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Removal of Coralele Navy Blue 3G Dye from Activated Carbon Synthesized from Paper Mill Sludge

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Abstract: The adsorption capacity of activated carbon synthesized from sludge from paper mills is investigated. Converting of paper mill sludge to adsorbent like activated carbon is a significant process since it decreases environmental problems connected with disposal of waste sludge. The dye (Coralele Navy Blue 3G) adsorption on activated carbon generated from paper mill sludge from synthetic textile waste water (STW) was investigated. The experimental design and data analysis were done using four factors and a full factorial central composite design based on response surface methodology (RSM). Initial dye concentration: 40-120 mg/l, Adsorbent dose: 1-10 gm/l, pH 3-9, and contact time: 0-150 minutes were used as input parameters, with percentage dye removal being the system's reaction. The ideal situation values of operational parameters are found to be initial dye concentration: 80 mg/l, Adsorbent dose: 5.5 gm, Contact time: 150 minutes, and pH: 6. Optimum dye removal is found to be 78.8%. The result indicated that paper mill sludge carbon can be used as an alternative adsorbent for treatment of effluents containing Coralele Navy Blue 3G dye.

I. INTRODUCTION

The presence of dyes in effluents is a cause for concern because of their negative effects on numerous forms of life. Dye emission in nature is a source of concern for both toxicological and aesthetic reasons [1]. Textile, leather, paper, plastics, and other businesses use dyes to achieve a certain aim, and they also use a lot of water. As a result, a lot of shaded wastewater is produced [2]. The shading is thought to have a substantial impact on water quality. Even little amounts of dyes in water – under 1 ppm for a few colours – are extremely noticeable and irritating [3,4]. The most commonly used substance for dyeing cotton, wood, and silk is MB. As a result, both humans and animals suffer from eye burns. It has the ability to move quickly. Various techniques have recently been considered for improving less

expensive and practical adsorbents. A few labourers have proposed a variety of non-regular ease adsorbents, including normal materials, biosorbents, and waste materials from agriculture and industry. These substances could be used as adsorbents to remove colours from an arrangement.

Textile Industries

Among the numerous engineering disciplines, Textile engineering is growing increasingly popular as the textile industry improves. Textile engineering encompasses all aspects of the environment. The textile industry is a large industry that deals with the design and manufacture of cloth and yarn. For fabric manufacture, the textile industry uses a variety of natural and synthetic fibres. The textile

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business often consumes a lot of energy and water. During the manufacturing process, this industry employs a variety of chemicals.

A. The finishing and dyeing activities consume 60% of the industry's resources. The majority of the environmental issues associated with the textile sector are tied to water pollution. The textile industry plays a significant role in the country's economy.

B. Literature Survey

Torregrosa-Macia et al. (2004), provides the impression that a solid adsorbent with a broader pore size distribution can be obtained only through chemical activation. Physical activation improves the pore structure of the adsorbent, while CO/CO₂ causes partial oxidation of the carbonised. [12]

Yadav et al, (2012) studied Activated carbon obtained from the paper industry is used to remove colour from paper mill effluent. The effects of various operating variables such as pH, adsorbent dose, including effect of concentration, solution, contact time, and particle size were studied and investigated for optimum colour removal amounting to 60 minutes of contact time for adsorption equilibrium at a dosage of 2 g/L of activated carbon. The material had a maximum removal capability of 97 percent when adsorbent dosages were increased from 0.5 to 2.0 g/l, and the percentage removal increased from 28 to 97 percent. The removal rate of dye is also improved by reducing the size of the adsorbent material. [13].

II. MATERIAL AND METHODS

A. Chemicals and Glassware

Analytical grade reagents were employed to prepare the solution work, and distilled water was used for research. Corale Navy blue 3G dye was employed for the initial adsorption studies, and zinc chloride was used to chemically activate the adsorbent. Chemicals such as sodium hydroxide and hydrogen chloride were used to change the pH from acidic to basic. These compounds were obtained from the department's laboratory. The Borosil glassware used in the research included beakers, volumetric flasks, conical funnels, pipettes, measuring cylinders, and other items. The glassware was washed numerous times in water before being used, and then washed again in water. After that, distilled water was used for the final rinse.

B. Instrumentation

A rotary shaker was utilised to conduct the adsorption trials. The sludge was mixed with zinc chloride using a magnetic stirrer for activation. An ultraviolet spectrophotometer was used to determine the absorbance. An oven was used to dry the materials. A muffle furnace at 8000 C was employed to carbonise the material. Glass beakers were used to manage the solutions. A digital balance was used to weigh the samples.

C. Preparation of Adsorbent

1.

The material used to prepare activated carbon was collected from the local paper mill.



Fig.2.1 Paper mill sludge

2. The sludge was then dried in oven for 3 days and crushed into smaller size.



Fig.2.2sludgefordrying Fig. 2.3crushedsludge Fig.2.4sievedsludge

3. Zinc chloride was employed to chemically activate the sludge. A magnetic stirrer was used to mix 20 grammes of raw material that had been activated with 0.1 N ZnCL₂. The amount of ZnCL₂ needed to activate the material in a 1:1 ratio was estimated. The slurry was then held at 800 C for 8 hours on a magnetic stirrer.

4. The slurry was filtered out after 8 hours and dried in the oven for 24 hours.

5. The slurry was removed from the oven for pyrolysis after 24 hours. The slurry was held within a muffle furnace at 800 C for 2 hours during pyrolysis. The raw material and ZnCL₂ slurry turned yellow.

6. The carbonization process was carried out with a nitrogen flow rate of 100 cm³/min.

RESULTS AND DISCUSSION

A. Result of proximate analysis of the sludges

From the proximate analysis it was clearly verified that there is an increase in fixed carbon content after activation.

Table 3.1:- Result of Proximate Analysis

Component	Before activation	After activation
Fixed carbon	12.932	18.786

B. Adsorption Studies

1.

Calibration curve of Coralele navy blue 3

G dye

The adsorbance of solutions with concentrations ranging from 40 to 120 mg/l was measured using a UV spectrophotometer. The calibration curve was created by plotting these results, and it was used as a reference for all adsorption calculations throughout the project. The majority of the adsorbance values were maximal at 541 nm, hence this wavelength was used to study all of the adsorbance results.

2.

Parametric Study for the Adsorption of Coralele Navy blue 3G Dye

Various parameters such as initial dye concentration, adsorbent dose, contact time and pH were optimized by using central composite design. It reduced

the experimental work to 30 trials. The results of the trials are shown in

C. Effect of Various Parameters

Based on the adsorption

values obtained using various experimental runs, the effect of different parameters is explained as under:

1. Effect of Contact Time

Figures 3.2, 3.3, and 3.4 depict the effects of altering pH, adsorbent dosage, and beginning dye concentration on the adsorption of coralele navy blue 3G dye, respectively. The adsorption rate increased with the passage of time, as indicated in the graphs. The adsorption percentage increases as the contact period increases from 0 to 150 minutes. At a contact time of 150 minutes, the maximum adsorption was investigated. It was discovered that if the contact period was increased beyond 150 minutes, the

adsorption may be increased even more. There is always a limit to contact duration after which adsorption cannot be enhanced

any further and instead begins to decrease as active sites become saturated over time.

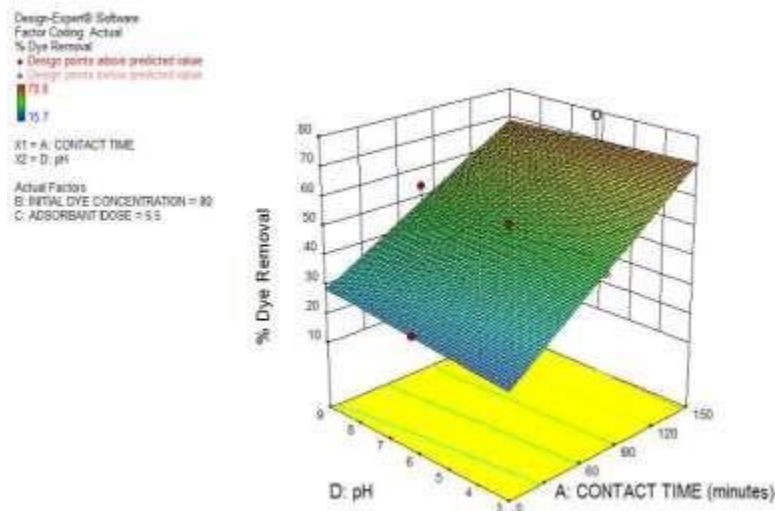


Figure3.2:-
Effect of contact time with change in pH at Adsorbent dosage 5.5g/l and initial dye concentration of 80 mg/l

Figure3.3:- Effect of contact time with change in initial dye concentration at Adsorbent dosage 5.5g/l and pH 6

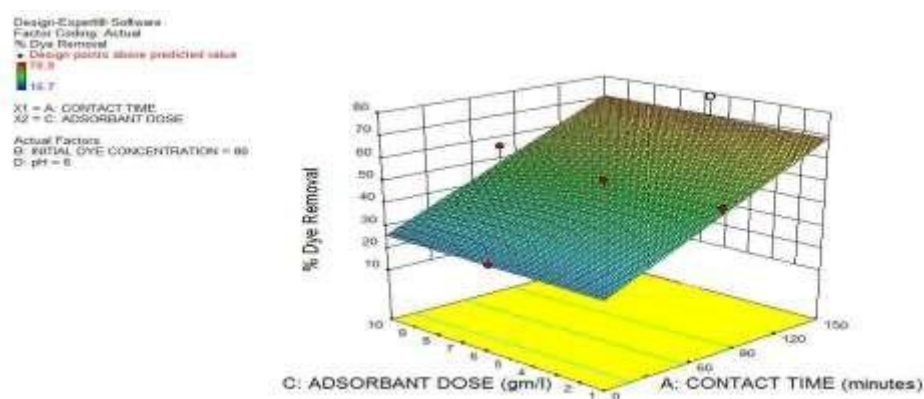
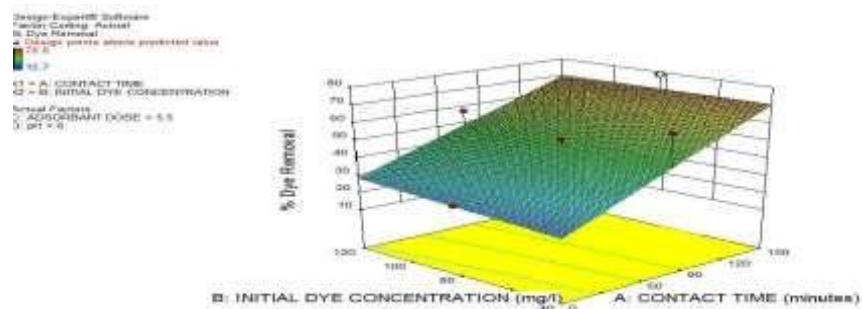
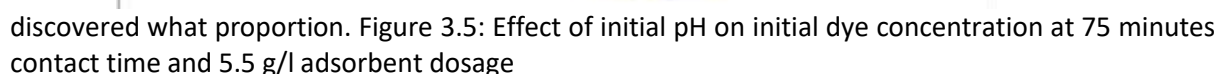


Figure3.4:-
Effect of contact time with change in adsorbent dose at pH 6 and initial dye concentration of 80mg/l

2. Effect of pH of the solution:

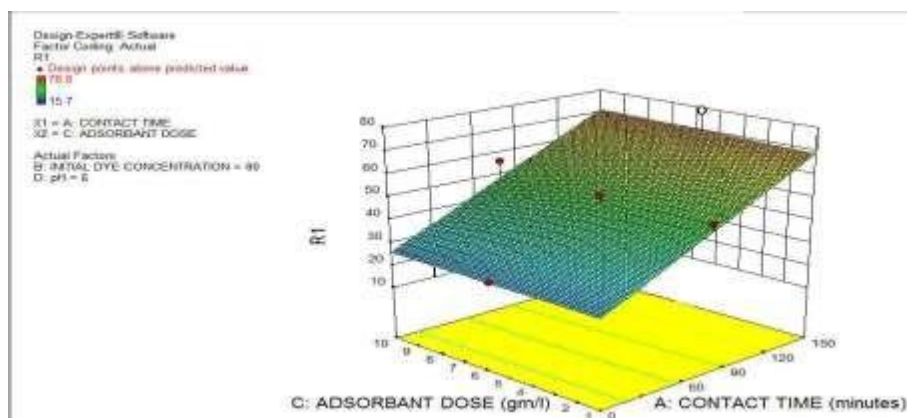
In the experiment, 100 ml dye solutions with different doses of the adsorbent were



Figures 3.8, 3.9, and 3.10 indicate that as the adsorbent dose was raised, the adsorption % increased as well. At 5.5 g/l, dye removal was found to be optimal. After that, the adsorbent dosage has no discernible effect on dye removal. This was due to the fact that as the adsorbent dose was increased, the active sites increased as well, but beyond a certain point, the dye began to fade.



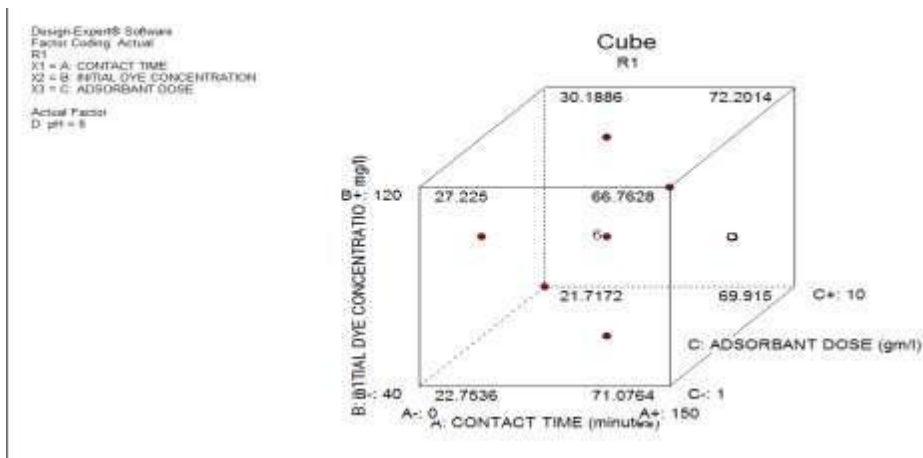
Effect of adsorbent dosage with change in pH at contact time 75 minutes and initial dye concentration of 80 mg



/l.

4. Effect of initial dye concentration

By adjusting the dye concentration from 40 to 120 mg/l, the effect of dye concentration on percentage dye removal was investigated. The dye concentration was found to have a significant impact on dye removal. Figures 3.11, 3.12, and 3.13 show the effect of dye concentration, accordingly. Because a high dye concentration results in a high driving force for mass transfer, the adsorption capacity increases as the initial dye concentration rises. Due to the high concentration of dye, the active sites of the adsorbent are surrounded by a greater number of dye molecules, resulting in more efficient adsorption. The original dye concentration that worked best was 80 mg/l. Cubical representation for effect of contact time, pH and adsorbent dose keeping initial dye concentration of



80 mg/l is shown in Figure 3.14.

Figure 3.14:- Effect of contact time, pH, and adsorbent dose at initial dye concentration of 80 mg/l.

7.6 Optimum parameters

The following are the optimum values for the operational parameters obtained from the central composite design: -

- 150-minute contact time • pH = 6
- 5.5g/l adsorbent dosage
- 80 mg/l initial dye concentration

A verification run was carried out with the optimised set of operational parameters in order to corroborate the outcome obtained through optimization. The expected response was 70.99, but after completing experiments on the identical optimum settings, the actual value was 78.8. Both numbers were found to be fairly close, indicating that the model was successful.

E. Model validation

The reactions of paper mill sludge carbon as an adsorbent for the adsorption of coralele navy blue 3G dye from aqueous solution were measured. The percentage error between the

actual and projected dye removal levels was determined to be less than 10% for each trial, as shown in Table 3.6, which shows the model's validation.

Table3.6:-Centralcompositedesignusedandresponsesofadsorption

S.No.	pH	Contact Time minutes	Adsorbent Dose g/l	Initial Dye Conc. mg/l	%Dye Removal		% error
					Predicted	Actual	
1	3	0	10	40	16.14	15.7	2.79
2	6	75	5.5	80	47.73	51.1	6.60
3	3	0	1	40	16.86	16	5.40
4	9	150	10	120	72.32	67.3	7.45
5	3	150	1	120	64.68	61	6.04
6	6	75	5.5	40	59.37	65	8.67
7	3	0	10	120	22.46	22.3	0.71
8	6	75	10	80	50.51	56	9.81
9	6	75	5.5	80	49.73	51.1	2.68
10	6	75	5.5	80	47.73	51.1	6.60
11	9	75	5.5	80	48.69	54	9.83
12	9	0	1	120	30.41	28.07	8.35
13	9	0	10	40	18.30	18.1	1.09
14	6	75	5.5	80	47.73	51.1	6.60
15	9	0	1	40	21.64	21.02	2.97
16	9	150	10	40	63.29	58	9.13
17	6	0	5.5	80	25.47	25.5	0.11
18	6	75	5.5	80	47.73	52	8.21
19	9	0	10	120	32.92	31	6.19
20	3	150	10	40	75.53	70	7.91
21	9	150	1	120	68.84	64.4	6.90
22	3	150	10	120	72.09	67.83	6.28
23	9	150	1	40	68.82	63.1	9.07
24	6	150	5.5	80	70.99	78.8	9.91
25	3	150	1	40	73.33	68.37	7.26
26	6	75	1	80	46.95	49.86	5.83
27	6	75	5.5	80	47.73	51.1	6.60
28	3	75	5.5	80	46.77	46	1.67
29	3	0	1	120	21.04	20.45	2.86
30	6	75	5.5	120	52.09	57.5	9.40

The above research has potential application because it addresses an environmental issue by adding a new dimension to the disposal of pulp and paper effluent and producing an useful adsorbent from this waste that may be utilised to remove carcinogenic dyes used in textile industries.

CONCLUSIONS

The influence of an industrial waste-based adsorbent, paper mill sludge carbon, on the adsorption of the dye, Coralele navy blue 3G, from aqueous solution was demonstrated in this work. The current study's findings demonstrated that paper mill sludge carbon has the potential to remove Coralele navy blue 3G colour. Various parameters such as contact time, pH, adsorbent dosage, and starting dye concentration were investigated. The reaction conditions were optimised using a central composite design. pH was set to 6, contact period was set to 150 minutes, adsorbent dose was set to 5.5g/l, and the starting dye concentration was set to 80 mg/l. The dye removal rate was found to be 718.8% under these conditions. The central composite design has proven to be a success.

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