherm

S.No	Isotherm Model	Equation
1	Langmuir	$x = x_0kc / (1+kc)$
2	Freundlich	$q_e = k_F c_e^{1/n}$
3	Dubinin Radushkevich Model	$q_e = x_m \exp(-\beta F^2)$
4	Temkin	$q_e = RT/b \ln(K_T C_e)$

The linearized isotherm plots are given in Figures 4, 5, 6 and 7.

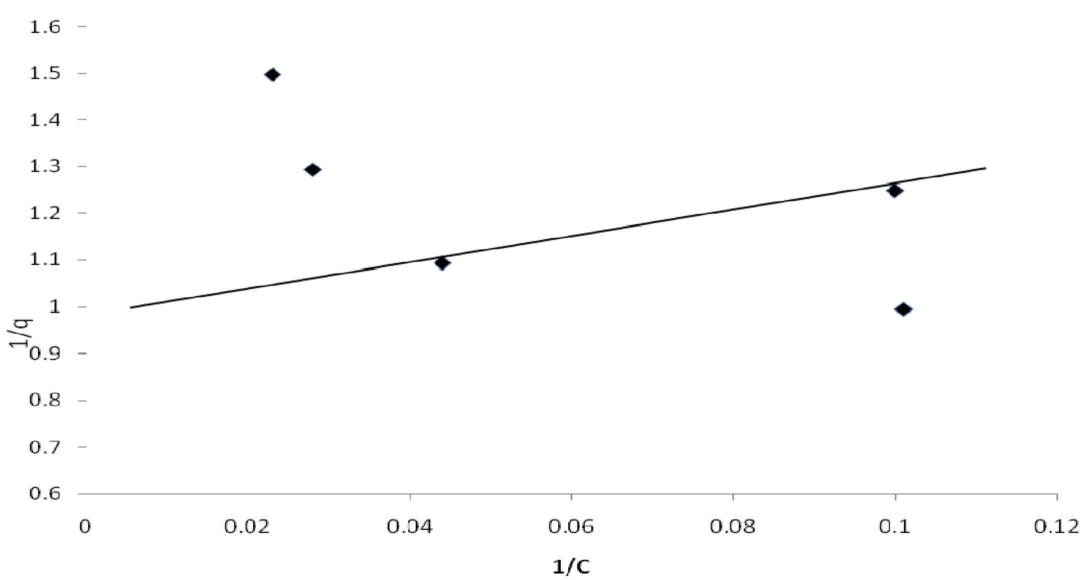

Fig: 4 Langmuir plot for removal of colour by coir pith

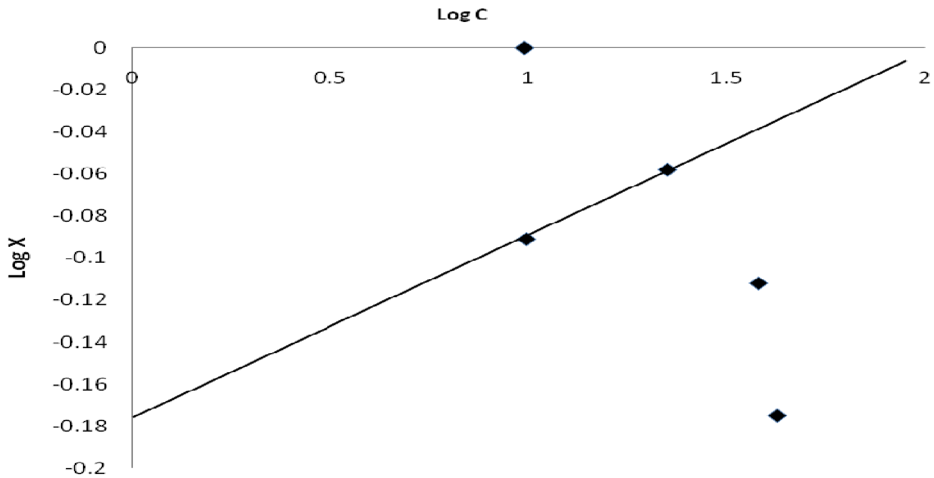

Fig:5 Freundlich plot for removal of colour by coir pith

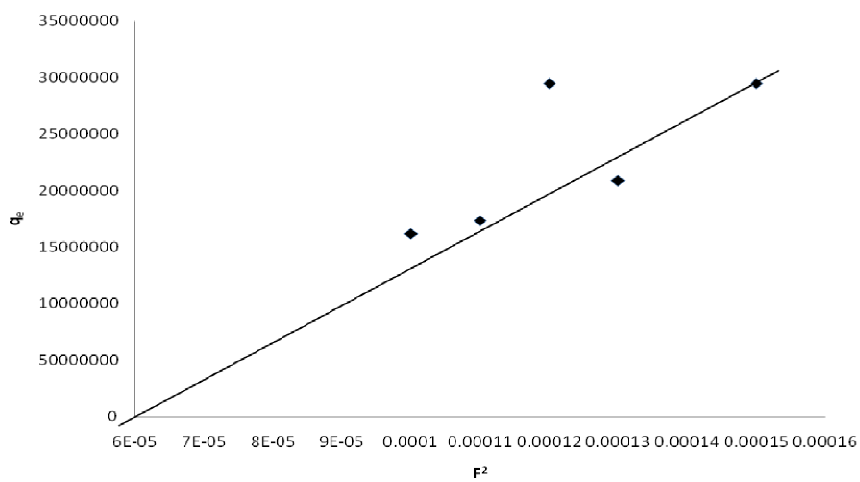

Fig:6 Dubinin Radushkevich plot for removal of colour by coir pith

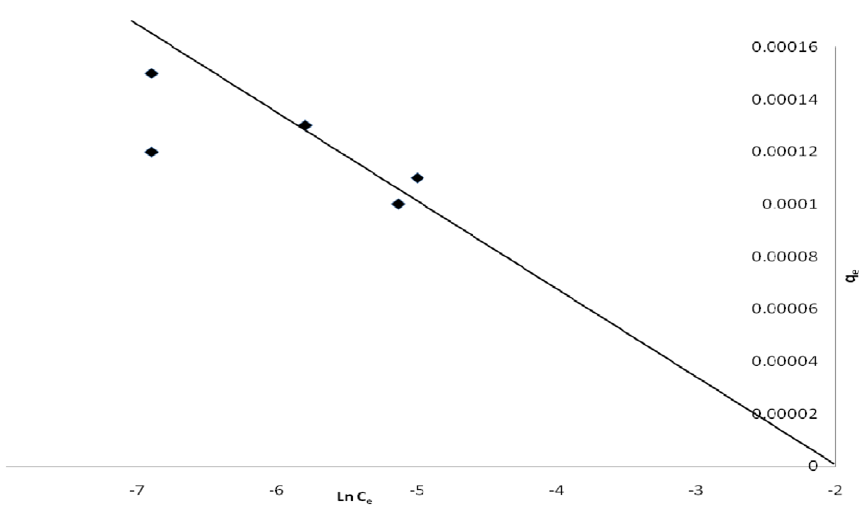

Fig:7 Temkin plot for removal of colour by coir pith

In this study the different aspects of the colour removal by coir pith is showed. Results showed that the specific colour removal was found to increase with increase in biomass loading. The equilibrium data fitted very well with Dubinin Radushkevich and Temkin isotherm models.

CONCLUSION

Starting the results of the present study, it is concluded that, the adsorption protocol is a very effective process for the decolorization of textile wastewater, as we can reach 90% decolorization in few minutes. There is a require to increase the adsorption process effectively by varying parameters to bring down the values to permissible limits for wastewater before discharging it to the water environment. The present investigations showed the different aspects of the colour removal by coir pith. Results showed that the specific colour removal was found to decrease with an increase in biomass loading the effects of process parameters like pH, bio mass loading and contact times were studied. The removal of colour by coir pith was increased by increasing the biomass loading and PH up to the optimum level ,it was studied 40 g and 6.5. Further studies shown the optimum contact time were 6 hrs. The adsorption isotherms could be well fitted by the Langmuir equation followed by Dubinin Radushkevich and Temkin equation. The biosorption process could be best described by the second-order equation.

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