STUDIES AND CHARACTERIZATION OF *QUISQUALIS INDICA* POWDER FOR SORPTION OF ALIZARINE GREEN DYE

Dr. P. Brahmaji Rao[1] and Khaja Moyunuddin Mohammad[2]

[1]Associate Professor, Dept of Environmental Sciences, Acharya Nagarjuna University, Nagarjuna Nagar, Guntur- 522510, Andhra Pradesh, INDIA
[2]Research Scholar, Dept of Environmental Sciences, Acharya Nagarjuna University, Nagarjuna Nagar, Guntur- 522510, Andhra Pradesh, INDIA
Corresponding Author: Khaja Moyunuddin Mohammad
Email: chemkhaja@gmail.com

Abstract
Coordinated Industrialization brought about the huge release of dyes into squander water. These squanders inturn debase the normal territory of the living species. Biosorption, the best practice for the expulsion of dyes is considered for the current research examination. Quisqualis Indica powder is utilized for the expulsion of Alizarine green dye from fluid arrangement. The boundaries researched incorporated agitation time, biosorbent size, pH, initial concentration, dose of biosorbent and temperature. The kinetic review integrated lagergren first request and pseudo second request models. The concentrate additionally included thermodynamics and isotherms like Langmuir, Freundlich and Temkin. The exploratory information was connected for relapse investigation and the information was very well fitted.
Keywords: FTIR, SEM, pH, size, time and temperature.

DOI: 10.53555/ecb/2022.11.11.136

Introduction

A strong, pervasive risk to human health arises from natural occurrences in some water resources, which calls for management and removal from drinking water. One of the biggest environmental issues among the 21 nations in the globe impacted by groundwater contamination is the removal of color from textile effluents. In today's industrialized world, dyes are utilized extensively. People constantly ignore their unpleasant character because of their synthetic origin and complicated aromatic molecular structures, which render them inert and difficult to biodegrade when released into waste systems. Some have an adverse effect on aquatic life in rivers when they are released **[1]**.

Activated carbon is the industrial sorbent most commonly employed. It is not expected to be cost-effective, though, and is a pricey material until regeneration becomes quite simple. Researchers have looked at using a variety of agricultural byproducts and products to extract colors from aqueous solutions. The method's cost-effectiveness is its clear benefit. Therefore, it's necessary to look for more affordable and efficient sorbents**[2]**.

When designing sorption systems, the equilibrium sorption isotherm is crucial. The capacity of the sorbent is determined by equilibrium studies, which also characterize the sorption isotherm using constants whose values represent the sorbent's affinity and surface characteristics. The ratio of the amount sorbed to the amount left in the solution at equilibrium at a given temperature is often described using sorption isotherms, which show

the equilibrium relationships between sorbent and sorbate **[3]**. Wastewater containing dyes is generally treated using physical or chemical methods. These include of precipitation, ozonation, adsorption, oxidation, irradiation, ion exchange, and photodegradation in addition to chemical coagulation/flocculation.

Although these methods have their limits, some of them have been demonstrated to be beneficial. The overuse of chemicals or the buildups of concentrated sludge with disposal issues are a few of these, along with costly plant needs and operating expenses, ineffective color reduction, and susceptibility to a fluctuating wastewater input. One possible substitute for current treatment techniques for wastewater treatment is the use of biomaterials as biosorbents. Biosorption is the process of absorbing a solute utilizing biomaterials, such as living or dead microbial cells. Good removal efficacy, low cost, and great selectivity are the key benefits of biosorption. Many low-cost biomaterials have been tested worldwide for dye biosorption **[4]**.

Experimental Procedure

Biosorbent

After gathering a leaf of Quisqualis indica, the biomass was repeatedly cleaned with distilled water until all dirt was removed, and it was then dried for 72 hours at 60º C. For later use in the tests, the dried biomass was crushed, sieved, and kept in storage.

Adsorbate

A precisely weighed one-gram amount of alizarine cyanine was dissolved in double-distilled water to yield a 1000 mg/L stock solution. By diluting the stock solution with double-distilled water, experimental solutions with the appropriate concentrations were created.

Analytical measurements

A UV-vis spectrophotometer was used to measure the alizarine cyanine dye concentration at a wavelength equal to the dye's maximum absorption in nanometers. Plots of calibration curves were made between the dye solution's concentration and absorbance.

Batch experiments

250 mL conical flasks were used for batch studies, and 50 mL of wastewater containing dye and biomass were added. In order to investigate the effects of significant variables such as pH, adsorbent dose, starting dye concentration, contact time, and temperature, these flasks were shaken at a constant speed of 150 rpm in an orbital shaker that was temperature-controlled. The samples were taken out at the proper intervals, and the leftover dye concentration was examined using the supernatant. Dilute aqueous solutions of 0.1N HCl or 0.1N NaOH were added to change the pH. A 50 mL dye solution was interacted with various concentrations of biomass until equilibrium was reached in order to determine the ideal quantity of adsorbent per unit mass of adsorbate. By examining the adsorptive absorption of the dye from the aqueous solution at various time intervals, the kinetics of adsorption were ascertained. By stirring an alizarin cyanine dye solution at various concentrations with a known quantity of Quisqualis indica leaf powder until equilibrium was reached, the adsorption isotherm was discovered. The investigation focused on the effects of temperature at 273, 283, 303, 313, and 323, K, on the sorption properties. The initial concentration of dye was 20–200 mg/L.

Results and Discussion:

Effect of agitation time

Figure 1 shows the percentage of Alizarine cyanine green dye biosorption plotted against

fermentation time. The percentage of biosorption remains relatively constant after the 40-minute fomentation season. Thus, 40 minutes is the balance turbulent time. When 10 g/l of 53 m biosorbent is introduced to 50 mL of aqueous solution in a typical experiment, the agitation duration of 5 to 40 minutes raises the percentage of biosorption from 11 to 69 percent. As more of the green Alizarine cyanine dye is absorbed onto the biosorbent's surface over time, the biosorbent's surface area diminishes **[5].**

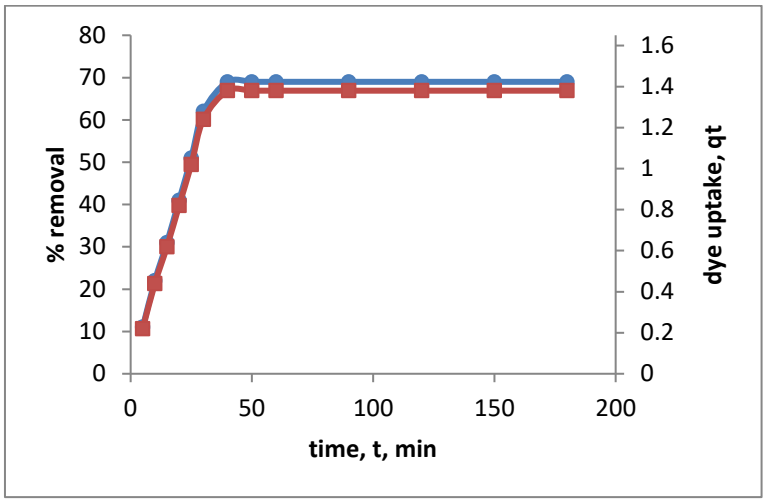

Figure 1: Effect of agitation time on % biosorption of Alizarine cyanine green dye

Effect of biosorbent size:

The link between the proportion of absorbed Alizarine cyanine green dye and the size of the biosorbent is shown in the figure. 2. As the size of the biosorbent increases from 53 to 152 µm, the rate of biosorption decreases from 69% to 50%. When the size of the molecule decreases, the biosorbent's surface area increases, and more dynamic locations are more effectively given to the biosorbate **[6]**.

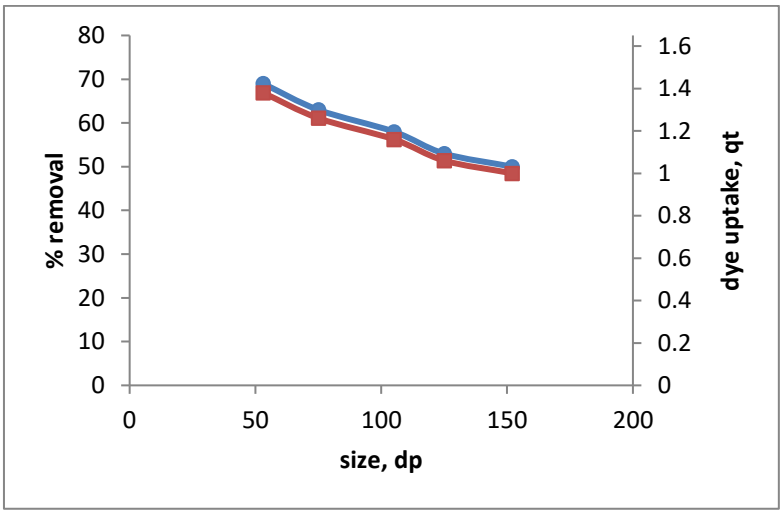

Figure 2: Variation of % biosorption with biosorbent size

Effect of pH in aqueous solution:

The relationship between the fluid arrangement's pH and the amount of absorbed green alizaririne cyanine is seen in Figure 3. The color's degree of biosorption increases significantly as pH rises from 2 to 6, and it decreases as pH falls beyond 6. The degree of biosorption increases from 57 to 76 percent in the pH range of 2 to 6 when 50 mL of fluid

arrangement is mixed with a 10 g/L dosage of biosorbent of 53 m sizes in a standard test **[7]**.

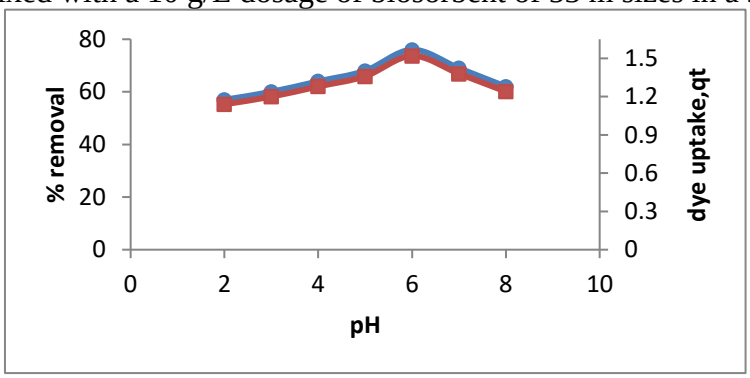

Figure 3: Dependence of % biosorption on pH of aqueous solution

Effect of initial concentration of Alizarine cyanine green dye:

The impact of the green dye alizarine cyanine's starting concentration on the percentage of biosorption at equilibrium agitation time is shown in Figure 4. A lower proportion of dye is removed for a greater concentration of dye in the aqueous solution when Alizarine Cyanine Green Dye Co. is increased from 20 to 200 mg/L. This causes a progressive decline in the percentage of biosorption from 76 to 55 percent (1.52 to 11 mg/g) **[8]**.

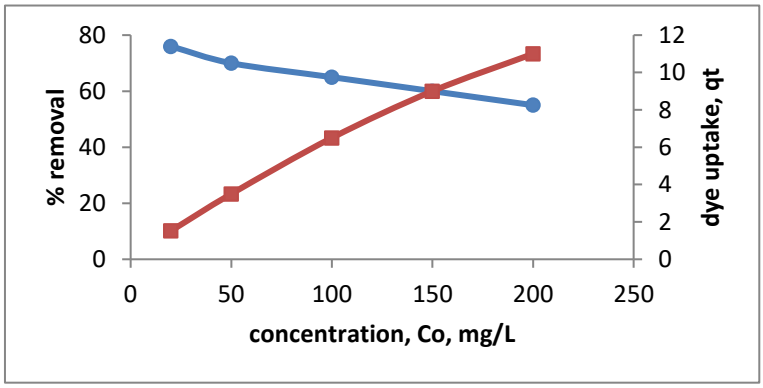

Figure 4: % biosorption of initial concentration of Alizarine cyanine green dye

Effect of biosorbent dosage:

Fig. 5 illustrates how the dose of the biosorbent affects the percentage of green dye biosorption (alizarine cyanine) from the aqueous solution (pH = 6). The proportion of biosorption increases from 76 to 91 percent when the dose is raised from 10 to 35 g/L. Because increasing w from 35 to 80 g/L does not significantly enhance the percentage of biosorption (91 to 92 percent), all additional tests are conducted with w = 35 g/L **[9]**.

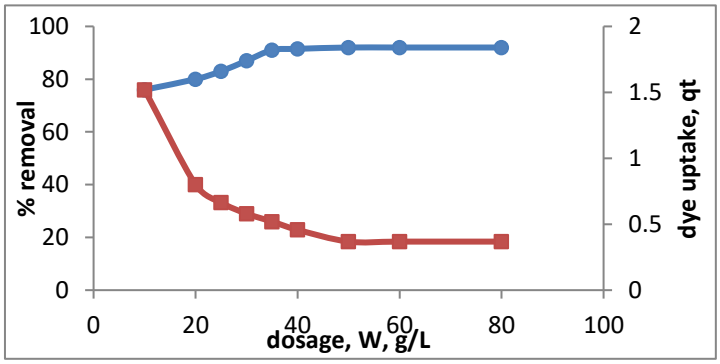

Figure 5: % biosorption of Alizarine cyanine green dye on biosorbent dosage

Effect of biosorbent temperature:

The green Alizarine cyanine color's biosorption rate is plotted against the biosorbent's temperature in the figure. Figure 6. The percentage of biosorption increases from 86% (0.5733 mg/g) to 92.5 percent (0.6166 mg/g) with a temperature increase from 283 to 323 K. This behavior is clear since raising the dose would allow for the biosorption of alizarine cyanine green dye at more active sites **[10]**.

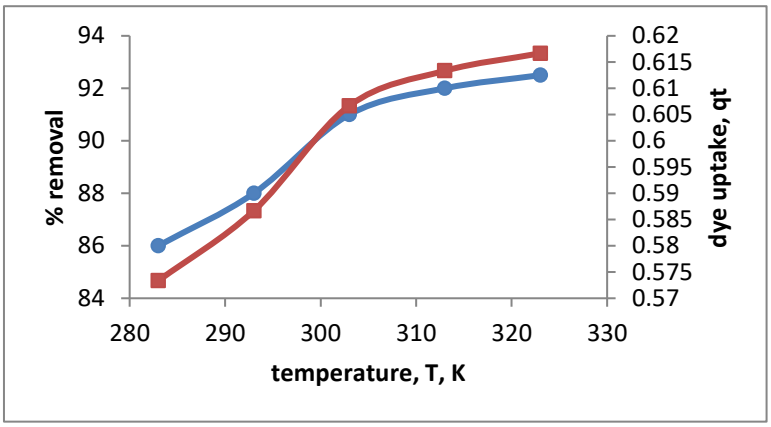

Figure 6: Dependence of % biosorption of Alizarine cyanine green dye on biosorbent temperature

Isotherms

Langmuir isotherm:

Langmuir isotherm is drawn between Ce/qe and Ce in fig. 7 for the present data. The resulting equation is

(Ce/qe) = 0.0566 Ce + 3.2184 ------- (1)

The (correlation coefficient of 0.9863) confirms strong binding of Alizarine cyanine green dye to the surface of Quisqualis indica leaf powder **[11]**.

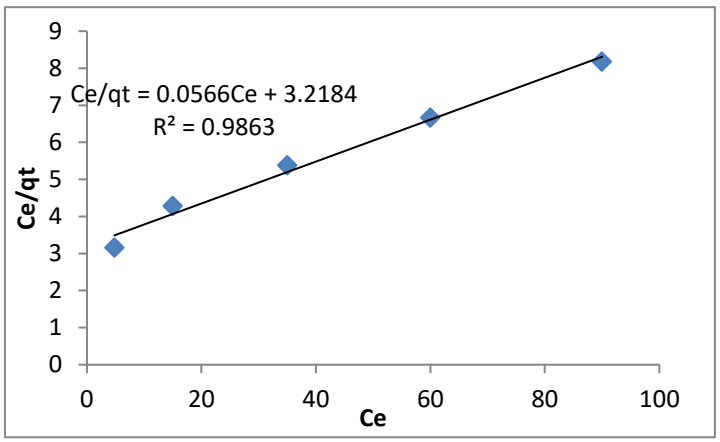

Figure 7: Langmuir isotherm for biosorption of alizarine cyanine green dye

Freundlich isotherm:

Freundlich isotherm, drawn between log Ce and log qe in fig.8 has resulted in the following equation

log qe = 0.6847 log Ce - 0.6217 ------ (2)

The equation has a correlation coefficient of 0.9965. The 'n' value of 0.6291 indicates favorable biosorption satisfying the condition of 0<n<1.

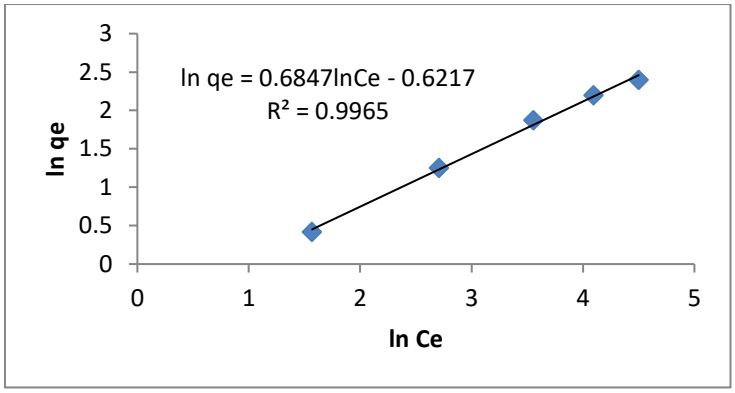

Figure 8: Freundlich isotherm for biosorption of Alizarine cyanine green dye

Temkin isotherm:

The plot between qe and ln Ce is shown in fig. 9. The equation for Alizarine cyanine green dyebiosorption is

qe = 3.2408 ln Ce – 4.3429 ------ (3)

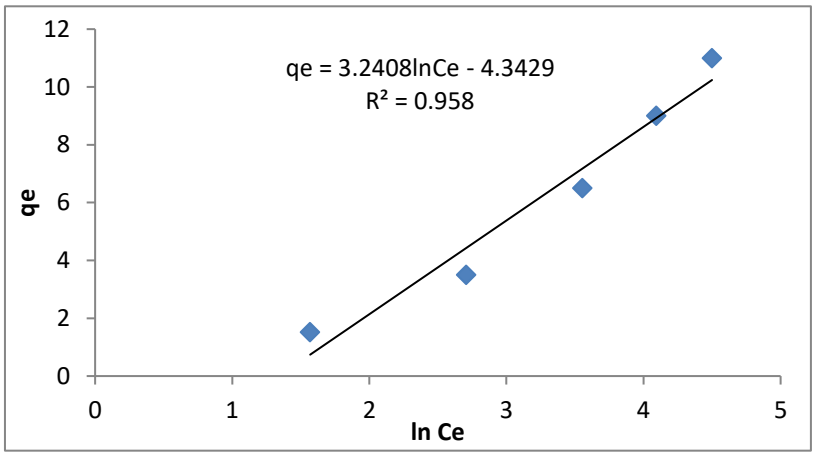

Figure 9: Temkin isotherm for biosorption of Alizarine cyanine green dye

Table 1 compiles the isotherm constants. The results show that the Freundlich (R2=0.9965), Temkin (R2=0.958), and Langmuir (R2=0.9863) isotherms accurately capture the biosorption data.

Table – 1 Isotherm constants (linear method)

Langmuir isotherm	Freundlich isotherm	Temkin isotherm
qm =17.6678 mg/g	Kf = 0.5370 mg/g	AT=0.26182L/mg
KL = 0.01758	n = 0.76	bT = 777.321
R2 = 0.9863	R2 = 0.9965	R2 = 0.958

Kinetics

First order kinetics:

For the biosorption of Alizarine Cyanine Green Dye, Figs. 10 and 11 depict the pseudosecond order kinetics plot and Lagergren plot. First and second order rate equations' rate constant values are compiled in Table 2. It is observed that both first- and second-order rate equations adequately describe the interactions involved in biosorption **[12]**.

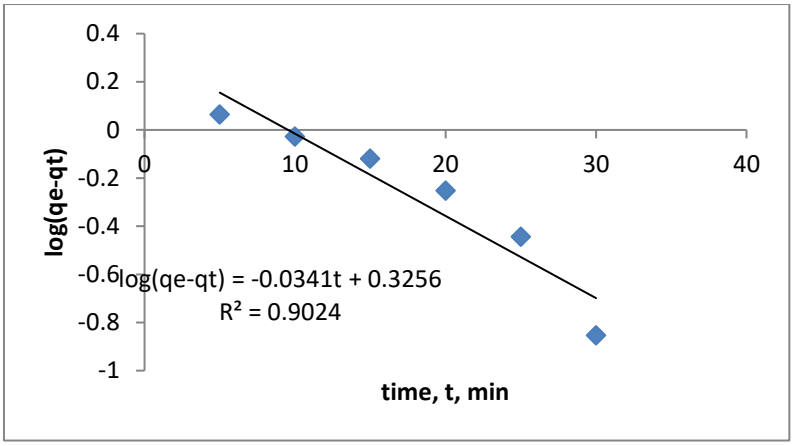

Figure 10: First order kinetics for biosorption of Alizarine cyanine green dye

Pseudo second order kinetics

Plotting (t/qt) vs "t" provides a linear connection that, if the pseudo second order kinetics is relevant, enables the estimation of qe and K2. The kinetics are examined in this work using 50 mL of an aqueous solution (C0= 20 mg/L) at 303 K over interaction times ranging from 5 to 40 minutes.

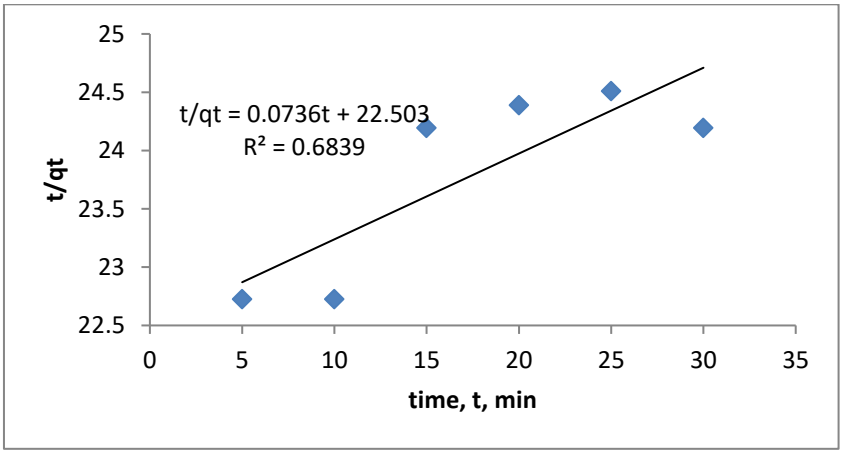

Figure 11: Second order kinetics for biosorption of Alizarine cyanine green dye

Table – 2 Equations and rate constants

Order	**Equation**	**Rate constant**	**R2**
Lagergren first order	log(qe-qt)=–0.0341t+ 0.3256	0.07853 min-1	0.9024
Pseudo second order	t/qt = 0.0736 t + 22.503	0.00024g/(mg-min)	0.6839

Thermodynamics:

Figure 12 shows the plot created by Van't Hoff. Based on the data, it is calculated that the biosorption of Alizarine cyanine green dye will result in a Gibbs free energy shift (ΔG) of –11132.5 J/mol. The spontaneous and thermodynamically possible character of biosorption is indicated by the negative ΔG value. There is 14.1037 kJ/mol K in the ΔH parameter. The exothermic character of biosorption is indicated by the negative ΔH. The ΔS parameter for the biosorption of Alizarine Cyanine Green Dye is determined to be 36.7874 J/mol K **[13]**.

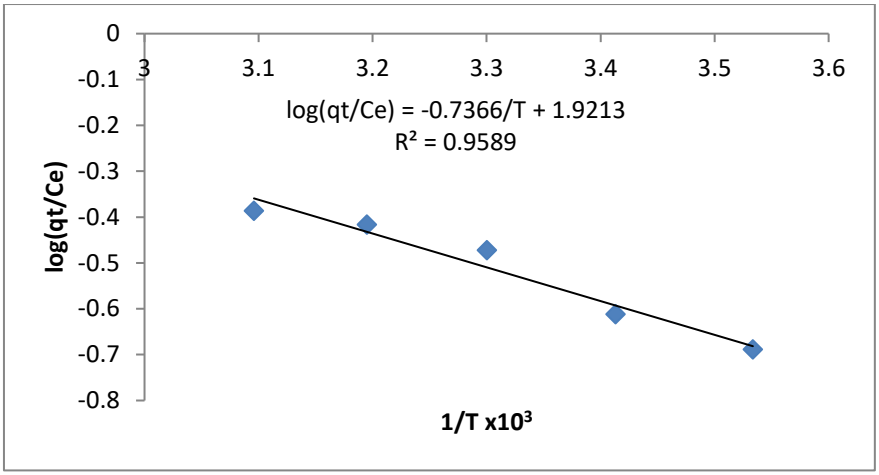

Figure 12 van't hoff's plot for biosorption

Characterization of Quisqualis indica leaf powder

FTIR analysis

Figure 13(a) displays the FTIR spectrum of untreated Quisqualis indica leaf powder. Figure 13a displays the results of FTIR measurements for algal biomass loaded with alizarine cyanine green color. The shift of the strong peak at 1246.02 cm-1 to 1244.09 cm-1 indicates that SO3 stretching is involved in the biosorption process. The band shifts from 1400.32 cm-1 to 1396.46 cm-1 [53–54], indicating that –C–N stretching is involved. The biomass loaded with Alizarine Cyanine Green Dye does not display the bands at 929.69 cm-1 and 968.27 cm-1, which are designated for the existence of CH⁉CH2 and S=O and S-O stretching, respectively.

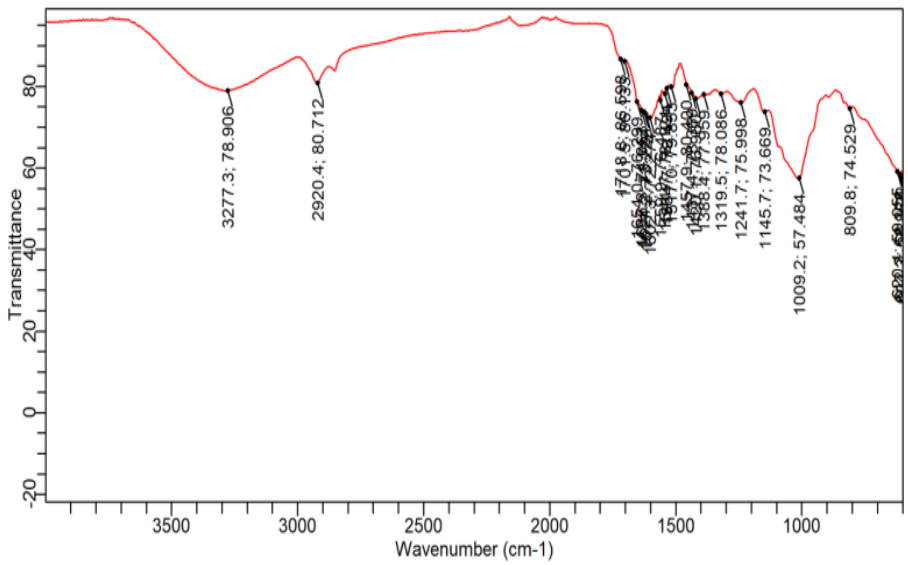

Figure 13(a): FTIR spectrum of Alizarine cyanine green dye untreated Quisqualis indica leaf powder

In powder filled with Alizarine Cyanine Green Dye, the peak at 2924.09 cm-1 designated for CH2 stretching vibrations in untreated powder is not visible. Figure 13b illustrates how the CH2 stretching vibrations participate in biosorption. The biomass loaded with alizarine cyanine green dye does not exhibit the strong peak at 2924.09 cm-1, which is identified as CH2 vibrations **[14]**.

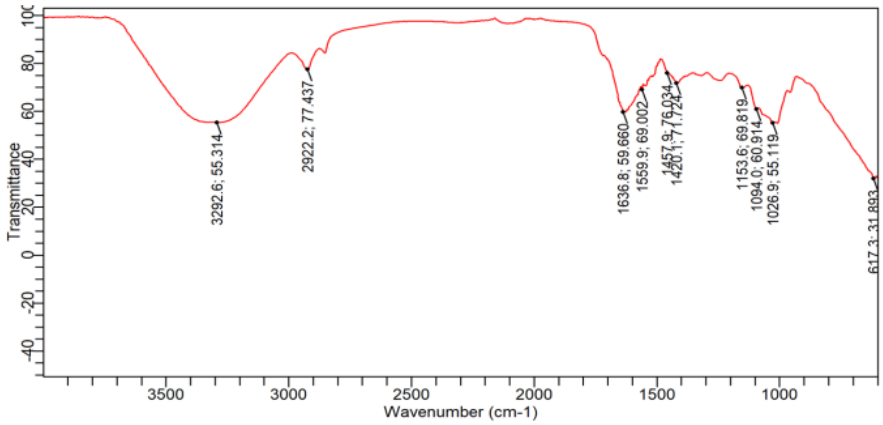

Figure 13(b): FTIR spectrum of Alizarine cyanine green dye treated Quisqualis indica leaf powder

X-Ray Diffraction:

In figures 14(a) & (b), untreated powder XRD patterns are displayed. The XRD patterns seen in Figures 14(a) and (b) are amorphous and lack distinct peaks. The existence of CoCr2CoCr2O4, Co0.8Cr0.2, and Co7Cr8 is confirmed by the peaks at 2θ values of 0.625, 0.234, and 0324 (ICDD files). The equivalent d-values for them are 2.9472, 1.9124, and 4.8127 **[15]**.

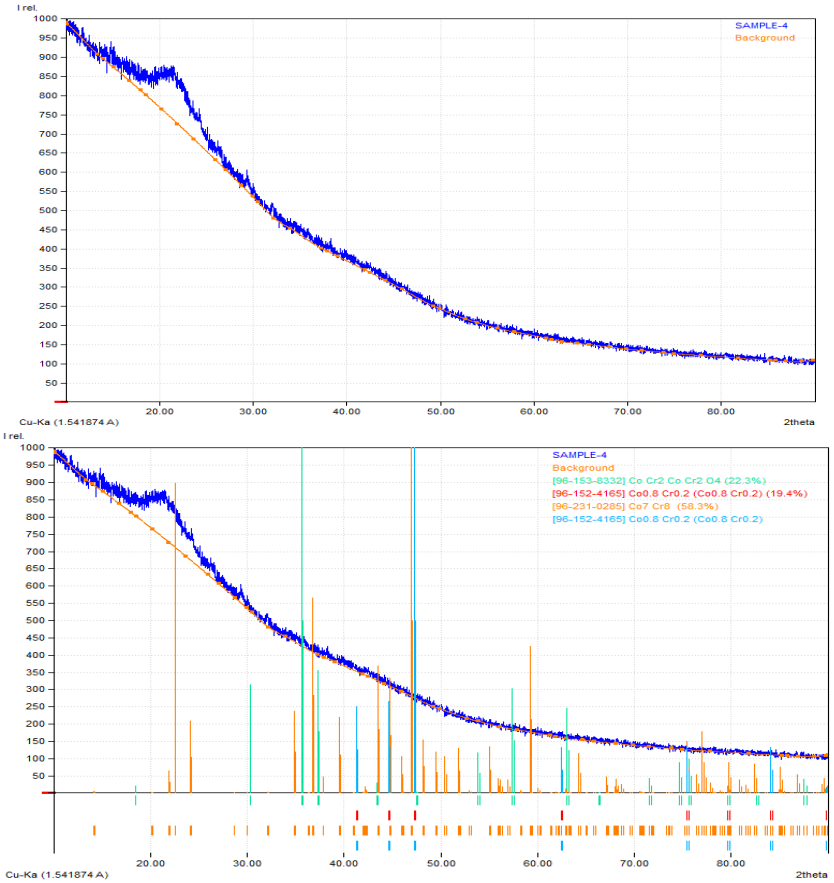

Figure 14(a): XRD pattern of Alizarine cyanine green dye untreated Quisqualis indica leaf powder

Figure 14(c) displays the untreated powder's XRD patterns. The XRD patterns seen in Fig. 14(d) are amorphous in character and lack distinct peaks. According to the ICDD data, the

existence of CTi, C3.75-2Ti6.73Ti6.73C3.72, CTi Khamrabaevite, and CTi Titanium carbide is confirmed by the peaks at 2θ values of 0.5, 0.856, 0.1, 0.531, and 0.258. The d-values that correlate with these are 2.6558, 2.3, 1.6263, 1.3870, and 1.3279.

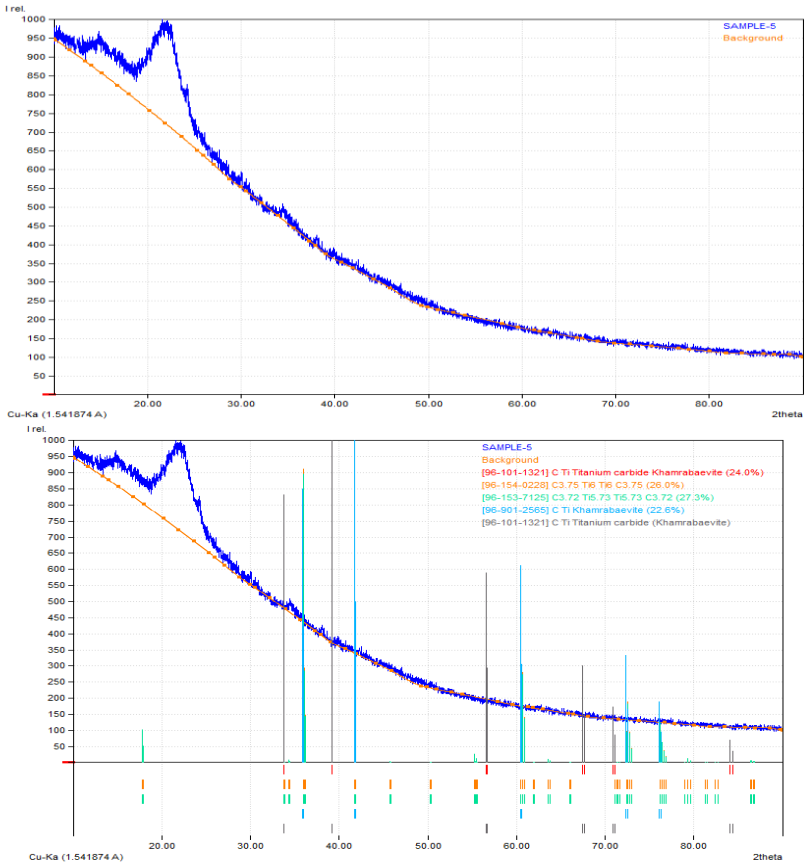

Figure 14(b): XRD pattern of Alizarine cyanine green dye treated Quisqualis indica leaf powder

Scanning Electron Microscope (SEM):

The surface morphology of the untreated Quisqualis indica leaf powder powder is depicted as porous and uneven in the SEM images presented in figures. 15(a)&(b). The increased surface area and porosity are confirmed by the surface area study conducted following loading with Alizarine Cyanine Green Dye. The surface's capacity to biosorb dye is higher. This is seen at various points in Figures 15(a) and (b) **[16, 17]**.

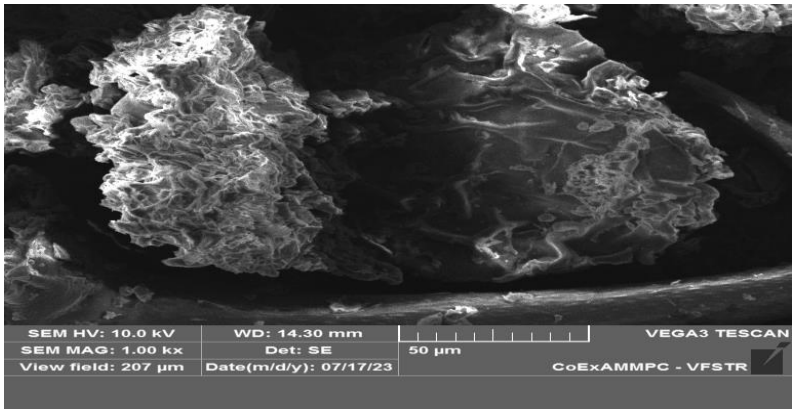

Figure 15(a): SEM pattern of Alizarine cyanine green dye untreated Quisqualis indica leaf powder

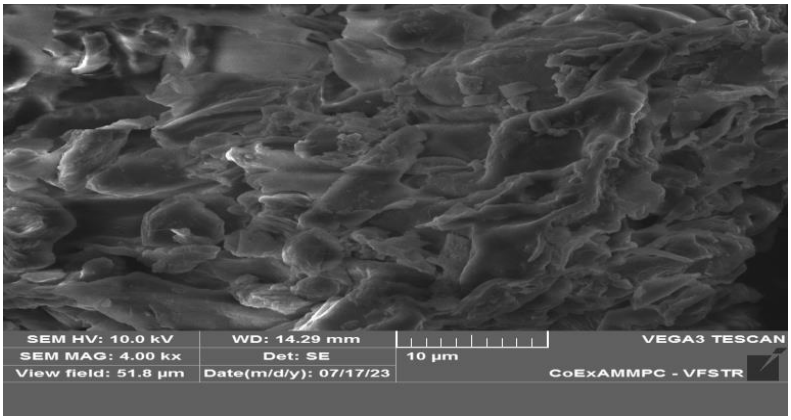

Figure 15(b): SEM pattern of Alizarine cyanine green dye untreated Quisqualis indica leaf powder

The surface morphology of the untreated Quisqualis indica leaf powder powder is depicted as porous and irregular in the SEM images presented in figures. 15(c)&(d). The increased surface area and porosity are confirmed by the surface area study conducted following loading with Alizarine Cyanine Green Dye. The surface's capacity to biosorb dye is higher. This is shown in figures 15(c) and (d) in various places.

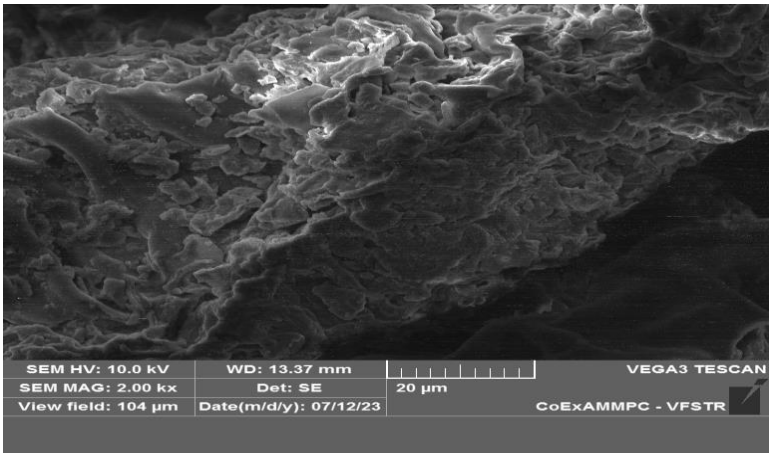

Figure 15(c): SEM pattern of Alizarine cyanine green dye treated Quisqualis indica leaf powder

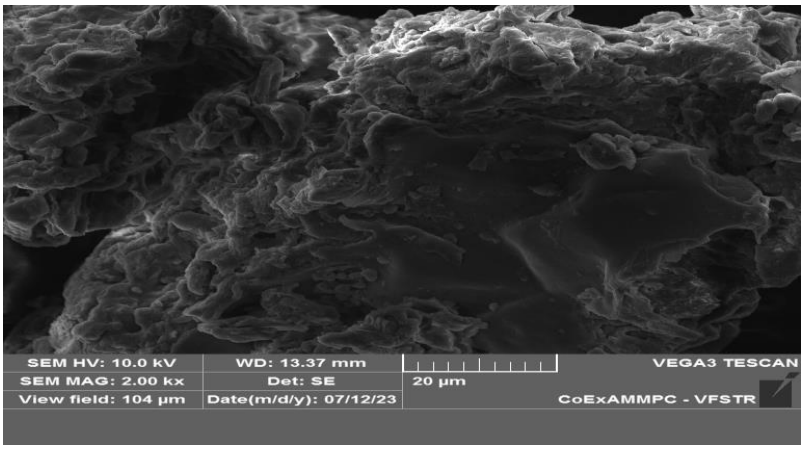

Figure 15(d): SEM pattern of Alizarine cyanine green dye treated Quisqualis indica leaf powder

Conclusion

Studies on equilibrium and kinetics were conducted to evaluate the efficacy of using quisqualis indica leaves powder in the elimination of Alizarine Green dye. The starting solution pH, temperature, initial dye concentration, dose of the biosorbent, and contact duration were all taken into consideration when doing the experiments. The initial dye concentration, temperature, and pH of the solution all had an impact on the biosorbent's capacity. It takes 40 minutes to reach the equilibrium of AG dye biosorption.

The dose for biosorption that works best is 1.75 g, or 35 g/L. The highest level of biosorption is detected at pH = 6. The analysis also shows that: Biosorption is spontaneous because ΔG is negative (-11132.5 J/mole); Biosorption is endothermic because ΔH is positive (14.1037 J/mole); and Biosorption is irreversible because ΔS is positive (36.7874 J/mole-K). The current study finds that instead of using the costly procedures now used to remove colors from textile effluents, quisqualis indica leaves powder might be used as an inexpensive and environmentally acceptable biosorbent.

References

1. Tripathi RD, Srivastava SS, Singh N, Tuli R, Gupta DK, Maathuis FJM (2007) Arsenic hazards: strategies for tolerance and remediation by plants. Trends Biotechnol 25:158–165
2. Robinson, T., McMullan, G., Marchant, R. & Nigam, P. (2001). Remediation of dyes in textile effluent: a critical review on current treatment technologies with a proposed alternative. Bioresour. Technol. 77, 247-255.
3. Wang, B.E., Hu, Y.Y., Xie, L., & Peng, K. (2008). Biosorption behavior of azo dye by inactive CMC immobilized Aspergillus fumigatus beads. Bioresour. Technol. 99(4), 794-800. Waranusantigul, P., Pokethitiyook, P., Kruatrachue, M. & Upatham, E.S. (2003). Kinetics of basic dye (methylene blue) biosorption by giant duckweed (Spirodela polyrrhiza). Environ. Pollut. 125, 385-392.
4. Georgin, Jordana, Bianca Silva Marques, Enrique Chaves Peres, Daniel Allasia, and Guilherme Luiz Dotto. "Biosorption of cationic dyes by Pará chestnut husk (Bertholletia excelsa)." Water Science and Technology 77, no. 6 (2018): 1612-1621.
5. Ho, Yuh-Shan, Tzu-Hsuan Chiang, and Yu-Mei Hsueh. "Removal of basic dye from aqueous solution using tree fern as a biosorbent." Process Biochemistry 40, no. 1 (2005): 119-124.
6. Singh, Pradeep Kumar, and Ram Lakhan Singh. "Bio-removal of azo dyes: a review." International Journal of Applied Sciences and Biotechnology 5, no. 2 (2017): 108-126.
7. Kabbout, Rana, and Samir Taha. "Biodecolorization of textile dye effluent by biosorption on fungal biomass materials." Physics Procedia 55 (2014): 437-444.
8. Ayan, Ebru Mavioglu, Asli Toptas, Gulsah Kibrislioglu, Esra Evrim Saka Yalcinkaya, and Jale Yanik. "Biosorption of dyes by natural and activated vine stem. Interaction between biosorbent and dye." Clean–Soil, Air, Water 39, no. 4 (2011): 406-412.
9. Bouras, Hadj Daoud, Zelal Isik, Ezgi Bezirhan Arikan, Ahmed Réda Yeddou, Noureddine Bouras, Abdelmalek Chergui, Lidia Favier, Abdeltif Amrane, and Nadir Dizge. "Biosorption characteristics of methylene blue dye by two fungal biomasses." International Journal of Environmental Studies 78, no. 3 (2021): 365-381.

10. Chen, Chia-Yun, Jen-Chao Chang, and Arh-Hwang Chen. "Competitive biosorption of azo dyes from aqueous solution on the templated crosslinked-chitosan nanoparticles." Journal of Hazardous Materials 185, no. 1 (2011): 430-441.
11. Deniz, Fatih, and Remziye Aysun Kepekci. "Dye biosorption onto pistachio by-product: A green environmental engineering approach." Journal of Molecular Liquids 219 (2016): 194-200.
12. Bustard, M., G. McMullan, and A. P. McHale. "Biosorption of textile dyes by biomass derived from Kluyveromyces marxianus IMB3." Bioprocess Engineering 19, no. 6 (1998): 427-430.
13. Jaikumar, V., and V. Ramamurthi. "Effect of biosorption parameters kinetics isotherm and thermodynamics for acid green dye biosorption from aqueous solution by brewery waste." International journal of chemistry 1, no. 1 (2009): 2.
14. Chu, Wan-Loy, and Siew-Moi Phang. "Biosorption of heavy metals and dyes from industrial effluents by microalgae." Microalgae biotechnology for development of biofuel and wastewater treatment (2019): 599-634.
15. Zaheer, S., H. N. Bhatti, S. Sadaf, Y. Safa, and M. Zia-ur-Rehman. "Biosorption characteristics of sugarcane bagasse for the removal of Foron Blue E-BL dye from aqueous solutions." JAPS: Journal of Animal & Plant Sciences 24, no. 1 (2014).
16. Priyantha, Namal, Linda BL Lim, D. T. B. Tennakoon, Elaine TZ Liaw, Chieng Hei Ing, and Anushka B. Liyandeniya. "Biosorption of cationic dyes on breadfruit (Artocarpus altilis) peel and core." Applied water science 8 (2018): 1-11.
17. Chakravarty, Poulomi, Kuldeep Bauddh, and Manoj Kumar. "Remediation of dyes from aquatic ecosystems by biosorption method using algae." Algae and environmental sustainability (2015): 97-106.