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Utility of plant cellulose waste for the bioadsorption of brilliant green dye pollutant

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Abstract: Dyes are usually present in higher quantities in the effluents from textile industries. The effectiveness of adsorption for dye removal from waste water has made an ideal alternative to other expensive treatment methods. The present study deals with the adsorption of Brilliant Green dye (BG) on sugarcane Raw Bagasse (RB) and chemically activated raw baggase (CAB). Baggase is a solid waste obtained after extraction of the juice from the sugar cane. The effect of contact time, initial concentration and adsorbent dosage was studied using batch adsorption at neutral pH (7.0) for the removal of BG dye. The results showed that as the amount of the adsorbent was increased, the percentage of dye removal increased accordingly. Higher adsorption percentages were observed at lower concentrations of BG. CAB showed a better performance compared to RB. Equilibrium isotherms for the adsorption of BG on RB and CAB were analyzed by Freundlich isotherm mathematical model.
Keywords: CAB (Chemically activated Bagasse), RB (Raw Bagasse), Brilliant green.

Introduction

Dyes are the chemicals which on binding impart its colour to the binding material. Dyes are ionic, aromatic organic compound with structures including aryl rings which have delocalised electron systems. The colour of the dye is due to the presence of a chromophore group. A chromophore is a radical configuration consisting of conjugated double bonds containing delocalised electrons. Textile, dye production and other industries using dyes and pigments, generates the wastewater containing dyes and organic content.

Dyes are widely used in industries such as textile, rubber, paper, plastic, cosmetic etc. Among these various industries, textile ranks first in usage of dyes for coloration of fibre[1]. It was estimated about 10,000 different commercial dyes and pigments exists, 7 x 10^5 tones of dyes are produced annually world wide. Approximately 50% of these are discharged as a effluents from textile and dye industries[2]. Industrial effluents from the dye industries represent major environmental problems. Even small concentrations of discharged dyes increases turbidity and high pollution strength on the aquatic environment; in addition to the toxic degradation of products formed[3, 4]. The adsorption process is one of the effective methods for removal of dyes from the waste effluent. The process of adsorption has an edge over the other methods due to its sludge free clean operation and dyes can be removed completely even from the diluted solution[5].

Activated carbon (powdered or granular) is the most widely used adsorbents because of its excellent adsorption efficiency over the organic compound, but commercially available activated carbon is very expensive when employed in large scale[6]. Furthermore, regeneration of activated carbon by refractory technique results in a 10-15% loss of adsorbents and its dye uptake capacity**.** This had leads to further studies for cheaper substitutions of adsorbents. There are numerous numbers of low cost,

commercially available adsorbents which have been used for the dye removal[1] (Table. 1).

However the adsorption capacities of these adsorbents mentioned are not very large but the adsorbents which are more economical, easily available and highly effective are still needed. In the present work the use of sugarcane-bagasse (agriculture waste) as an adsorbent material for brilliant green dye removal from aqueous media was used. The adsorption equilibrium and kinetic studies were carried out by varying the initial dye concentration temperature and contact time.

Materials and methods

The sugarcane bagasse was collected from sugar cane mill, Bangalore (India). The collected biomaterial was cut into segment of 10 cm length and soaked in distilled water for 48 hrs to remove soil and dust particles, then dried overnight at 110^0C in hot air oven. Dried straw segment was grounded and sieved using 120 and 200 mesh number screens; the baggase powder retained on the 200 mesh number screen was selected and used as a Raw Baggase.

In the preparation of CAB, one part of the Raw sugarcane baggase was treated with four part of concentrated sulphuric acid (Merck AR grade) by weight and then kept in hot air oven for 24 hrs at 110 °C (Lawrence & Mayo) for drying. The carbonized material was washed with distilled water and soaked in 1% sodium bicarbonate solution overnight to remove traces of acid and dried at 110°C for 24 hrs. . The treated material was then grounded; sieved using 100 and 200 mesh number screens and the baggase powder retained on the 200 mesh number screen was used as CAB adsorbent. The Brilliant Green Dye procured from Merck Mumbai, India was used.

Table 1: Some low cost materials for dyes removal

Adsorbents	Dyes
Bamboo dust, coconut shell	Methylene blue
groundnut shell, rice huskSilk cotton hull	Rhodamine-B, Congo red, methylene blue
sago waste, maize cob coconut tree sawdust	methyl violet, malachite green
Parthenium hysterophorus	Methylene blue, brilliant green
Rice husk	Brilliant green
Rice husk	Safranine, methylene blue
Biogas residual slurry	Congo Red, Rhodmine-B, acis violet, acid
Hardwood	Astrozone blue
chiitosan	Acid blue 25, basic blue 69
Orange peel	Acid violet 17,Congo red, Rhodamine-B
Indian Rosewood	Brilliant green
Banana and orange peels	Methyl orange, methylene blue, Rhodamine-B,
Banana pith	Congo red, Rhodamine-B, acid violet, acid
Hardwood	Astrozone blue.
Mahogany sawdust, rice husk	Acid yellow 36

In the present work Freundlich[7] adsorption isotherm model was used to predict the adsorption behaviour for the adsorption of Brilliant Green dye on RB and CAB. Fredulich equation[8] is given by the expression-

$C^* = k [v (C_0 – C^*)]^n$

Where C_0 and C^* are the initial and equilibrium concentration of dye, g/L

v is the volume of solution / Kg of adsorbent, L/g

k and n are constants and these can be estimated by plotting a graph of

$\ln C^* = \ln k + n \ln [v(C_0 – C^*)]$

The plot of $\ln C^*$ v/s $\ln [v(C_0 – C^*)]$ gives a linear plot with intercept in ln k and slope n.

Experimental

Adsorbents (RB and CAB) of varying weight from 0.1 gm to 1.0 gm were taken separately in a conical flask containing 100ml aqueous dye solution of known concentration and shaken well using an orbital shaker (Remi). Initial dye concentration (varied from 50 – 200 ppm) was measured at different time interval (15, 30, 60 and 90 min), at temperature (30°C) for neutral pH(7.0). At the end of predetermined time intervals, mixtures were taken out and subjected for centrifugation (Remi) at 3000 rpm for 10 min, the supernatant collected was analysed for residual concentration of Brilliant green dye at 550nm using UV – VIS spectrophotometer (Elico). The amount of Brilliant green dye adsorbed was calculated from the concentrations in solution before and after adsorption. All the experiments were performed in triplicate.

Results and Discussion

The adsorption experiments are carried out to find the effect of dye concentration, adsorption concentration and temperature.

Effect of initial dye concentration

The influence of the initial concentration of Brilliant Green in the solutions on the rate of adsorption on RB and CAB was studied. The experiments were carried out at different initial concentrations of Brilliant Green (50, 100 and 200ppm), different time intervals (30, 60 and 90 min) at 30^0C for constant adsorbent 1 g/L for RB and CAB. It was observed that the percentage of dye adsorption increases initially and attains equilibrium within 60-90 min. RB and CAB could remove Brilliant Green dye to an maximum of 45.08% **(Fig. 1) and 95.03% (Fig. 2)** respectively for initial dye concentration of 50ppm. The large fraction of the total dye concentration was removed after 15 min. The percent adsorption of dye was decreased with increase in initial dye concentration, due to decrease in resistance to dye uptake and consequently increase in mass transfer driving force. These results indicated the profile of dye uptake is a single, smooth and continuous curve leading to saturation due to formation of monolayer coverage on the surface of adsorbent[9].

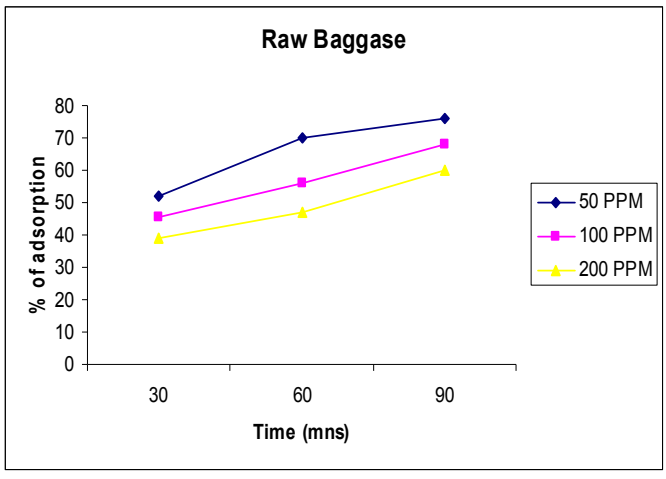

Fig. 1 Effect of initial dye concentration on Raw Baggase

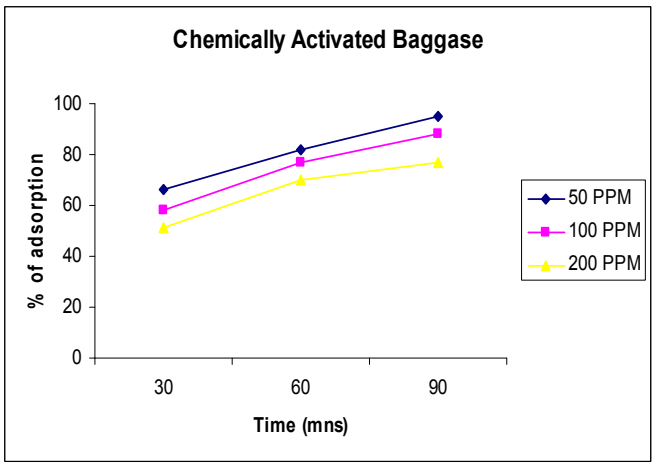

Fig. 2 Effect of initial dye concentration on Chemically Activated Bagaase

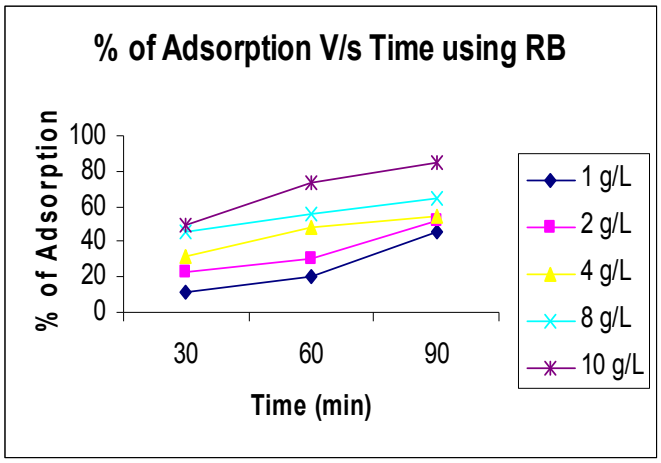

Fig. 3: Effect of adsorbent (RB) concentration on adsorption

Effect of adsorbent concentration

The weight of the adsorbent was varied from 1.0 gm/L to 10 gm/L for RB (**Fig.3) and CAB (Fig.4**) respectively on aqueous dye solution. The dye concentration was maintained constant at a concentration of 50 ppm. CAB gave the greater removal at all the levels of adsorbent dosage. An equilibrium percentage removal rate of 85.38% for RB and 98.0% for CAB was achieved with 10 g/L in 90 min. Initially the rate of adsorption was found to be rapid due to availability of more active sites for adsorption, as the time increases the formation of unimolecular layer over the surface of the active sites results in decrease in adsorption and attains equilibrium. The subsequent slow rise is observed in percent removal, which states that adsorption and intra-particle diffusion taking place simultaneously with dominance of adsorption. With rise in adsorbent dose, there is less commensurate increase in adsorption, resulting from lower adsorptive capacity utilization of adsorbent.

Thus, the results obtained from this section of experiment indicate that chemically activated baggase has a large potential as an adsorbent for dye removal than raw baggase due to cellulosic materials are transformed in to carbonized material due to concentrated sulphuric acid treatment. These carbons may have mesopore structure which adsorbs medium size molecules[10].

In adsorption isotherm for RB and CAB at equilibrium conditions, a Freundlich adsorption isotherm model is used for adsorption of crystal violet dye on RB and CAB.

The graph $\ln C^*$ V/s $\ln(V(C_0 - C^*))$ was plotted for an RB and CAB as shown in Fig. 5 and Fig. 6. The values of n and K is found be .0789 and ln -3.363 respectively for RB and 2.3 and 1.6 respectively for CAB. The value of n is greater than 1 for CAB, which shows that CAB is a very good adsorbent for adsorption of Brilliant Green.

The value of n is lesser than 1 for RB shows that it is poor adsorbent for brilliant green when compared to CAB. The R^2 value is found to be 0.0476. Therefore the fit is not considered to be a best fit for RB.

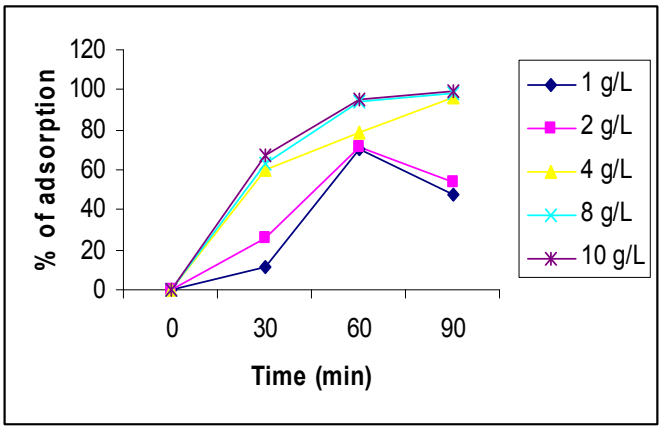

Fig. 4: Effect of adsorbent (CAB) concentration on adsorption

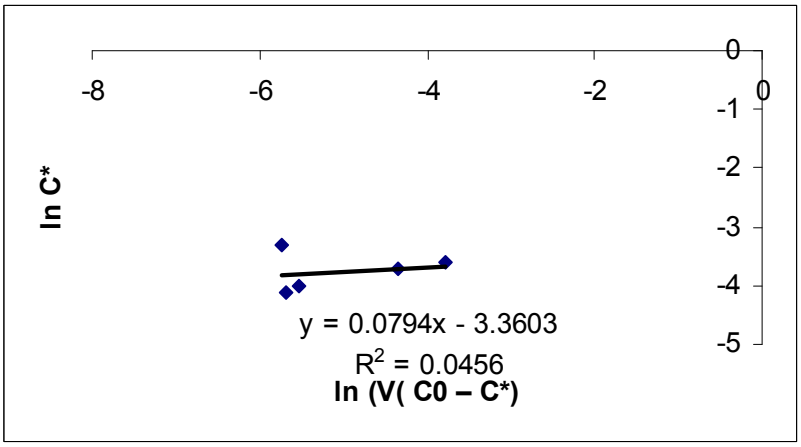

Fig 5. Adsorption isotherm for raw baggase

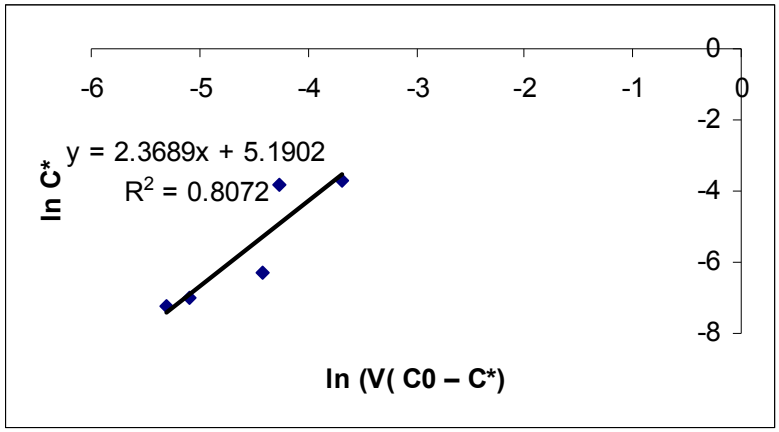

Fig. 6: Adsorption isotherm for chemically activated baggase

Discussions :

Following conclusions were drawn based on findings. CAB was found to be suitable adsorbent for the adsorption of Brilliant Green dye of initial concentration 50 ppm which was considered to be optimum concentration for maximum adsorption of 95% between at constant temperature of 30°C. The value n is greater than 1 for CAB shows that it is efficient adsorbent for Brilliant Green dye similarly, the value for RB is less than 1 clearly indicated that it is poor candidate for adsorption of Brilliant Green dye.

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