Response Surface Optimization for an Eradication of Dye onto Ground Nut Shell

R. Mandapati, T. Subbaiah, V. Ponnam, H. Gunti*

Abstract*: The present investigation focuses on an effective dye expulsion in distinction to deliquescent solution using an agricultural dissipation adsorbent. Experiments were conducted on a survey of groundnut shell for sorption of Congo red dye. Several criterions comparatively adsorbate concentration, adsorbent loading, pH, and agitation time effects deliberated by conducting batch studies. Central composite design in Response surface methodology was correlated for optimized process parameters. Interaction effects of both adsorbate and adsorbent were studied with the help of Analysis of Variance.

***Keywords*: Groundnut shell, Congo red dye, Response surface methodology, Central composite design, ANOVA, Optimization.**

I. INTRODUCTION

Dyes separation from an effluent streams stood as a challenging task for industries like pharmaceuticals, food, paper, textile, cosmetics leather and plastic. These effluents play a prominent role in high toxicity of aquatic species and rise as more effective one for survival process with reduction of photosynthetic activity [1, 2]. Human beings get allergies, eye irritations and cancer by the discharge of dyes into water streams. Techniques used in general for the removal of dyes are expensive with a huge amount of sludge with an impact to environmental problems. Bioosrption method was opted in this study due to it is cheap, efficient, simple and easy to run [3-5].

(-N=N-) group attached to aromatic rings helps in the characterization of azo dyes structure. Congo red endures as frequently utilized dyestuff; comprehend to human mutagen entity [6-8]. Due to adhesion properties and low cost it is used extensively in dye industry [9-10]. Various materials are used as adsorbents for dye removal.

The present study focuses on Congo red sorption against deliquescent solution using groundnut shell.

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II. MATERIAL AND METHOD

A. Chemicals

The entire chemicals utilized here are of analytical grade. Congo red (CI = 22120), HCl and NaOH was asset in distinction to Sigma Aldrich.

B. Instrumentation

Spectrophotometer (model: SS5100H; premier color scan instruments) at a wavelength of 490nm was used for dye concentrations. The sorption studies were performed in D Lab orbital shaker Model SK-0330-Pro. Solution pH was checked with Sartorious PB-11 pH meter. Contech weighing balance-0.001g accuracy was used for biomass weighing. Biomass was dried in lab oven (kemi).

C. Biosorbent

Adsorbent-groundnut shells were collected from Guntur District, Andhra Pradesh, India. The groundnut shells were rinsed several times with water to avoid dust, color and other substances. Wet biomass was sundried for 3-4 days for avoiding moisture content. The dried samples were crushed with roll crusher and sieved with 150 mesh size sieve. Sieved biomass samples were packed in a polythene bags in order to prevent from bound moisture.

D. Preliminary design: Central composite design

The influence of operative criterions such as adsorbate concentration, adsorbent loading, pH and agitation time for biosorption process was identified as well as examined for single response. The range of four parameters was shown in Table 1. At present Central composite design (CCD) in response surface methodology (RSM)-opted considering Congo red solutions removal effectively. With the selection of factorial experimental design as 2^4, the obtained results were of 26 experimental runs with 6-central points. Experimental design was studied using Design expert 11 software.

Table 1: Operational parameters range

Parameters	Range
Dye concentration (A)	20-100 mg/l
Adsorbent dose (B)	0.1-5 g
pH (C)	3-10
Agitation time (D)	1-120 min

E. Biosorption experiments

Experiments were opted contemporary batch mode. Stock solution of 100 mg/l and synthetic solutions (20-100 mg/l) endures by dissolving

Congo red dye using deionized water. Solutions pH adjustment with 0.01M HCl/NaOH. Assimilation of adsorbent-adsorbate was transferred to Erlenmeyer bottle which was filed in shaking incubator for a period of equilibrium-120 min; 180rpm. Samples do aseptic at predetermined interval, filtered through a whattman paper. Congo red solution analysis performed using spectrophotometer considering absorbance wavelength of 497 nm. Percentage evacuation rest in Eq.1

$$\% \text{ Removal} = \frac{(C_i - C_f)}{C_i} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

Where C_i is initial concentration

C_f is final concentration

III. RESULT AND DISCUSSION

The suggested model for sorption of Congo red solution using central composite design was Quadratic model with a sequential p-value of < 0.0001, lack of fit p-value of 0.6104, R^2 value of 0.9912. The equation representing quadratic model was shown in Eq.2

$$\% \text{ Removal of dye} = 88.53 - 4.47 * A + 12.37 * B - 1.33 * C + 5.60 * D - 1.58 * AB + 0.6744 * AC - 3.08 * AD - 0.8556 * BC + 6.89 * BD + 0.0669 * CD - 4.19 * A^2 - 7.62 * B^2 - 1.96 * C^2 - 12.79 * D^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

A. Analysis of Variance for quadratic model

Table 2: Analysis of variance, significance test

Source	Sum of squares	Df	Mean square	F-Value	P-Value	
Model	8071.98	14	576.57	88.86	<0.0001	Significant
A-dye concentration	332.95	1	332.95	51.31	<0.0001	
B-adsorbent dose	2555.47	1	2555.47	393.83	<0.0001	
C-pH	29.34	1	29.34	4.52	0.0569	
D-agitation time	522.98	1	522.98	80.60	<0.0001	
AB	39.72	1	39.72	6.12	0.0309	
AC	7.28	1	7.28	1.12	0.3123	
AD	152.09	1	152.09	23.44	0.0005	
BC	11.71	1	11.71	1.81	0.2061	
BD	758.86	1	758.86	116.95	<0.0001	
CD	0.0716	1	0.0716	0.0110	0.9183	
A^2	242.84	1	242.84	37.42	<0.0001	
B^2	802.51	1	802.51	123.68	<0.0001	
C^2	53.38	1	53.38	8.23	0.0153	
D^2	2262.02	1	2262.02	348.60	<0.0001	
Residual	71.38	11	6.49			
Lack of Fit	34.89	6	5.82	0.7969	0.6104	not significant
Pure Error	36.49	5	7.30			
Cor Total	8143.36	25				

The model F-value of 88.86 resulted as significant. By virtue of noise instance, a contingent of assimilating 0.01 % F-value. P-values < 0.0500 imply significant illustrative denomination. A, B, D, AB, AD, BD, A^2, B^2, C^2, and D^2 resulted as significant terms. The lack of fit F-value-0.080 resulted as non significant model term in pertinent to pure error. According to fit statistics obtained R^2 value is 0.9912. In this case predicted R^2 (0.9502) is amity with adjusted R^2 (0.9801) and only difference between these two are <0.2. The conspiracy of normal residuals and actual vs predicted values were shown in Fig 1. The predicted values are mostly coinciding with actual values. 3-D surface plots for adsorption of dye onto groundnut shell was shown in Fig.2

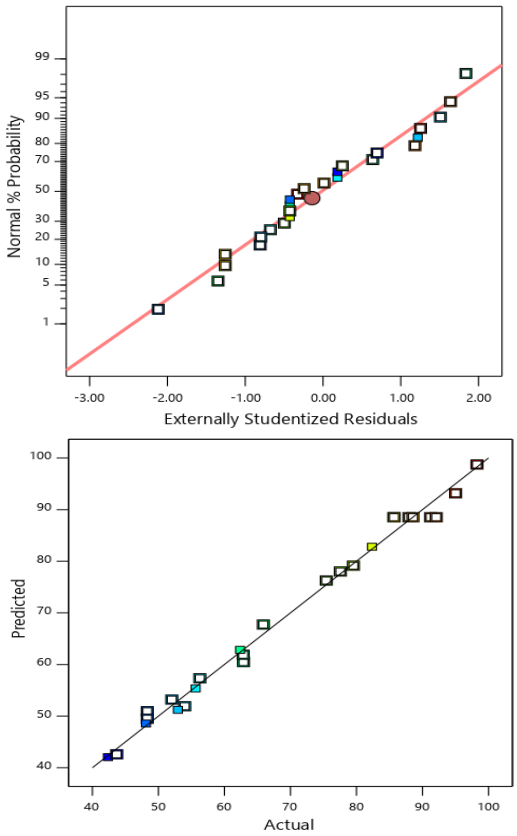

Fig.1 Diagnostics plots

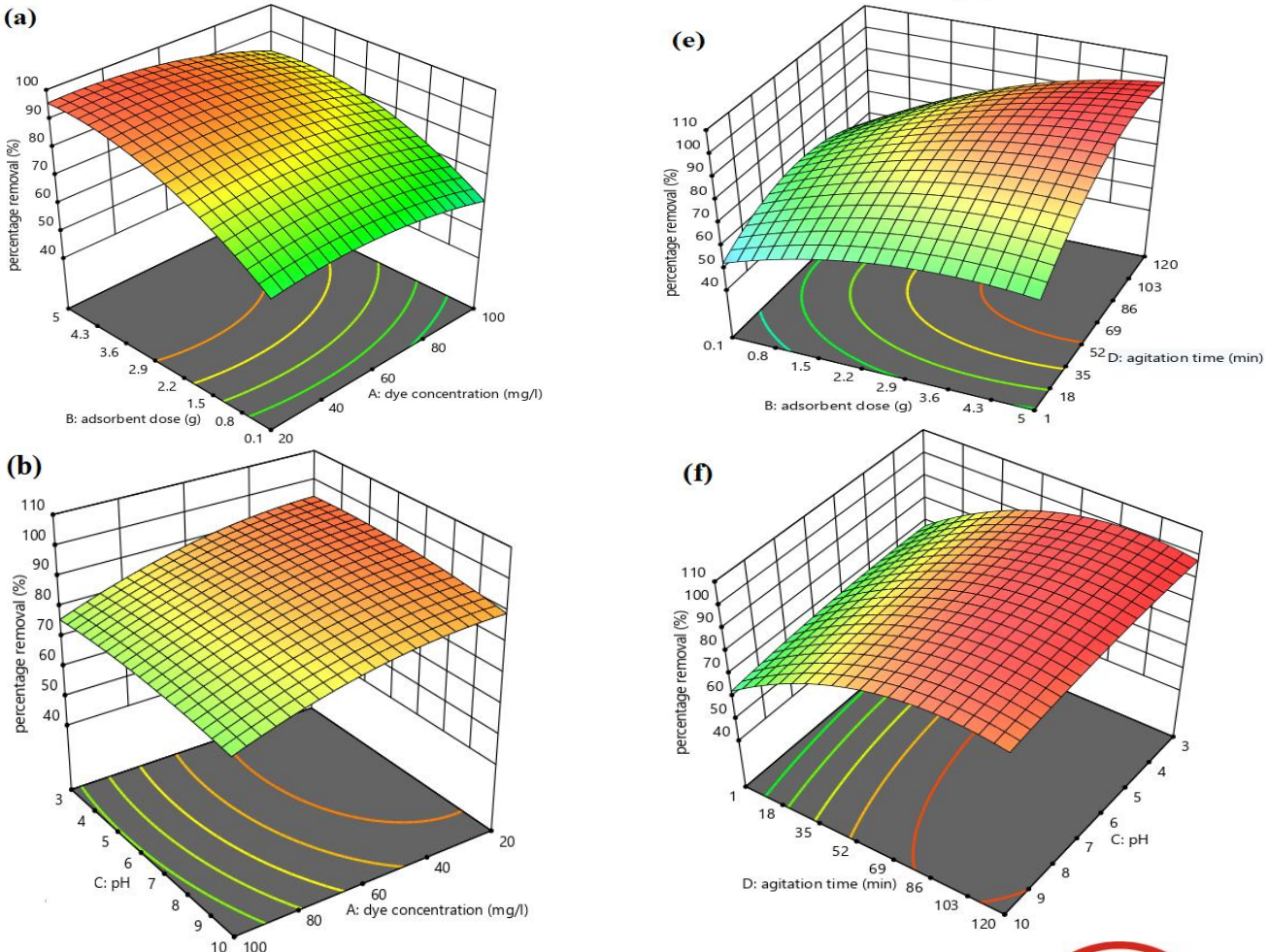

Fig.2 Response surface plots for Congo red dye removal

The optimized conditions with desirability of 0.93 for the sorption of Congo red solutions on to groundnut shell are shown in Fig.3.

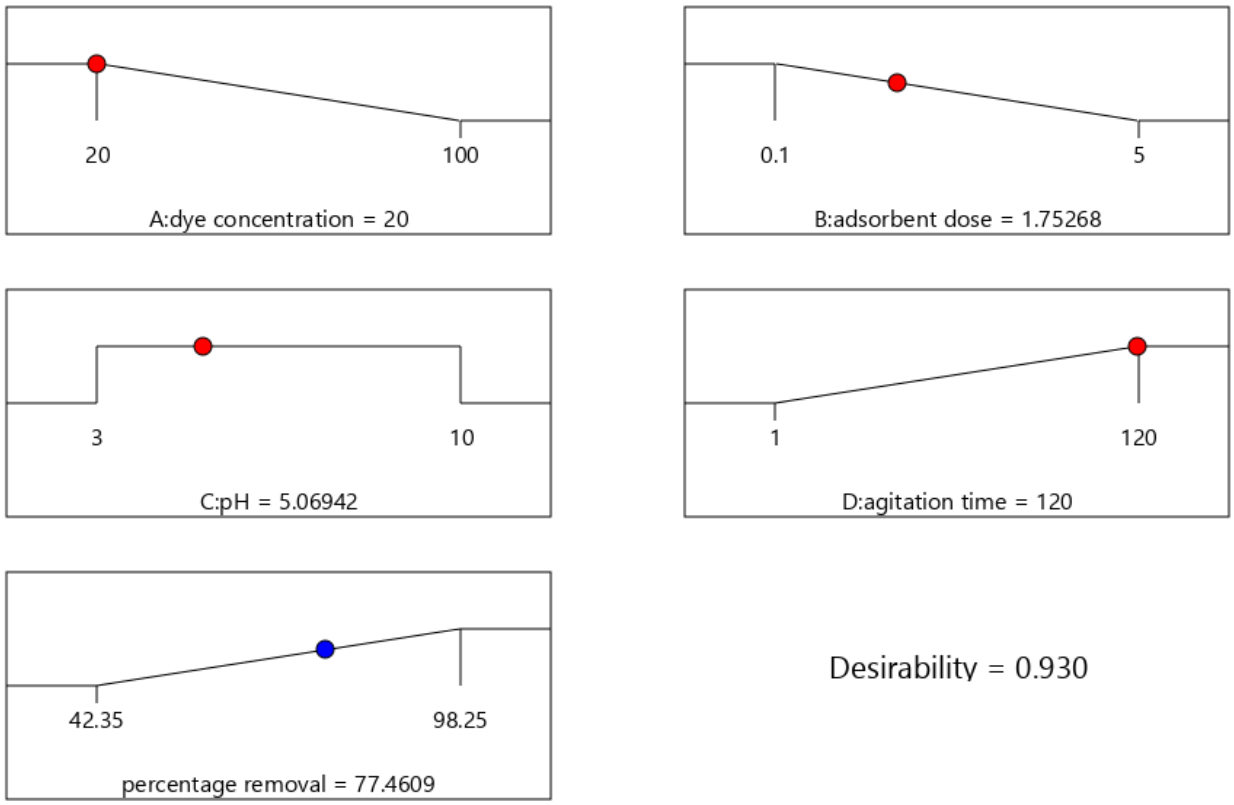

Fig.3 Desirability ramp for optimization of 6 goals

IV. CONCLUSION

In this work a waste product from groundnuts was opted as peculiar adsorbent for Congo red sorption from deliquescent solutions. The obtained R^2 value was 0.9912.The maximum percentage removal was observed as 98.25%. The preliminary conscience was mostly coinciding by predicted values. The optimum conditions using central composite design for dye sorption were observed as dye concentration-20 mg/l; adsorbent dose-1.75 g; pH-5.06; agitation time-120 min and percentage removal of 77.46%. the desirability value was 0.93.

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