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Studies for removal of Alizarine cyanine Green dye from Aqueous Solution by sorption using Hypnea Valentiae red algae powder

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***Abstract*— The three important environmental factors for humans are Air, Food and Water, and food which are being polluted and require special attention for their originality, which must be restored. The operating parameters used in this experiment are agitation time, the size of the biosorbent, the pH of the solution, the initial concentration of the solution, the dosage of the biosorbent, and the temperature of the solution. The use of Hypnea valentiae red algae powder as a potential biosorbent for the removal of Alizarine cyanine green dye was the subject of the current study. The Central composite desing was used for optimization The ideal size of biosorbent is 53 µm, pH was gotten at 5.0 and introductory centralization of AG dye is 20 mg/L were looked at utilizing each consider turn with CCD. The energy and isotherm studies are likewise concentrated alongside thermodynamic review.**

***Index Terms*—Time, pH, Concentration, Temperature, RSM, CCD**

I. INTRODUCTION

Overuse of water resources, unplanned urbanization, and growing industrialization are all contributing factors to the everyday degradation of water quality. Major contaminants found in wastewater discharge that disrupt the aquatic ecosystem include metal ions and various forms of colors.

In order to prevent pollution of the marine environment and ecosystem, dyes—colored compounds—used to color fabrics, wools, and fiber from a variety of sectors, including textile, food processing, ink, cosmetics, pharmaceutics, printer inks, leather, and plastics manufacturing must be removed after use.

Enough water is necessary for both the evolution of normal biological systems and the advancement of humans. Overexposure to dyes can lead to respiratory issues, skin irritation, and in certain cases, an increased risk of cancer in humans.

Therefore, it is crucial to successfully remove color from wastewater to ensure that treated wastewater is safely released into streams. The issue of modern profluent pollution is growing more and more problematic for the climate, especially in developing countries. Industry has a significant impact on water supplies, and effective contamination insurance solutions are necessary to prevent the degradation and ruin of these resources. As current duties evolve, the material and coloring companies contribute to the global expansion of natural pollution.

In the pecking order, ecological hues bio magnify and develop in the tissues of both persons and organisms. Generally speaking, there is no special way to get rid of colors that, once identified, continue to circle about in the atmosphere at steadily rising focal points. The expanded modern movement brought about by the modern transition led to the introduction of synthetic materials and colors, which pose risks to the health of humans and the environment.

II. PROCEDURE FOR EXPERIMENTATION

A. Materials

Analytical grade reagents, including the color, were utilized without further purification. A precisely weighed amount of the dye was dissolved in distilled water to create a stock solution with a mass of 1000 mg L–1. The dye stock solution was then diluted with distilled water to get the working solutions at the appropriate concentrations. 0.1 M HCl and 0.1 M

NaOH solutions were used to change the initial pH of the solutions.

B. Biosorption Studies

In 250 mL conical flasks with 50 mL of the total working volume, batch biosorption studies were carried out with varying starting Alizarine cyanine green dye concentrations from 20 to 200 mg L–1 at pH 2–8 and Hypnea valentiae powder concentrations of 0.5–4 g L–1. After that, the flasks were stirred at room temperature at °C for 5 to 180 minutes. At regular intervals, a part of the samples were taken and centrifuged. The dye's equilibrium concentration was measured at 460 nm using a UV–vis spectrophotometer.

III. RESULTS AND DISCUSSION

3.1Effect of agitation time:

Plotting the percentage biosorption of Alizarine cyanine green hue against fomentation duration in Fig. 1 for disturbing periods 5 to 180 min. did not definitively establish the harmonious turmoil. Nine percent, or 0.18 mg/g, of the green dye Alizarine Cyanine is absorbed in the first five minutes for every 10 g/L of 53 m-sized biosorbents. Up to 30 minutes, the biosorption percentage increases steadily until it reaches 60% (1.2 mg/g) [1].

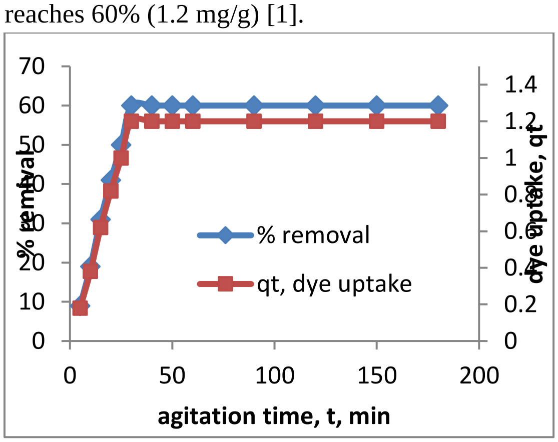

Fig.1 Effect of agitation time on % biosorption of Alizarine cyanine green dye

3.2 Effect of biosorbent size:

The results are displayed in Fig. 2, where the green hue represents the rate of biosorption of Alizarine Cyanine as a function of biosorbent size. The proportion of biosorption drops from 60% to 40% when the biosorbent size grows from 53 to 152 m. The number of active sites in the biosorbent is therefore better exposed to the biosorbent. [2].

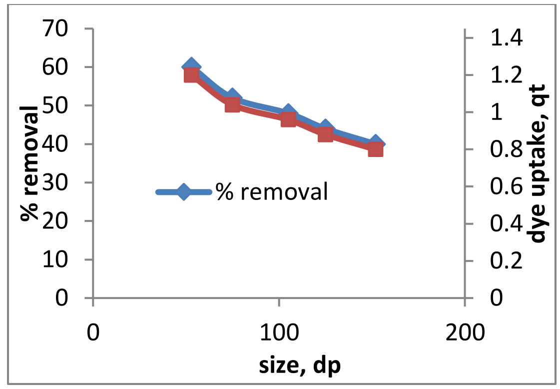

Fig.2 Variation of % biosorption with biosorbent size

3.3 Effect of pH:

In the current study, 10 g/L of 53 µm size biosorbent is used to change the fluid arrangement pH between 2 and 8 (Co = 20 mg/L) to get biosorption information. The effect of an aqueous solution's pH on the biosorption of the green dye alizarine cyanine is shown in Figure 3. The rate of biosorption increases from 56% (1.12 mg/g) to 79% (1.58 mg/g) when pH climbs from 2 to 5, however, the percentage of biosorption falls above pH 5 [3].

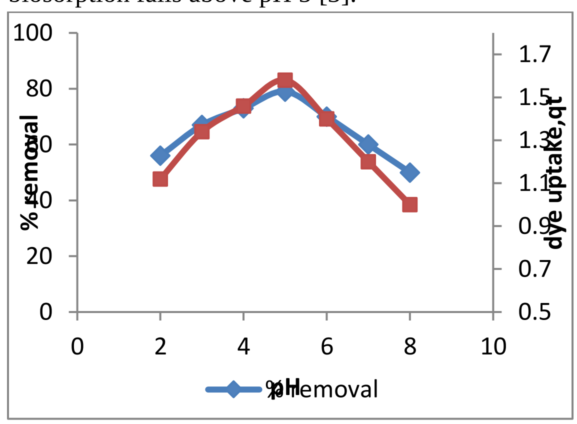

Fig.3 Dependence of % biosorption on pH of aqueous solution

3.4 Effect of initial concentration of Alizarine cyanine green dye:

Figure 4 When Co is increased from 20 to 200 mg/L, the percentage of biosorption falls from 79% (1.58 mg/g) to 57% (11.4 mg/g). An increase in biosorbate to the same number of active sites on the biosorbent is the cause of this behavior. However, beyond a concentration of 20 mg/L, the proportion of biosorption drastically drops [4].

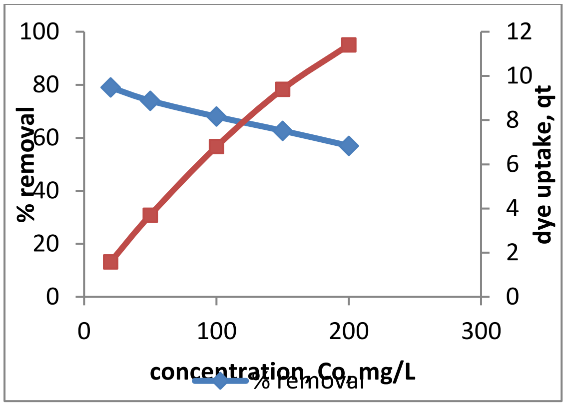

Fig.4 % biosorption as a function of initial concentration of Alizarine cyanine green dye

3.5 Effect of biosorbent dosage:

In Fig. 5, the biosorbent dosage is shown against the rate of biosorption of Alizarine cyanine green hue. The dosage is increased from 10 to 30 g/L, expanding the biosorption from 79% (1.58 mg/g) to 87% (0.58 mg/g). The percentage of Alizarine Cyanine Green Dye Biosorption very slightly varies from 87 percent (0.58 mg/g) to 90 percent (0.36 mg/g) when "w" is increased from 30 to 80 g/L. All subsequent studies are carried out at a dose of 30 g/L [5].

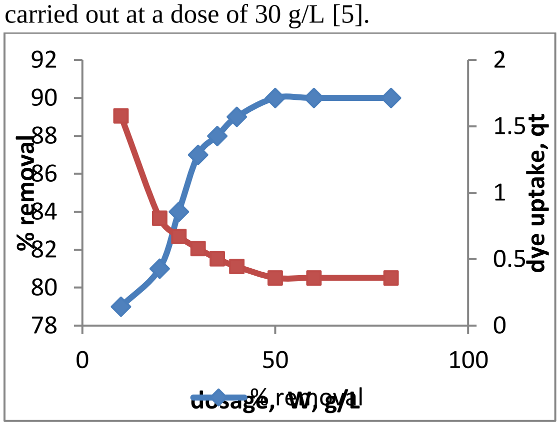

Fig.5 Dependence of % biosorption of Alizarine cyanine green dye on biosorbent dosage

3.6 Effect of biosorbent temperature:

In Fig. 6, the biosorption rate of Alizarine cyanine green hue is plotted against the biosorbent temperature. The biosorption rises from 82% (0.1518 mg/g) to 88% (0.58 mg/g) as the temperature rises from 283 to 323 K. The reason for this behavior is that a higher dose would result in more active sites being accessible for the biosorption of alizarine cyanine green dye [6].

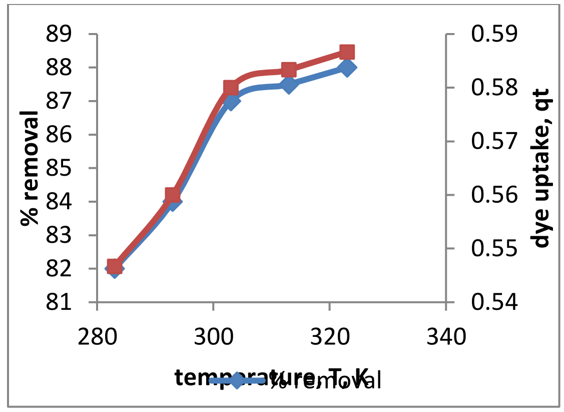

Fig.6 Dependence of % biosorption of Alizarine cyanine green dye on biosorbent temperature

3.7 Thermodynamics of biosorption:

Temperature dependence of biosorption is often associated with changes in three thermodynamic parameters: Gibbs free energy (ΔG), entropy (ΔS), and biosorption enthalpy (ΔH) [7]. Figure 7's Vant Hoff plot illustrates how temperature affects the biosorption of alizarine cyanine green hue. The resulting equation is:

$$\log (qe/Ce) = -0.4968\,(1/T) + 0.94 \quad R^2 = 0.9267 \quad (1)$$

ΔH = 9.5123 J/mole, ΔS = 18.1706 J/mole-K, and ΔG = –5496.19 J/mole are the values used in the current experiment. An endothermic biosorption is indicated by a positive ΔH [7]. The spontaneity of biosorption is indicated by a negative value of ΔG. Since ΔS is greater than zero, the biosorption process is irreversible.

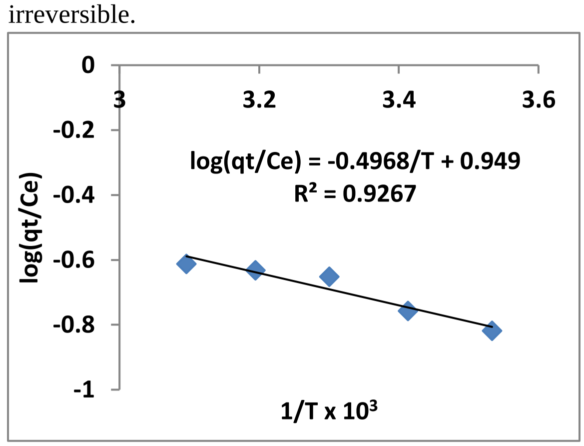

Fig.7 van't hoff's plot for biosorption

3.8 Optimization using Response Surface Methodology (RSM):

A Focal Composite Plan (CCD) is used to analyze the effects of four independent elements on the biosorption of Alizarine Cyanine Green Color, including temperature, pH, initial convergence of the color in a watery arrangement, and biosorbent data.

Table 1 Levels of different process variables in coded and un-coded form for % biosorption of Alizarine cyanine green dye using Hypnea Valentiae red algae powder

Variable	Name	Range and levels				
		-2	-1	0	1	2
X1	Biosorbent dosage, w, g/L	10	20	30	40	50
X2	Initial concentration, Co, mg/L	10	15	20	25	30
X3	pH of aqueous solution	3	4	5	6	7
X4	Temperature, T, K	283	293	303	313	323

% biosorption of Alizarine cyanine green dye (Y) is function of dosage (X1), initial concentration (X2), pH of aqueous solution (X3), and Temperature of aqueous solution (X4). The multiple regression analysis of the experimental data has yield the following equation:

$$Y = -2142.03+44.93\,X1+6.60\,X2+2.05\,X3+13.26\,X4 - 4.55\,X12 - 0.16X22 - 0.03\,X32 - 0.02\,X42 + 0.05\,X1X2 - 0.00\,X1X3 - 0.00\,X1X4 + 0.00\,X2X3 - 0.00\,X2X4 - 0.00\,X3X4 \quad .....(2)$$

Table 2 ANOVA of Alizarine cyanine green dye biosorption for entire quadratic model

Source of variation	SS	df	Mean square (MS)	F-value	P > F
Model	1080.687	14	77.19192	233914.90	0.00000
Error	0.005	15	0.00033		
Total	1080.692				

3.9 Interpretation of residual graphs:

A normal probability plot (NPP) is a visual aid that is employed to analyze whether a set of data is routinely distributed more widely. The discrepancy between the anticipated and observed values of the regression is referred to as the "residual". Figure 8 Figure 9 displays the normal probability curve for the available data. It is evident that the exploratory data has been judiciously edited to reflect a typical dispersion [8].

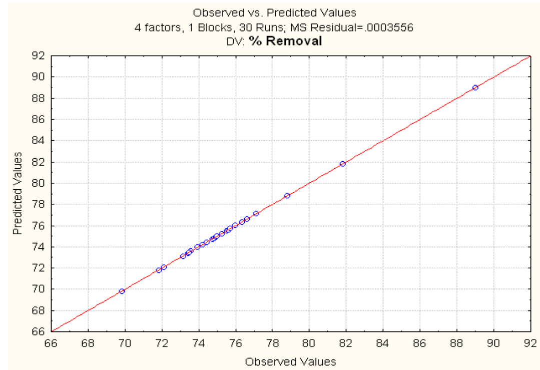

Fig. 8 Normal probability plot for % biosorption of Alizarine cyanine green dye

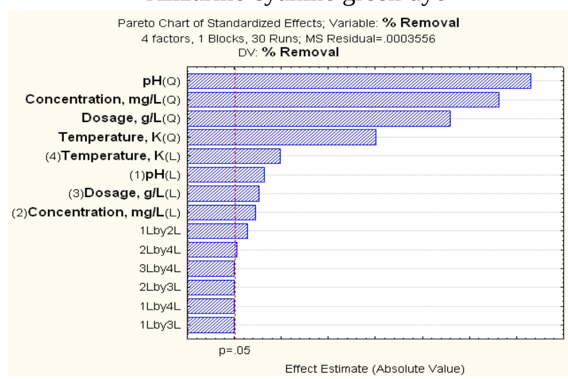

Fig.9 Pareto chart

Three-dimensional response surface contour plot view

The percentage of the green dye Alizarine Cyanine that biosorbs, when combined with powdered red algae from Hypnea Valentiae, is depicted in [Fig. 11].

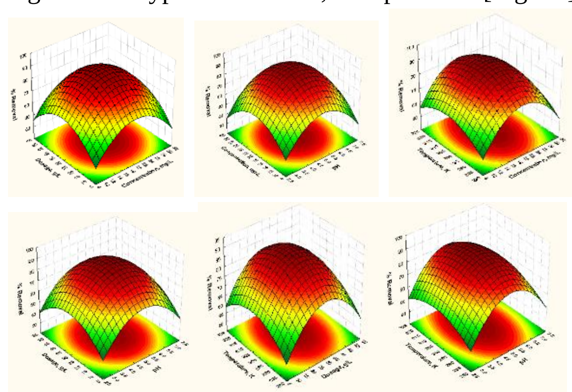

Fig.10 Response surface contour plots in three dimensions.

It is anticipated that the following circumstances will lead to the highest possible biosorption of alizarine cyanine green dye: Temperature: 304.7211 K; pH of aqueous solution: 5.0557; biosorbent dosage: 30.6110 g/L; initial concentration of Alizarine Cyanine Green Dye: 20.2153 mg/L; percentage of Alizarine Cyanine Green Dye biosorption: 89.09808.

VI. CONCLUSION

While the majority of Hypnea Valentiae obtained excellent removal efficiency, the efficiency determination parameters varied depending on the study that was evaluated. The majority of each biomass evaluated has a remarkable removal effectiveness of up to 90%, making comparisons between them difficult. 30 minutes is the biosorption equilibrium agitation time with increasing pH, from 2 (56%) to 5 (79%). The dose for biosorption that works best is 30 g/L, or 0.58 mg/g. The highest absorption capacity is 17.211 mg/g at 303 K. When the following processing settings are applied, using CCD, the greatest biosorption of Alizarine cyanine green dye (89.09808 %) onto Hypnea Valentiae red algae powder is observed: pH =5.0557, w = 30.6110g/L, C0 = 20.2153 mg/L, and T = 304.7211 K. Additionally, the study shows that biosorption is endothermic (ΔH = 9.5123), irreversible (ΔS = 18.1706 J/mole-K), and spontaneous (ΔG = -5496.19 J/mole).

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