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Research Article

Sustainable Adsorption Studies of Lissamine Blue Dye from Aqueous Media Using Natural *Parthenium hysterophorus* Powder

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Abstract
Biosorption is a technique that makes use of biological agents such as agricultural waste, microbial biomass, algae, fungi, and plant-derived biosorbents to absorb the dye molecules physically and chemically. Some of the important features of the process include high efficiency of absorption, low operational cost, regeneration of the biosorbent material, and absence of sludge formation. Parameters like pH, temperature, time of contact, dye concentration, and dose of the biosorbent play a significant role in adsorption. The current work deals with the utilization of *Parthenium hysterophorus* powder as biosorbent for Lissamine Blue dye removal. The equilibrium studies are performed and their respective values obtained are 40 mins at pH 4 and dosage of 30g/L.
Keywords: Sorption, Time, Isotherms, Lissamine Blue.

1. Introduction

Contamination of water resources from industrial discharges has emerged as a major environmental problem. Among other pollutants, synthetic dyes are regarded as one of the most toxic substances due to their stable and complicated aromatic composition as well as inability to decompose naturally [1]. Textile, leather, paper, cosmetic, plastic, and printing industries produce large amounts of wastewater containing colored contaminants. The presence of dyes even in small amounts causes decreased penetration of light into the water bodies, adversely affects ecosystems, and creates significant harm to people and animals, inducing allergic reactions and cancer [2]. There are some traditional methods that can be used for removing dyes from wastewaters, such as adsorption, coagulation, chemical precipitation, ion exchange, filtration through membranes, and advanced oxidation.

But there are some limitations associated with these techniques, including expensive cost of treatment, insufficient efficiency of the process, large amount of energy expenditure, and creation of toxic sludge [3]. Biosorption has emerged as one of the promising alternative technologies for dye removal owing to its simplicity, effectiveness, and environmental friendliness. The process of biosorption is characterized by the uptake of contaminants by biological substances through the process of adsorption, ion-exchange, complexation, and electrostatic interactions. Many biosorbents, which include bacteria, fungi, algae, agricultural wastes, and plant biomass, have shown great potential in removing various kinds of dyes [4].

The success of the process of biosorption is governed by certain process conditions like pH value, temperature, time, biosorbent dosage, and initial dye concentration. Over the past few years, considerable effort has been made to improve biosorption capacity by modifying the properties of biological materials. With the availability of biological materials in plenty, their cost-effectiveness, and renewability, biosorption appears to be a good choice in the field of wastewater treatment [5].

In this paper, attempts will be made to understand the phenomenon of biosorption, examine different kinds of biosorbents and mechanisms of adsorption, and study the influencing factors of biosorption process.

2. Experimental Procedure

2.1 Reagents and Materials

All the chemicals used for this experiment were of analytical grade and no further purification was done. The pH was adjusted using 0.1 N HCl and 0.1 N NaOH.

2.2 Preparation of Biosorbent

Collect *Parthenium hysterophorus* and take out any impurities stuck to them. For the removal of any impurities such as dust or anything soluble in nature, wash the *Parthenium hysterophorus* well in distilled water until the water used becomes clear. For the purpose of removing moisture content from the *Parthenium hysterophorus*, dry them under direct sunlight or in a hot air oven set at a temperature between 60°C and 80°C until their mass stabilizes.

For obtaining finely ground particles of the material, grind the dried *Parthenium hysterophorus* mechanically. Sieve the grounded *Parthenium hysterophorus* to obtain fractions of required particle size (53, 75, 105, 125, 152 µm in this experiment).

2.3 Preparation of the 1000mg/L of Lissamine Blue Solution

All required solutions are prepared by using analytical grade chemicals and double distilled water. In a volumetric flask of 1000 ml, 1 g of Lissamine Blue is dissolved with distilled water to obtain 1000 ppm (mg/L) of Lissamine Blue stock solution.

2.4 Studies on Equilibrium Biosorption

Parthenium hysterophorus powder that had been weighed in advance was introduced into a given volume of aqueous solution for a period of time in an orbital shaker in order to carry out the biosorption process.

The procedures employed in evaluating the parameters discussed above are explained below:

- ✓ Agitation time
- ✓ Biosorbent size
- ✓ pH
- ✓ Initial concentration
- ✓ Biosorbent dosage
- ✓ Temperature

3. Results and Discussion

3.1 Effect of Agitation Time

From the graph obtained by plotting the percent biosorption of Lissamine Blue dye versus agitation time, as shown in Figure 1, the equilibrium agitation time can be determined at an interval of 3 to 180 minutes. The sizes of the biosorbents used were 53 µm with a concentration of 10 g/L (0.5 g of biosorbent with 50 mL of water). Initially, the rate of biosorption was fast. For the first 40 minutes, there was an increase in percent elimination rate of the dye. Thereafter, the percent of biosorption remained relatively constant indicating that equilibrium had been achieved. From the initial dye concentration (C0) of 20 ppm, there is an achievement of maximum percent biosorption clearance of approximately 75% [6].

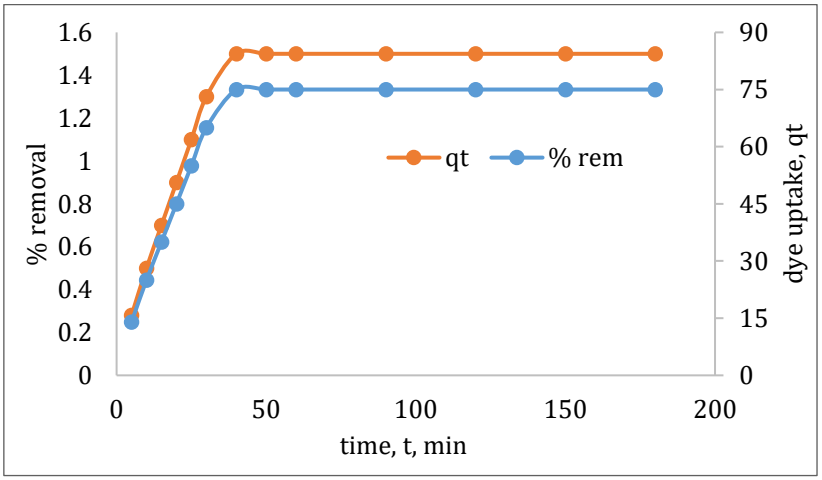

Figure 1. Effect of time on % removal of dye.

3.2 Effect of Biosorbent Size

The variations in the size of the biosorbent particles and the percentage biosorption of Lissamine Blue dye from the solution are determined. As illustrated in Figure 2 below, this is based on how much the percentage biosorption of Lissamine Blue dye depends on the particle size. It can be seen that by reducing the size from 150 µm to 53 µm, the percentage biosorption increased from 52% to 75% [7].

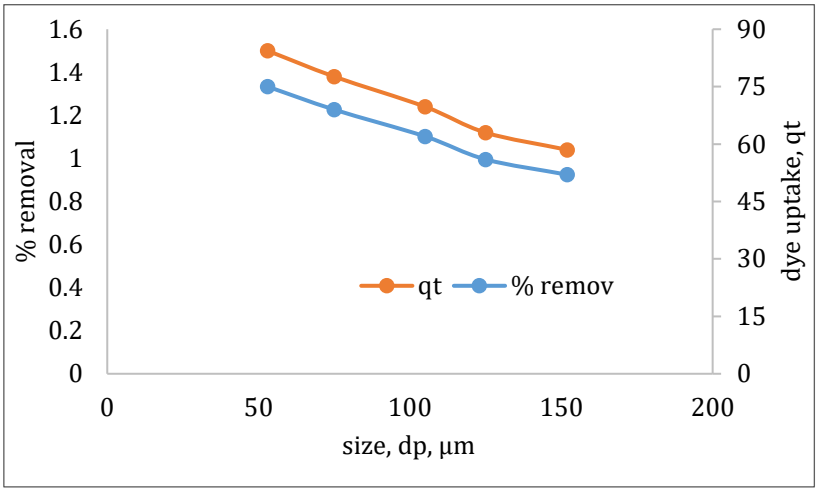

Figure 2. Effect of size on % removal of Lissamine Blue dye.

3.3 Effect of pH

Figure 3 shows how the pH of the solution influences the % biosorption of the Lissamine Blue dye. As can be seen from Figure 3, the influence of the pH on the % biosorption is very pronounced. The most effective biosorption was observed at a pH of 4, where about 87% of the dye was adsorbed. As the pH increases, the % biosorption falls down to approximately 70% [8].

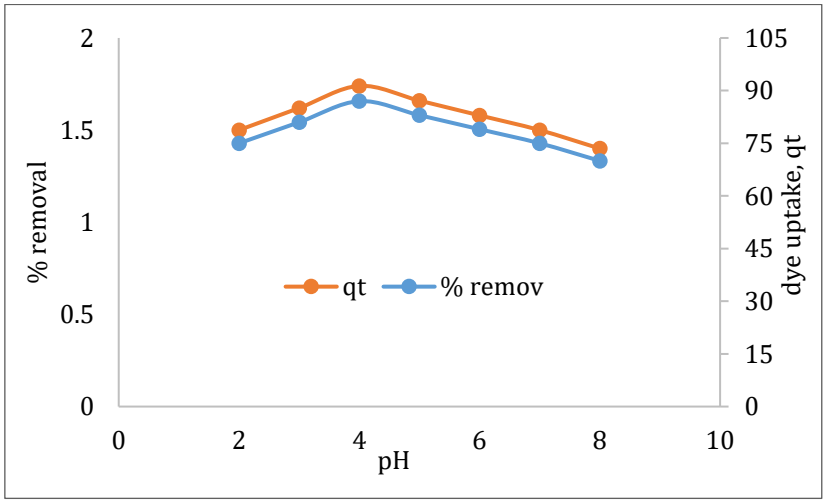

Figure 3. Effect of pH on % removal of Lissamine Blue dye.

3.4 Effect of Initial Concentration of Lissamine Blue Dye

In Figure 4, the influence of the concentration of Lissamine Blue dye on the aqueous solution on the percentage of the biosorption of Lissamine Blue dye is demonstrated. An increase in the value of C0 from 20 mg/L to 150 mg/L decreases the percentage biosorption of Lissamine Blue dye from 87 % to 65 %. It can be attributed to the increase in the concentration of the biosorbate to a constant number of sites on the biosorbent [9].

3.5 Effect of Biosorbent Dosage

Figure 5 presents the biosorption of Lissamine Blue dye in relation to the dose of biosorbent when the biosorbent is of size 53µm. From Figure 5, it can be observed that when the dose of biosorbent is increased from 10g/L to 30 g/L, the biosorption of Lissamine Blue dye increases from 87% to 95%. On increasing the value of "w" from 30g/L to 80g/L, there is very minimal change in the percentage of biosorption of Lissamine Blue dye i.e. from 95% to 96.5% [10].

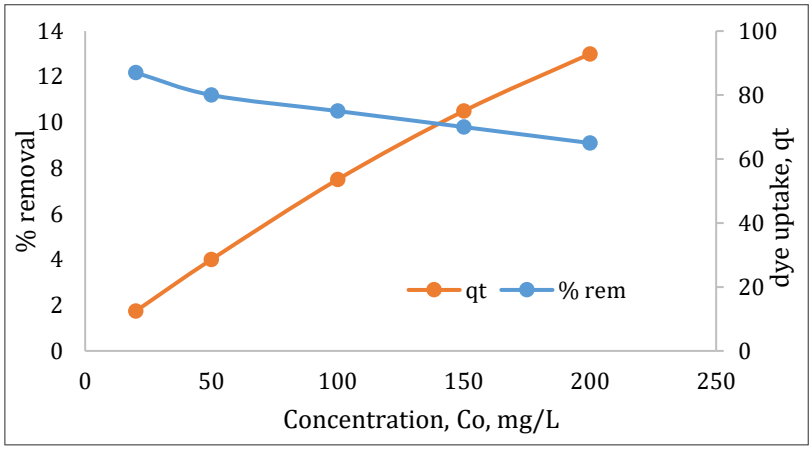

Figure 4. Effect of initial concentration on % removal of Lissamine Blue dye.

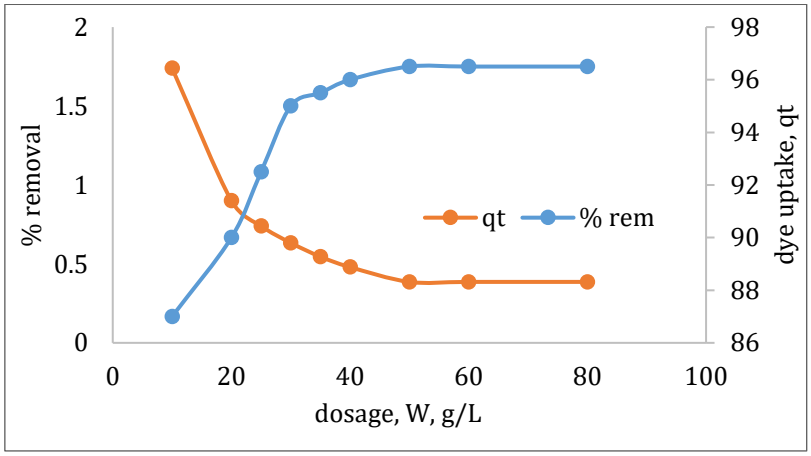

Figure 5. Effect of dosage on % removal of Lissamine Blue dye.

3.6 Effect of Temperature

The dye's uptake equilibrium was greatly affected by temperature. Figure 6 shows the effect of temperature changes on the absorption of the Lissamine Blue dye. The absorption of the Lissamine Blue dye increased with an increase in temperature up to 303K; otherwise, the same was observed to decrease beyond 303K. This implied that there was a different interaction between the dye and the ligands of the cell wall [11].

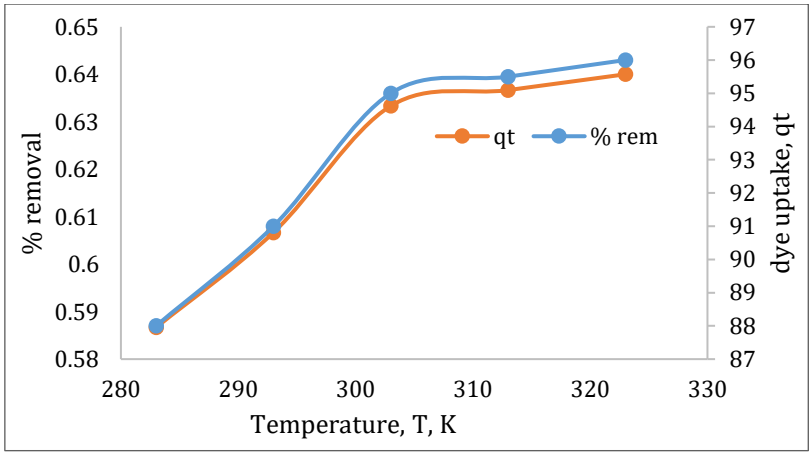

Figure 6. Effect of temperature on % removal of Lissamine Blue dye.

3.7 Isotherms Studies

3.7.1 Langmuir Isotherm

A Langmuir isotherm is plotted from the present data in Figure 7 between (Ce/qe) and Ce.
It gives the equation as:

$Ce/qe = 0.0544\ Ce + 1.7387,\ R^2 = 0.9687$

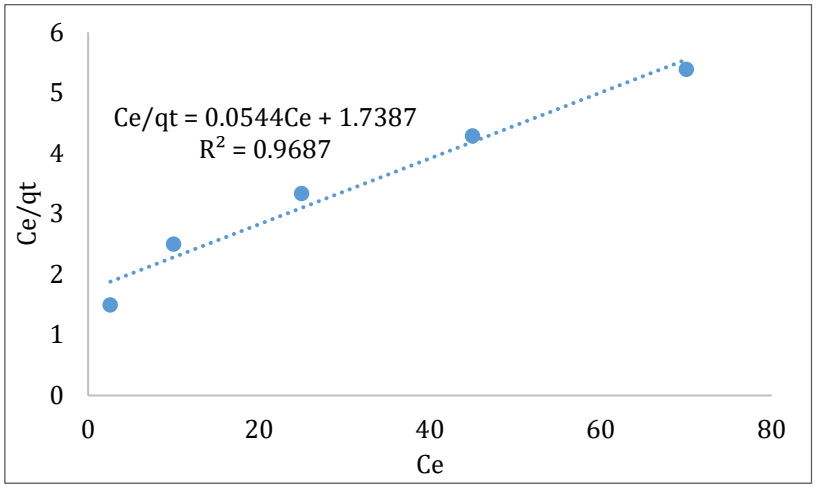

Figure 7. Langmuir isotherm.

3.7.2 Freundlich Isotherm

For Freundlich isotherm, the present data have been plotted between ln Ce and ln qe as presented in Figure 8 [12-13]. It results in the equation:

ln qe = 0.6208 ln Ce - 0.03, R^2 = 0.9983

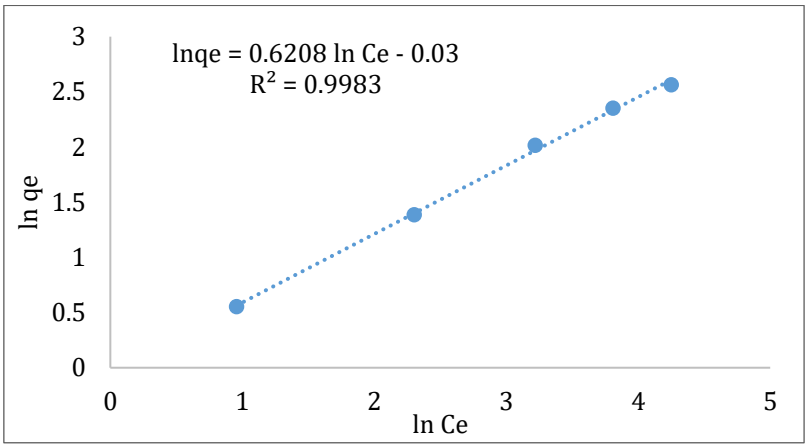

Figure 8. Freundlich isotherm.

3.7.3 Temkin Isotherm

The present data have been used to obtain the equation for Temkin isotherm, the plot of which is presented in Figure 9. The results in the equation:

qt = 3.406 ln Ce – 2.5512, R^2 = 0.9438

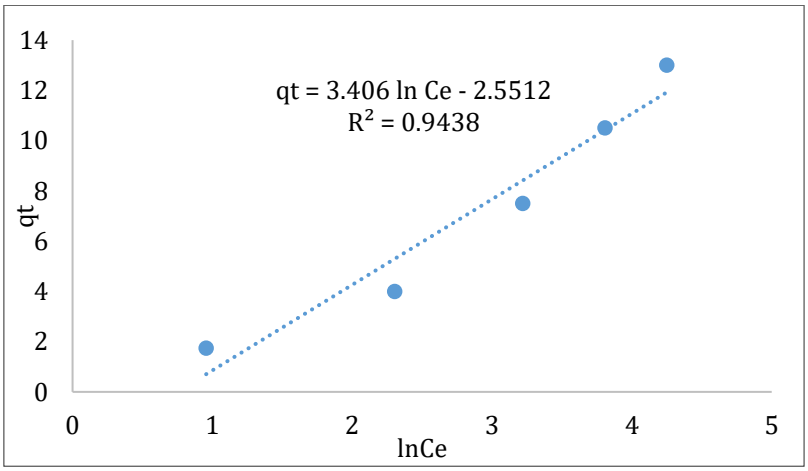

Figure 9. Temkin isotherm.

3.8 Kinetics Studies

3.8.1 First Order Kinetics

The order of adsorbate – adsorbent interactions have been described using kinetic models. Applying the initial condition qt = 0 at t = 0, we get log (qe – qt) = log qe – (K_1/2.303) t [14]. Plot of log (qe–qt) versus 't' gives a straight line for first order kinetics, facilitating the computation of first order rate constant (K_1). If the experimental results do not follow the above equation. The resulting equation is:

$\log(qe-qt) = -0.03t+0.303$, $R^2 = 0.9393$

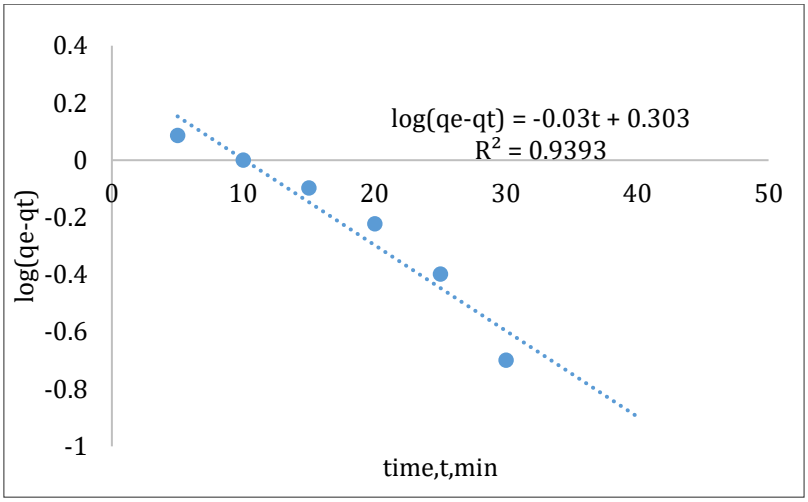

Figure 10. First order kinetics studies of Rose Bengal dye.

3.8.2 Pseudo Second Order Kinetics

If the pseudo second order kinetics is applicable, the plot of (t/qt) versus 't' gives a linear relationship that allows computation of qe and K_2. In the present study, the kinetics are investigated with 50 mL of aqueous solution (C0= 20 mg/L) at 303 K plot between (t/qt) and 't' for 53 µm [15]. Pseudo second order kinetic equation: Rearranging the terms, we get the linear form as: (t/qt) = (1/ K_2qe^2) + (1/qe) t. The resulting equation is:

$t/qt = 0.2004t + 17.711$, $R^2 = 0.8983$

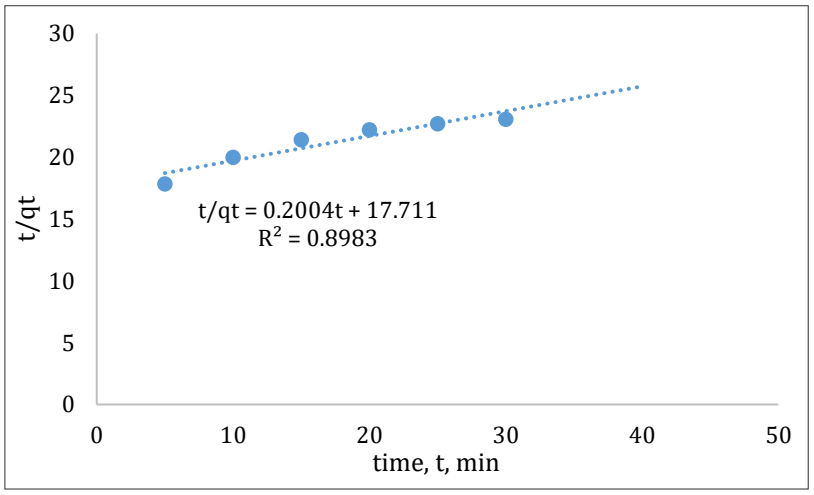

Figure 11. Second order kinetics studies of Rose Bengal dye.

3.9 Thermodynamics Studies

Preliminaries are directed to understand the Rose Bengal dye removal varying the temperature from 283 to 323 K [16]. The Van't Hoff plots showing the effect of temperature on removal of nickel metal is showed up in Figure 12. The resulting equation is:

$\log(qt/Ce) = -1.2464/T +3.8167$, $R^2 = 0.9265$

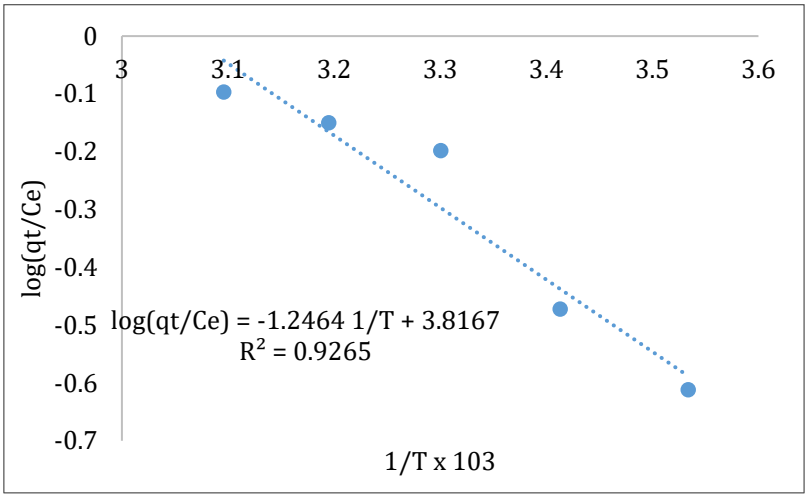

Figure 12. Thermodynamics studies of Rose Bengal dye.

4. Conclusions

In this research, we explored whether *Parthenium hysterophorus* powder can be used as a biosorbent for removing Lissamine Blue dye from water solutions, both experimentally and theoretically as a result of which the following results were derived: Equilibrium time of agitation required for dye biosorption is 40 min; increasing the biosorbent particle size from 53 µm (75%) to 152 µm (52%) reduces biosorption percentage of Lissamine Blue dye; the percentage biosorption of dye from the solution increases significantly with rising pH from 4 (87%) to 8 (70%); optimal dosage required for biosorption is 30 g/L. Therefore, we can conclude that *Parthenium hysterophorus* powders listed above can be considered as a strong biosorbent able to remove dye Lissamine Blue.

Declarations

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Author Contributions: CAIR: Conceived and supervised the study, designed the experimental methodology, interpreted adsorption, equilibrium, kinetic, and thermodynamic results, critically reviewed and edited the manuscript, and approved the final version; JA: Conducted laboratory experiments, prepared *Parthenium hysterophorus* powder biosorbent and Lissamine Blue dye solutions, performed batch adsorption studies, collected experimental data, analyzed adsorption parameters, and contributed to manuscript drafting; RMK: Assisted in experimental data processing, literature review, interpretation of adsorption isotherm and kinetic studies, preparation of figures and tables, and manuscript revision; IMD: Contributed to literature review, interpretation of findings, manuscript editing, critical revision for intellectual content, and approved the final manuscript.

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References

1. Achak, M., Hafidi, A., Ouazzani, N., Sayadi, S. and Mandi, L. 2009. Low cost biosorbent "banana peel" for the removal of phenolic compounds from olive mill wastewater: Kinetic and equilibrium studies. Journal of Hazardous Materials, 166(1): 117-125.

2. Belala, Z., Jeguirim, M., Belhachemi, M., Addoun, F. and Trouvé, G. 2011. Biosorption of basic dye from aqueous solutions by date stones and palm-trees waste: Kinetic, equilibrium and thermodynamic studies. Desalination, 271(1-3): 80-87.
3. Brinza, L., Geraki, K., Breaban, I.G. and Neamtu, M. 2019. Zn adsorption onto Irish *Fucus vesiculosus*: Biosorbent uptake capacity and atomistic mechanism insights. Journal of Hazardous Materials, 365: 252-260.
4. Aksu, Z., Tatlı, A.İ. and Tunç, Ö. 2008. A comparative adsorption/biosorption study of Acid Blue 161: Effect of temperature on equilibrium and kinetic parameters. Chemical Engineering Journal, 142(1): 23-39.
5. Patel, R. and Suresh, S. 2008. Kinetic and equilibrium studies on the biosorption of reactive black 5 dye by *Aspergillus foetidus*. Bioresource Technology, 99(1): 51-58.
6. Hammari, A.M., Abubakar, H., Misau, M.I., Aroke, U.O. and Hamza, U.D. 2020. Adsorption equilibrium and kinetic studies of methylene blue dye using groundnut shell and sorghum husk biosorbent. Journal of Environmental Bioremediation and Toxicology, 3(2): 32-39.
7. Deniz, F. and Saygideger, S.D. 2010. Equilibrium, kinetic and thermodynamic studies of Acid Orange 52 dye biosorption by *Paulownia tomentosa* Steud. leaf powder as a low-cost natural biosorbent. Bioresource Technology, 101(14): 5137-5143.
8. Kocaman, S. 2020. Removal of methylene blue dye from aqueous solutions by adsorption on levulinic acid-modified natural shells. International Journal of Phytoremediation, 22(8): 885-895.
9. Akkaya, G. and Güzel, F. 2014. Application of some domestic wastes as new low-cost biosorbents for removal of methylene blue: Kinetic and equilibrium studies. Chemical Engineering Communications, 201(4): 557-578.
10. Ho, Y.S. and McKay, G. 1999. A kinetic study of dye sorption by biosorbent waste product pith. Resources, Conservation and Recycling, 25(3-4): 171-193.
11. Ho, Y.S., Chiang, T.H. and Hsueh, Y.M. 2005. Removal of basic dye from aqueous solution using tree fern as a biosorbent. Process Biochemistry, 40: 119–124.
12. Belmabrouk, H., Selmi, M., Alshahrani, T., Bajahzar, A. and Jabli, M. 2022. Experimental and theoretical study of methylene blue biosorption using a new biomaterial *Pergularia tomentosa* L. fruit. International Journal of Environmental Science and Technology, 19(12): 12039-12056.
13. Ncibi, M.C., Mahjoub, B. and Seffen, M. 2007. Kinetic and equilibrium studies of methylene blue biosorption by *Posidonia oceanica* (L.) fibres. Journal of Hazardous Materials, 139(2): 280-285.
14. Lima, E.C., Royer, B., Vaghetti, J.C., Simon, N.M., da Cunha, B.M., et al. 200. Application of Brazilian pine-fruit shell as a biosorbent to removal of reactive red 194 textile dye from aqueous solution: Kinetics and equilibrium study. Journal of Hazardous Materials, 155(3): 536-550.
15. Ouettar, L., Guechi, E.K., Hamdaoui, O., Fertikh, N., Saoudi, F. and Alghyamah, A. 2023. Biosorption of triphenyl methane dyes (malachite green and crystal violet) from aqueous media by alfa (*Stipa tenacissima* L.) leaf powder. Molecules, 28(8): 3313.
16. Sarma, J., Sarma, A. and Bhattacharyya, K.G. 2008. Biosorption of commercial dyes on *Azadirachta indica* leaf powder: a case study with a basic dye Rhodamine B. Industrial and Engineering Chemistry Research, 47(15): 5433-5440.

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