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OPTIMIZATION OF PROCESS PARAMETERS FOR BRILLIANT GREEN REMOVAL

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ABSTRACT

The Taguchi method was used as the experimental design to determine the optimum conditions of BG removal onto RHA from aqueous solution. The experimental conditions were studied in the range of 2-10 for pH, 5-500 min for time (t), 40-60 ^{o}C for temperature (T), and 10-500 mg/l initial adsorbate concentration (C_o). Orthogonal array (OA) L_{25} (5^4) consisting of four parameters with five levels was chosen. The total optimum purification conditions obtained from this study were pH=6, t= 5, T= 50 and C_o= 500, respectively.

Keywords: *Brilliant green, Adsorption, Taguchi, Rice husk ash*

1. INTRODUCTION

Brilliant green (BG) dye is used for the production of cover paper in the paper industry. About 0.8-1.0 kg of BG is consumed per ton of paper produced. However, BG dye causes irritation to the gastrointestinal tract, symptoms may include nausea, vomiting and diarrhea. It may cause irritation to the respiratory tract; symptoms may include coughing and shortness of breath. BG containing effluents are generated from textiles, printing and dyeing, paper, rubber, plastic industries, etc Mane et al. 2007 [1]. Adsorption on activated carbon has been found to be an effective process for dye removal, but it is

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too expensive. Consequently numerous low cost alternatives have been proposed elsewhere Garg et al. 2003 [2]. Taguchi method has been shown to be an effective means for the improvement of the productivity in the research and development stage, so that high quality items can be produced quickly at low cost. It has found much application in a wide range of industrial fields all over the world because of its universal applicability to all engineering fields Copur et al. 2003 [3].

In this work, the influences of process variables such as dye concentration, pH, temperature and contact time were investigated using an L_{25} (5^4) orthogonal array for the adsorption of Brilliant green (BG) onto rice husk ash (RHA).

2. MATERIAL AND METHODS

The BG stock solution was prepared in double-distilled water. All the test solutions were prepared by diluting the stock with double- distilled water. Spectrophotometrically calibration curve was plotted between absorbance and concentration of the standard dye solution. Rice husk ash (RHA) was used as an adsorbent. Batch adsorption experiments were carried out as per Taguchi orthogonal array L_{25} (5^4) [Table 1] to elucidate the effect of pH, contact time, temperature and adsorbate initial concentration for BG removal onto RHA. The dosage of RHA was kept constant in all the experiments. The uptake of BG onto RHA was determined by following equation

$$q_e = (C_o - C_e)V/w$$

Where, q_e is the amount of dye adsorbed per unit weight of activated red mud (mg/g); C_o the initial concentration of BG (ppm); C_e the concentration of BG in solution at equilibrium time (ppm); V the solution volume (l); w is the activated carbon dosage (g).

3. RESULT AND DISCUSSION

The experimental data were analyzed by Minitab software to evaluate the effect of each parameter on the optimization criteria. Table 1 shows the results and corresponding calculated S/N ratio data for BG removal onto RHA based on L_{25} (5^4) matrix design. To use the S/N ratio for the optimal removal performances, S/N calculation was performed to maximize BG uptake.

The adsorbate initial concentration had the most important effect on the BG removal process, because, with the increase of the BG concentration in aqueous solution, the rate of removal of BG is increased.

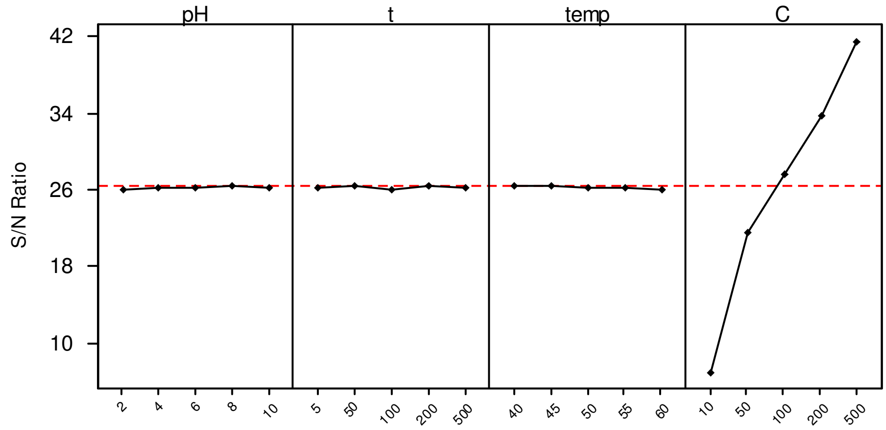

Fig.1. S/N plot for BG removal onto RHA

The results also showed that at high temperature (60°C), reduces the rate of BG removal. It is desired that low temperatures must be selected for higher removal. From Fig. 1 Contact time between adsorbate and adsorbent shows that there is not enough fluctuation in S/N ratio, so it provides flexibility for selecting contact time. If the experimental plan given in Table 1 be studied carefully. It can be observed that the conditions corresponding to optimum conditions for highest BG uptake onto RHA and these are pH=6, t= 5, T= 50 and C_o= 500.

The degrees of the influences of parameters on BG removal are given at the graphs in Fig.1. The optimal level of a process parameter is the level with the highest S/N ratio. At first sight, it is difficult and complicated to deduce the experimental conditions for the data given in figure. Let us consider with parameter pH. Now, let us try to determine the experimental conditions for the first data point. The pH for the serial no 1-5 is 2. The experimental conditions for the second data point 5-10, are those for which its pH is 4 (i.e. experiments nos. 4, 7, 9, 16, and 22), and so on. The numerical value of the maximum point in each graph marks the best value of that particular parameter (Table 1).

The results of analysis of variance (ANOVA) are given in Table 2. Statistical analysis of variance was performed to check whether the process parameters are statistically significant or not. The *F*-value for each process parameter indicates which parameter has a significant effect on the BG removal and is simply a ratio of the squared deviations to the mean of the squared error. Usually, the larger the *F*-value, the greater the effect on the BG removal. Optimal conditions for the process parameters can be predicted using ANOVA analysis and performance characteristics. The results of ANOVA analysis for the removal of BG onto RHA is given in Table 2. Larger the F-value more is the effective parameter in the BG uptake. The sequential order of the process variables is Co>T>t>pH for BG removal onto RHA.

Table1. S/N ratios for BG-RHA system

S. No	pH	t	temp	C	qe	S/N ratio
1	2	5	40	10	2.35	7.42
2	2	50	45	50	12.24	21.76
3	2	100	50	100	22.64	27.10
4	2	200	55	200	49.69	33.93
5	2	500	60	500	110.44	40.86
6	4	5	45	100	24.58	27.81
7	4	50	50	200	49.48	33.89
8	4	100	55	500	112.70	41.04
9	4	200	60	10	2.20	6.85
10	4	500	40	50	12.19	21.72
11	6	5	50	500	124.47	41.90
12	6	50	55	10	2.21	6.88
13	6	100	60	50	11.89	21.50
14	6	200	40	100	24.83	27.90
15	6	500	45	200	49.40	33.87
16	8	5	55	50	11.97	21.56
17	8	50	60	100	24.72	27.86
18	8	100	40	200	49.33	33.86
19	8	200	45	500	124.34	41.89

20	8	500	50	10	2.25	7.06
21	10	5	60	200	46.81	33.41
22	10	50	40	500	124.01	41.87
23	10	100	45	10	2.25	7.03
24	10	200	50	50	12.34	21.83
25	10	500	55	100	24.75	27.87

Table 2. Analysis of Variance (ANOVA) for q_e, using Adjusted SS for Tests

Source	DF	Seq. SS	Adj. SS	Adj. MS	F	P
pH	4	40.4	40.4	10.1	1.07	0.431
t	4	42.7	42.7	10.7	1.13	0.407
temp	4	47.2	47.2	11.8	1.25	0.364
C	4	43949.2	43949.2	10987.3	1164.73	0.000
Error	8	75.5	75.5	9.4		
Total	24	44154.9				

4. CONCLUSION

The objective of experiment was to optimize parameters to get higher uptake of BG onto RHA; the higher the better characteristics were used. Table 1 shows the actual data for BG uptake with computed S/N ratio. The optimum conditions for BG uptake onto RHA obtained are pH=6, t= 5, T= 50 and C_o= 500.

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