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REMOVALS OF SUDAN RED G DYE FROM AQUEOUS SOLUTION BY ADSORPTION ON TO ACTIVATED CARBON PREPARED FROM MOSAMBI AND COTTON AN AGRICULTURAL WASTE

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Abstract: Synthetic dyes are widely used in industries such as rubber, textiles, plastics, paper, cosmetics etc. to colour their products. The effectiveness of adsorption for dye removal from wastewater has made it an ideal alternative to other expensive treatment methods. This study investigates physicochemical properties and chemical kinetics was examined for the same dye by using of Mosambi and Cotton as natural adsorbents for removal of dye. The effects of condition such as initial dye concentration, adsorbent dose, pH and contact time were studies. The result shows that some adsorbents have good potential of removal such as Mosambi, Cotton. The removal efficiency increase has adsorbents dose increases. This makes it an interesting option for dye removal from aqueous solution of dye.
Keywords: Synthetic dye; Adsorption; Adsorbent; Adsorption isotherm; Langmuir and Freundlich isotherm.

1. Introduction

The effluents from many textile plants contain proportions of dyes which are easily visible when the effluent enters a waterway.[1] The discharge of dyes in the environment is worrying for both toxicological and esthetical reasons. Industries such as textile, leather, paper, plastics etc., are some of the sources for dye effluents[2].The discharge of organic colour containing effluent cause huge damage to environment hence their removal has recently become the subject of interest.[3]

The removal of color from wastewater is often more important than the removal of the soluble colorless organic substances, which usually contribute the major fraction of the biochemical oxygen demand. Many methods have been reported for removing textile dyes from wastewater, among which are membrane filtration, coagulation/flocculation, precipitation, flotation, adsorption, ion exchange, ion pair extraction, ultrasonic, mineralization, electrolysis, advanced oxidation and chemical reduction. Biological techniques include bacterial and fungal biosorption and biodegradation in aerobic, anaerobic or combined anaerobic/aerobic treatment processes.[4] Adsorption is one of the most effective

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methods and activated carbon is the preferred adsorbent widely employed to treat wastewater containing different classes of dyes, recognizing the economic drawback of commercial activated carbon. Activated carbon has been widely used in waste water treatment to remove organic and inorganic pollutant[5]. Many investigators have studied the feasibility of using low cost plant materials (residues) like babul Seed[6], barley husk[7], sunflower stalks[8], peel of cucumis sativa fruit[9], orange peel and lemon peel[10], as carbonaceous precursors for the removal of dyes from water and wastewater. Previously the work on removal of textile Erichrome black T dye from aqueous solution from aqueous solution by adsorption technique using natural waste was investigated in this laboratory.[11-13] The present study was undertaken to evaluate the efficiency of a carbon adsorbent prepared from mosambi and cotton an agricultural waste for removal of Sudan Red G dye in aqueous solution. The main aim of the current study has been to visualize the pattern of adsorption of this dye to various situations such as initial dye concentration, adsorbent dose, pH and contact time. The effects of various operating parameters monitored and optimal experimental conditions were decided. These fundamental data will be useful for further applications in the treatment of practical waste or process effluents.

2. Materials and Method

2.1 Adsorbate:

Stock solution (1000 mg/L) of Sudan Red G Dye was prepared by dissolving 1g of dye in 1000 mL of double distilled water. The stock solutions were diluted with double distilled water to obtain required standard solution.[14] Batch adsorption studies were performed at room temperature (39$\pm$1°C). Table 1 enlists the properties of Sudan Red G Dye used. .

Table 1 Characteristics of Sudan Red G Dye

Molecular Formula	$C_{17}H_{14}N_2O_2$
CAS number	1229-55-6
CI Number	12150
Water Solubility	100 g/l

2.2 Adsorbents:

The mosambi peels and stems of cotton were collected from local area of Jalgaon district in clean plastic bags. These waste materials are washed with distilled water, dried in sunlight, then 60°C for 24 hours in hot air oven. The dried material was subjected for acid treatment (ratio 1:1) and kept at room temperature overnight and stored in a tight lid

container for further studies. It is then screened through a mesh sieve with a particle size range of 180-300 μm. Carbon was prepared by treating air-dried prepared fresh natural adsorbents with concentrated sulphuric acid in a weight ratio of 1:1 for 24 hours. The resulting black product was kept in an air-oven maintained at 105°C for 12 hours followed by washing with $NaHCO_3$ and water until free from excess acid and dried at 105±5 °C to get mosambi peel activated carbon and activated carbon of stem of cotton. Product obtained was ground well to fine powder and the physical properties are analyzed by usual standard methodologies.

2.2 Batch adsorption studies

Adsorption experiments were performed at room temperature (39±1°C), 0.004 g cc^{-1} of adsorbent was mixed with known initial dye concentration (50, 100, 150, 200 and 250 mg L^{-1} respectively) 100 mg L^{-1} dye solution was used for adsorbent dose variation study. For pH variation, 100 mg L^{-1} dye solution with 0.004 g cc^{-1} adsorbent dose was used. The adsorbent and adsorbate were separated by filtration and filtrate was analysed for residual Sudan Red G concentration spectrophotometrically using UV Visible spectrophotometer (Systronic, Model No. 166) at λ_{max}= 520 nm.

3. Results and Discussion

3.1 Characteristics of the adsorbent:

The physico chemical properties of the prepared activated carbon were determined by standard procedures. Surface area was determined by BET method. The physico- chemical properties are listed in Table 2.

Table 2: Characteristic of activated carbons of mosambi peels and stem of cotton

Sr No.	Properties	Mosambi Peel Activated Carbon	Stem of Cotton Activated Carbon
1	pH	7.7	7.3
2	Moisture Content (%)	6	7
3	Ash Content (%)	23	24
4	Apparent Density (g cc^{-1})	0.5494	0.431
5	Solubility in water (%)	0.34	0.54
6	Solubility in HCl (%)	0.89	1.78
7	Surface area (m^2g^{-1})	189	198

3.2 Effect of Dye Concentration:

To study the effect of different initial concentrations of Sudan Red G on adsorption behaviour, five concentrations (50, 100, 150, 200 and 250 mg/L) were used and the amounts adsorbed were calculated and given in Tables 3-4. The observed increase in the adsorption of Sudan Red G with increase in concentration may be due to sufficient adsorption sites at adsorbent. The amount of dye adsorbed (mg/g) increased with increase in time and the equilibrium for dye removal attainment was achieved after 120 min. The initial dye concentration provides the necessary driving force to overcome the resistances to the mass transfer of Sudan Red G between the aqueous and solid phases. The maximum adsorption is obtained by ACMP and ACCS which is 88.65 % and 91.27 % respectively.[15]

Table 3: Effect of different initial dye concentration on dye removal using ACMP (Adsorbent dosage=400mg/ 50 mL, initial pH=7.0, time 120 min.Size = 180 –300 micron)

Initial dye concentration (mg/L)	**Percentage of dye removal with time (min)**					
	15	30	45	60	90	120
50	24.14	39.66	51.72	67.24	82.76	86.21
100	17.65	37.25	64.71	78.43	86.27	87.25
150	26.53	46.94	64.63	75.51	87.07	87.76
200	29.10	51.85	60.85	77.78	87.83	88.36
250	37.99	52.84	61.14	74.67	87.77	88.65

Table 4: Effect of different initial dye concentration on dye removal using ACCS (Adsorbent dosage=400mg/ 50 mL, initial pH=7.0, time 120 min. Size = 180 -300 micron)

Initial dye concentration (mg/L)	**Percentage of dye removal with time (min)**					
	15	30	45	60	90	120
50	32.76	46.55	62.07	72.41	86.21	87.93
100	18.63	40.20	54.90	69.61	88.24	89.22
150	33.33	46.94	63.27	77.55	89.80	91.16
200	28.57	50.26	58.20	79.37	89.95	91.01
250	33.19	50.22	64.19	79.48	90.39	91.27

3.3 Effect of adsorbent dose variation:

The effect of adsorbent dose on removal of Sudan Red G was studied by varying the dose of adsorbent (0.002, 0.004, 0.006, 0.008 and 0.01 g/L) in the test solution while keeping the initial dye concentration 100 mg/L (Temperature 39± 1^{o}C) at pH=7. Experiments were carried out at different contact times for 120 mins. Tables 5-6 reveal that percent of adsorption increased with increasing adsorbents doses. The increase in the percent removal of dye with the increase in adsorbent dosage is due to the availability of larger surface area with more active functional groups. The maximum adsorption Sudan Red G is by ACMP and ACCS which is 90.38 % and 90.54 % respectively.[16]

Table 5: Effect of different concentration of ACMP on dye removal
(Dye concentration = 100 mg/l, initial pH=7.0, time 120 min. size = 180 - 300 Micron)

Adsorbent dose (g/100mL)	**Percentage of dye removal with time (min)**					
	15	30	45	60	90	120
0.2	12.61	30.25	33.61	51.26	68.91	69.75
0.4	17.65	37.25	64.71	78.43	86.27	87.25
0.6	37.65	54.12	65.88	78.82	87.06	87.06
0.8	33.33	54.17	69.44	79.17	88.89	90.28
1	21.15	42.31	59.62	80.77	90.38	90.38

Table 6: Effect of different concentration of ACCS on dye removal
(Dye concentration = 100 mg/l, initial pH=7.0, time 120 min. Size = 180 - 300 micron)

Adsorbent dose (g/100mL)	**Percentage of dye removal with time (min)**					
	15	30	45	60	90	120
0.2	16.36	33.64	40.00	52.73	65.45	67.27
0.4	24.55	48.18	60.91	75.45	89.09	89.22
0.6	46.36	62.73	72.73	82.73	90.00	86.75
0.8	46.36	55.45	70.00	87.27	91.82	89.74
1	53.64	64.55	73.64	88.18	92.73	90.54

3.4 Effect of pH variation:

Adsorption is also affected by change in pH of the solution as shown in Fig 1. The hydrogen ion concentration (pH) primarily affects the degree of ionization of the dye and the

surface properties of the adsorbents. Experiments were carried out at 100 mg/L initial dye concentration with 0.004 g/L adsorbent mass at room temperature (39 ± 1°C) for 3 hour equilibrium time. It is clear from the Fig 1 that for each initial concentration value of Sudan Red G, the percent removal increases as pH rises and after pH 7.0, the percent removal decreases with further increase in pH value. This clearly shows that the optimum pH for the present adsorbate-adsorbent system is 7.0.[17]

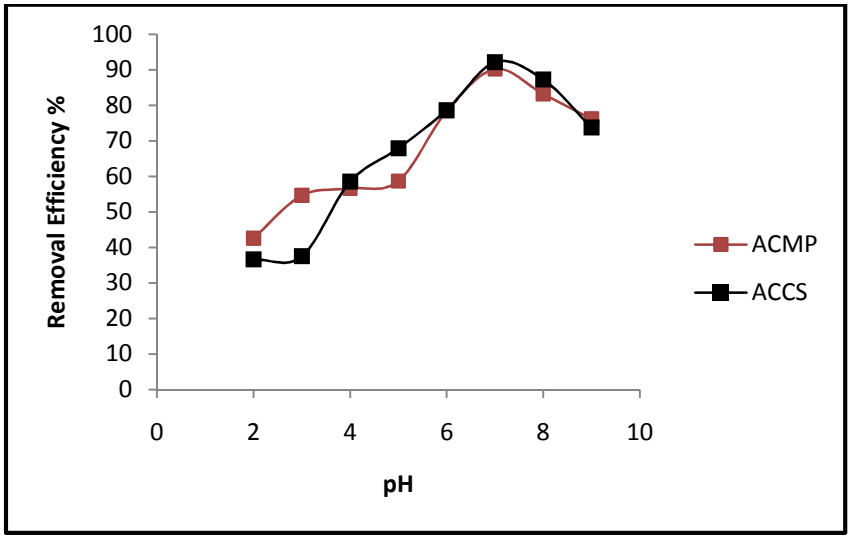

Fig 1 : Effect of pH on Sudan Red G removal

3.5 Adsorption Isotherm:

The experimental data are analyzed according to the linear form of the Langmuir and Freundlich isotherms.

The Langmuir isotherm is represented by the following equation

$$(Ce/qe) = (1/Qob) + (Ce/Qo) \quad \ldots\ldots \quad (1)$$

Here Ce is the equilibrium concentration (mg/L), qe is the amount adsorbed at equilibrium (mg /g). Qo and b is Langmuir constants related to the adsorption efficiency and energy of adsorption, respectively.[18]

The linear plots of Ce/qe versus Ce suggest the applicability of the Langmuir isotherms are given in Figures 2 and 4 for ACMP and ACCS respectively. The values of Qo and b were determined from slope and intercepts of the plots and are presented in Table 7.

Table 7: Langmuir and Freundlich isotherm of activated carbon prepared from ACMP, ACCS for Sudan Red G:

Adsorbents	Longmuir isotherm				Freundlich isotherm		
	Q_0	b	Correlation coefficient (r)	R_L	Intercept (k_f)	Slope (1/n)	Correlation coefficient (r)
ACMP	27.027	0.0400	0,929	0.236	0.246	0.623	0.943
ACCS	25.000	0.0237	0.877	0.3421	0.632	1.062	0.887

The essential characteristics of the Langmuir isotherm can be expressed in terms of a dimensionless constant separation factor RL that is given in Eq.2.

$$R_L = 1 / (1 + bCo) \quad \text{.....} \quad (2)$$

The value of RL indicates the type of the isotherm to be either favourable ($0 < RL < 1$), unfavourable ($RL > 1$), linear ($RL = 1$) or irreversible ($RL = 0$). The value of RL was found to be the values of RL were found between 0 and 1 for ACMP and ACCS suggesting the isotherm to be favourable at the concentrations studied[19].

The Freundlich equation is also employed for the adsorption of Sudan Red G on the ACMP and ACCS adsorbent. The Freundlich isotherm (Freundlich, 1906) is represented as

$$\log qe = \log kf + (1/n) \log Ce \quad \text{……} \quad (3)$$

Here qe is the amount of Sudan Red G dye adsorbed (mg/ g), Ce is the equilibrium concentration of dye in the solution (mg/L) and Kf and n are constants incorporating all factors affecting the adsorption capacity and intensity of adsorption, respectively. Linear plot of log qe versus log Ce shows that the adsorption of Sudan Red G follows also the Freundlich isotherm (Figure 3 and 5 for ACMP and ACCS respectively). The values of Kf and n given in the Table 7. As seen from Table 7, the increase in negative charges on the adsorbent surface that makes electrostatic forces like Vander Waals between the adsorbent surface and dye ion. The molecular weight, size and radii either limit or increase the possibility of the adsorption of the dye onto adsorbent. However, the values clearly show the dominance in adsorption capacity. The intensity of adsorption is an indicative of the bond energies between dye and adsorbent and the possibility of slight chemisorptions rather than physisorption. However, the multilayer adsorption of Sudan Red G through the percolation process may be possible. The 'n' value was 1.6051 and 0.9416 was in between 1 and 10 indicating the adsorption is much more favourable for a selected adsorbents.[20]

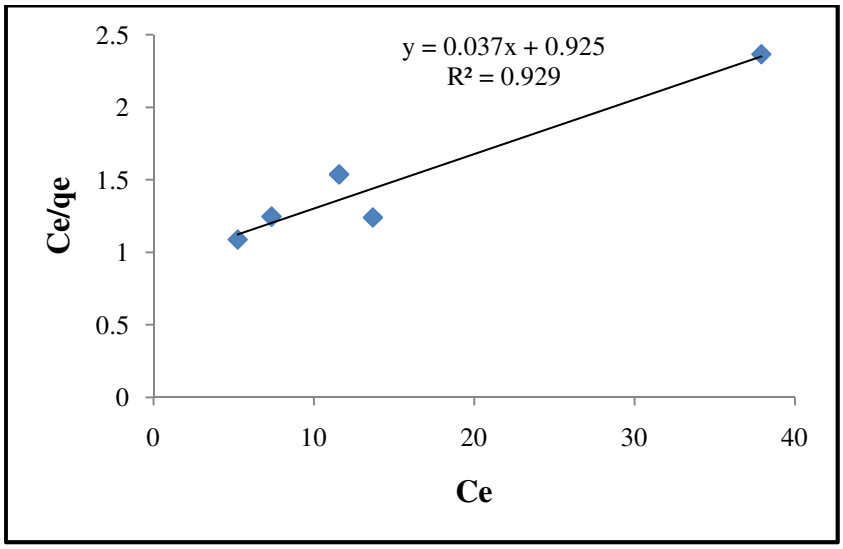

Fig 2: Langmuir isotherm for the removal of Sudan Red G by ACMP

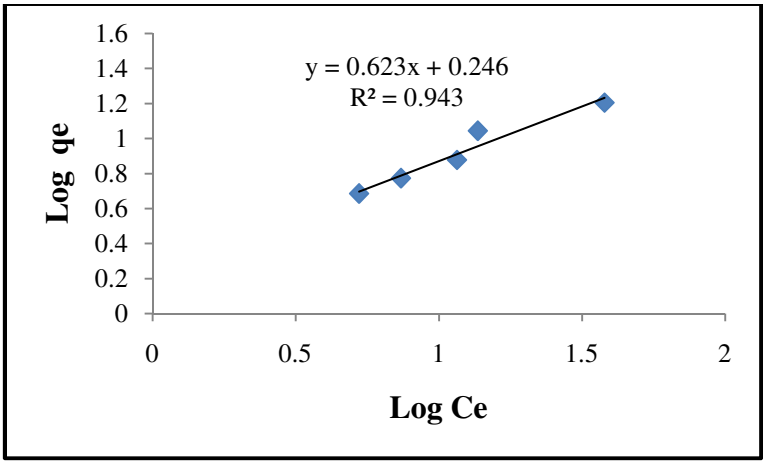

Fig 3: Freundlich isotherm for the removal of Sudan Red G by ACMP

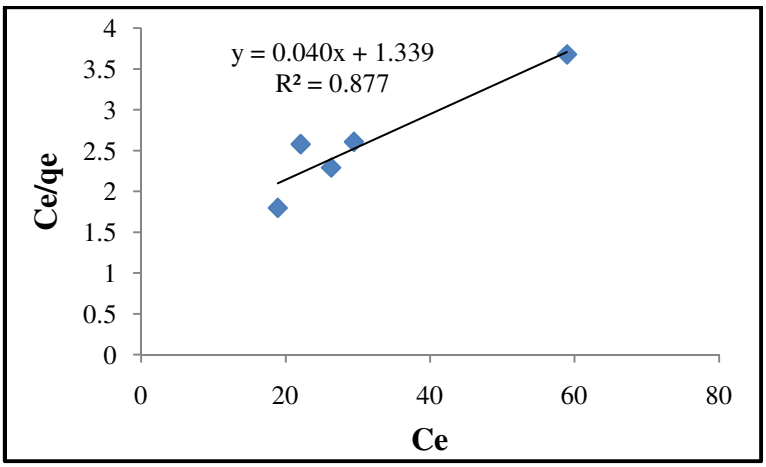

Fig 4: Langmuir isotherm for the removal of Sudan Red G by ACCS

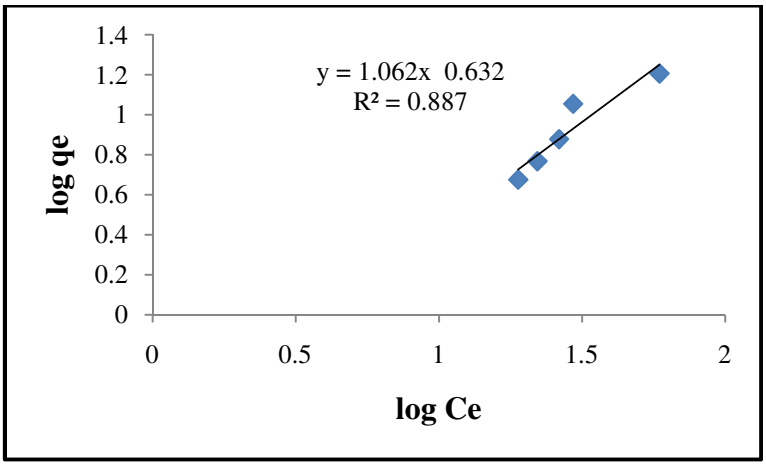

Fig 5: Freundlich isotherm for the removal of Sudan Red G by ACCS

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