ADSORPTIVE REMOVAL BRILLIANT GREEN ONTO CARBONISED *AEGLE MARMELOS*

L. S. YADAV, A. KUMAR

Abstract**—** A laboratory prepared granular adsorbent was used to remove dye, brilliant green (BG) from aqueous solution. The Taguchi method was applied as an experimental design to establish the optimum conditions for the removal of brilliant green in batch experiments. The orthogonal array L_{25} and the larger the better response category were selected to determine the optimum removal conditions.

Keywords**—***Aegle marmelos*, Brilliant green, Taguchi, Orthogonal array.

I. INTRODUCTION

INDUSTRIAL effluents containing dyes are very difficult to treat using conventional treatment methods [1]. Although many methods have been used for the removal of dyes [2]. In the present scenario, the use of low cost adsorbents has been employed successfully for the removal of pollutants from water.

The purpose of this study is to optimize the adsorption of brilliant green onto laboratory prepared low cost adsorbent employing Taguchi statistical method and to identify the contribution for each parameter. The chosen experimental factors and their ranges in the present work were: pH (2–10), temperature (40–60◦C), time of contact between adsorbent and brilliant green (5–500 min) and concentrations of the aqueous brilliant solution (10–500 mg/l).

II. MATERIALS AND METHODS

The adsorbent prepared from *aegle marmelos* was used in the present work [3]. The BG dye was used as an adsorbate. An accurately weighed quantity of the BG was dissolved in distilled water to prepare a stock solution. Experimental solutions of the desired concentrations were obtained by successive dilutions with distilled water. Concentrations of BG dye were determined by finding out the absorbance at the characteristic wavelength using a UV-spectrophotometer. [4].

For each experiment, 50 ml of dye solution of known C_o and a known amount of the adsorbents were taken in a 100 ml air-tight conical flask with a glass stopper. These mixtures were agitated in a temperature-controlled shaking water bath at a constant shaking speed of 250 rpm. The uptake q_t (mg/g) of BG by *aegle marmelos* at any time, *t* was calculated as:

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$$q_t = \left(\frac{C_o - C_t}{w} \right) V \quad (1)$$

Where C_o is the initial adsorbate concentration (mg/l), V the volume of the wastewaters in the flask (l), C_t the adsorbate concentration (mg/l) after t time, and w the mass of the adsorbent (g) used in the experiment.

Taguchi method uses the signal/noise (S/N) ratio to measure the quality characteristic deviating from the desired value. The experimental conditions having the maximum S/N ratio is considered as the optimal condition and the variability characteristics are inversely proportional to the S/N ratio. [5]-[7].

III. RESULT AND DISCUSSION

The objective of experiment is to optimize parameters to get higher uptake of BG onto *aegle marmelos*; the higher the better characteristics are used. Table 1 shows the actual data for BG uptake with computed S/N ratio. Whereas Table 2 show the mean S/N ratio for each levels of BG uptake. These data were then plotted as shown in Fig. 1.

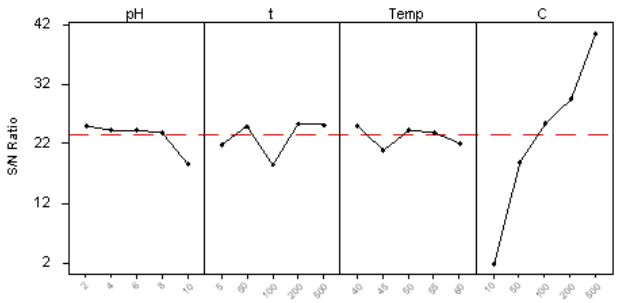

Fig.1. S/N graph for BG uptake onto *aegle marmelos*

TABLE 1
EXPERIMENTAL RESULTS FOR BG UPTAKE ONTO *AEGLE MARMELOS* AND CORRESPONDING S/N RATIO

1	pH	t	Temp	C	qe	S/N Ratio
2	2	5	40	10	2.177	6.7562
3	2	50	45	50	11.889	21.5028
4	2	100	50	100	12.592	22.0017
5	2	200	55	200	49.675	33.9227
6	2	500	60	500	112.234	41.0025
7	4	5	45	100	21.068	26.4724

8	4	50	50	200	36.438	31.2310
9	4	100	55	500	79.112	37.9649
10	4	200	60	10	2.018	6.0988
11	4	500	40	50	10.552	20.4667
12	6	5	50	500	112.098	40.9920
13	6	50	55	10	2.080	6.3632
14	6	100	60	50	7.100	17.0251
15	6	200	40	100	20.231	26.1205
16	6	500	45	200	38.144	31.6285
17	8	5	55	50	5.500	14.8080
18	8	50	60	100	19.075	25.6093
19	8	100	40	200	36.231	31.1815
20	8	200	45	500	112.098	40.9920
21	8	500	50	10	2.216	6.9118
22	10	5	60	200	10.713	20.5985
23	10	50	40	500	111.625	40.9552
24	10	100	45	10	0.171	-15.3459
25	10	200	50	50	11.120	20.9223
26	10	500	55	100	22.576	27.0731

A. Analysis of the S/N ratio

In the Taguchi method, the term 'signal' represents the desirable value (mean) for the output characteristic and the term 'noise' represents the undesirable value (standard deviation (S. D)) for the output characteristic. Therefore, the S/N ratio is the ratio of the mean to the S.D. Taguchi uses the S/N ratio to measure the quality characteristic deviating from the desired value. There are three categories of quality characteristics, i.e. the-lower-the-better, the higher- the-better, and the-nominal-the-better. To obtain optimal removal performance, the-higher-the-better quality characteristic was selected [8]. The S/N ratio Y is defined as

$$Y = -10\log\left[\frac{1}{n}\left(\sum_{i=1}^{n}\frac{1}{y_i^2}\right)\right] \quad (2)$$

Where, n is the number of tests and y_i is the comparison variables in the i th experiment.

Taguchi recommends analyzing the means and S/N ratio using conceptual approach that involves graphing the effects and visually identifying the factors that appear to be significant, without using ANOVA, thus making the analysis simple [9].

Table 1shows the experimental results for BG removal and the corresponding S/N ratio using eq 2. The mean S/N ratio for each level of parameters used in the present study is summarized in table 2 and called the S/N response table. In addition, the total mean S/N ratio for the 25 experiments is also calculated and listed in same table. Fig. 1, the S/N response graphs can be shown for BG uptake onto *aegle marmelos*. As shown in eq. (2), the greater is the S/N ratio, the smaller is the variance of BG uptake around the desired (the-higher-the-better) value. However, the relative importance amongst of the process parameters for BG uptake still needs to be known so that optimal combinations of the process parameter levels can be determined more accurately.

TABLE 2
RESPONSE TABLE FOR AVERAGE S/N RATIO FOR CR UPTAKE

Level	pH	t	T	C_o
1	25.04	21.93	25.09	2.16
2	24.45	25.14	21.05	18.95
3	24.43	18.57	24.42	25.46
4	23.90	25.62	24.03	29.72
5	18.84	25.42	22.07	40.39
Delta	6.20	7.04	4.05	38.23
Rank	3	2	4	1

B. Analysis of variance

The purpose of the analysis of variance (ANOVA) is to investigate which design parameters significantly affect the quality characteristic. Statistically, The *F* value for each design parameter is simply the ratio of the mean of squared deviations to the mean of squared error. Usually, when *F*>4, it means that the change of the design parameter has a significant effect on the quality characteristic [10].

TABLE 3
ANALYSIS OF VARIANCE (ANOVA) FOR QE USING ADJUSTED SUM OF SQUARES (SS) FOR TESTS

Source	DF	Seq. SS	Adj. SS	Adj. MS	F	P
pH	4	217.4	217.4	54.4	0.49	0.744
t	4	510.6	510.6	127.7	1.15	0.400
T	4	158.7	158.7	39.7	0.36	0.832
C	4	34895.8	34895.8	8724.0	78.53	0.000
Error	8	888.8	888.8	111.1		
Total	24	36671.3				

Table 3 shows the results of ANOVA for BG uptake onto adsorbents used in the present work. Concentration of BG is the significant parameter. Therefore, based on the S/N and ANOVA analysis, the optimal parameters for BG uptake were obtained. The optimal removal condition for maximum BG uptake was obtained as follows: pH=2, time=50, Temperature=60°C and BG concentration =500.Once the optimal level of the design parameters has been selected, the final step is to predict and verify the improvement of the quality characteristic using the optimal level of the design parameters.

The estimated S/N ratio using the optimal parameters for BG uptake can then be obtained and the corresponding to concentration can also be calculated by using eq 2. The comparison of the predicted BG uptake with the actual BG uptake using the optimal BG removal parameters indicating good agreement between the predicted and actual BG uptake being observed.

IV. Conclusion

The following conclusion can be drawn from the present study

- The high uptake of BG onto laboratory prepared adsorbents proves the efficacy of *aegle marmelos*.
- Higher the F value more the predominating factor in the BG uptake process.

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