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ECO-FRIENDLY ADSORPTION OF MALACHITE GREEN DYE FROM AQUEOUS MEDIUM WITH TRIDAX PROCUMBENS

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Abstract-The adsorptive elimination of Malachite green dye from aqueous medium was assessed using Tridax procumbens as eco-friendly adsorbent. A batch adsorption experiment was performed to examine effects of temperature, agitation speed, pH, contact time, adsorbent quantity, and dye concentration. After estimating experimental data using kinetic analysis and adsorption isotherms, it was discovered that the Freundlich isotherm model and pseudo-2nd-order kinetics perfect suit the data. Tridax procumbens, can utilized as an alternative to expensive adsorbents for the removal of malachite green from aqueous medium, according to the experimental results and separation factor R_L.

Keywords: Tridax procumbens, Bioadsorbent, Malachite green, Adsorption

I. INTRODUCTION

Wastewater containing poisonous dyes is typically treated using a variety of physio-chemical techniques, such as membrane filtration, precipitation, ozonation, irradiation, electrochemical destruction and electro-flotation [1]. But these techniques are costly, and small businesses cannot use them to treat large volumes of dye-containing wastewater [2]. The adsorption approach with adsorbent exhibits a more promising method for the treatment and removal of organic pollution in dirty wastewater among the many water purification procedures [3]. Adsorption has performed better than other techniques due to its simplicity of design and potential for low initial and land investment costs [4]. The demand for inexpensive agricultural adsorbents with the ability to bind pollutants has accelerated recently. Large quantities of various natural materials, as well as waste from industry and agriculture, can be used as inexpensive adsorbents. Because of its high porosity, activated carbon has a huge surface area, making it a more effective adsorbent material [5]. By altering the settings, coir pitch was able to adsorb the green coloring ingredient [6]. Waste jackfruit peel was employed as an adsorbent to remove Rhodamine B dye. When monolayer removing dyes, capacity was measured, it ranged from 4.361 to 1.98 mg/g [7]. Orange peel waste was used to study the adsorption of rhodamine B dye, Congo red, and procion orange [8]. Rhodamine B was similarly removed via adsorption using sodium monto morillonite clay [9]. The ability of 6RG to biosorb on almond shell was examined in relation to temperature, contact time, starting dye concentration, and pH change. Almond shell powder's dye removal capability was found to be 32.2 mg/g [10]. Animal bone meal, a cheap adsorbent, was likewise successful in removing rhodamine B through adsorption [11]. Activated carbon derived from rice husks, an agricultural waste, was used to adsorb rhodamine B color [12]. Fe_3O_4 modified by humic acid was created to eliminate rhodamine B. Rhodamine B was removed from water at an optimal pH of 98.5% [13]. The removal of reactive bright red dye from walnut shells that had undergone chemical modification was studied [14]. Investigations on the removal of methylene blue dye from aqueous solution using tea wastes revealed that the dye's removal capability was 461 mg/g [15]. The current experiment's goal is to investigate the mechanism of rhodamine B dye adsorption utilizing Tridax procumbens. The viability of applying this material as an inexpensive biosorbent to eliminate harmful rhodamine B dye was investigated. It was examined how temperature, contact time, initial dye concentration, pH, and rpm affected the results. The parameters of equilibrium, kinetics, and thermodynamics are examined.

II. MATERIAL AND METHODOLOGY

2.1 Adsorbent characterization: Tridax procumbens leaf was collected from farm and was kept for drying in sun rays. After that it was crushed in mixer and washed with water for several times, fine powder was kept in a container for experimental use. Adsorbent was analyzed using electron dispersive spectroscopy and scanning electron microscopy, Fourier Transform Infrared radiation for examine its shape, elemental composition and functional groups available on the adsorbent surface.

2.2 Adsorbate: Every necessary chemical was of high grade and was acquired from local chemical organization in Kolhapur, India. As a stock solution for the tests, 1 g of malachite green was dissolved in a thousand millilitres of double-distilled water. To achieve necessary dye solution concentration, the desired dilution was carried out.

Batch adsorption: For every experiment, 250 mL conical stopper flask with 100 mL of malachite green dye solutions with varying dye concentrations (3,6,9,12,15 mg/L) were used. Experiments were conducted using a horizontal shaker. Various amounts of bioadsorbent were used to optimize the adsorbent dosage. The effects of rotation and solution temperature on elimination of malachite green dye were also checked at various rotational speeds (50,60,70,80,90 and 100 rpm) and temperatures (30, 40, 50, 60,70 and 80 ºC). In order to investigate the bioadsorbent's ability to remove dye from water, the ideal contact time was also established. After 40 minutes, the Tridax procumbens reached equilibrium.

The Elico LI-120 pH meter was used to calibrate pH using 0.1 N HCl and 0.1 N NaOH, maintaining constant dye concentration of 15 m_g/L for the Tridax procumbens. Ideal parameters were 2 g of adsorbent,50^{o}C and 40 minutes of contact time.

The filtrate was examined for dye concentration (15 mg/L) following saturation. The Lab India Analytical UV 3000+Model UV spectrophotometer was utilized to check remaining concentration of malachite green dye. Both the concentration and absorbance of the dye solution were calibrated using a wavelength of λ = 617 nm. The formula which was used to know the dye removal % is written below.

Removal %=$\frac{C_O - C_e}{C_O} \times 100$

Where C_o = dye solution starting concentration (15 m_g/L).

C_e is the dye solution equilibrium concentration.

dye solution's equilibrium concentration. This is amount of malachite green dye retained per milligram of adsorbent

q=$\frac{(C_O - C_e)V}{M}$

where q is quantity of dye deposited (mg/g) per milligram of adsorbent; V is dye solution volume (L), and m is the biosorbent mass (g).

III. RESULT WITH DISCUSSION

3.1 SEM and EDX evaluation:

Through scanning electron microscopy, the porous and layered structure of the Tridax procumbens was visible (Fig. 1).

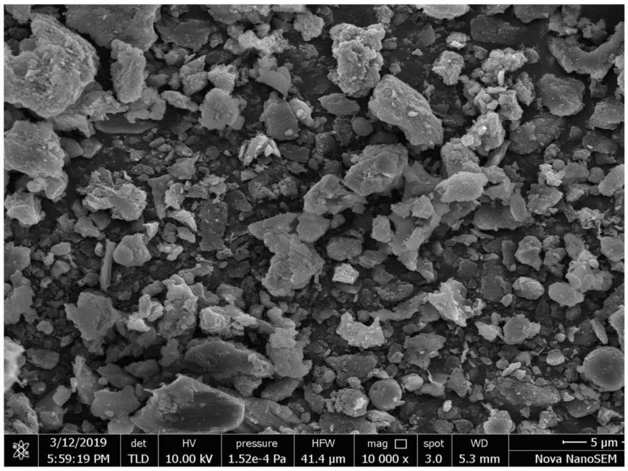

Fig.1 SEM image of Tridax procumbens

According to elemental analysis, the main sources of microorganisms are carbon and oxygen (Table 1).

TABLE-1 ELEMENTAL ANALYSIS Tridax procumbens

Element	Wt%	Element	Wt%
C	33.05	Ca	1.16
O	45.97	N	0.91
Si	09.35	Mg	3.15
Al	3.42	P	0.03

3.2 FTIR analysis

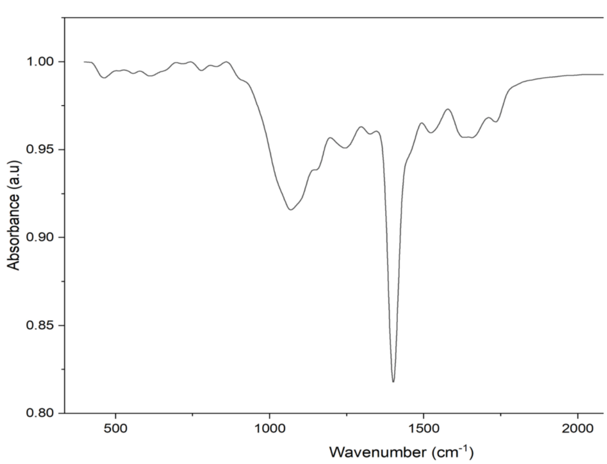

Fig.2 FTIR image of Tridax procumbens

The FTIR plot for Gliricidia Sepium is shown in Fig 2. The plot shows two major peak values. The peak point at 1200 $(cm)^{-1}$ possibly as a result of C-O stretching which shows presence of ether group. The peak point at 1400 $(cm)^{-1}$ probably as a result of of C=O stretching which shows presence of carboxylic acids.

3.3 Impact of initial concentration and contact time

Bioadsorbent Tridax procumbens, Fig. 3 illustrates how contact duration affects dye removal capacity. For the Tridax procumbens, the eradication capacity was higher for the first 10 minutes and decreases as the time goes on increasing, after which it became static. When aqueous dye concentration was increased from 3 to 15 m_g/L, the removal of dye capacity showed a declining tendency. As dye concentration went from 74 to 29%, the percentage elimination dropped. Positively charged ions may have perforated the adsorbent's surface with tiny pores, causing the dye to be removed quickly during the first 10 minutes. After 10 minutes, the rate of elimination reduced, and saturation was reached after 40 minutes.

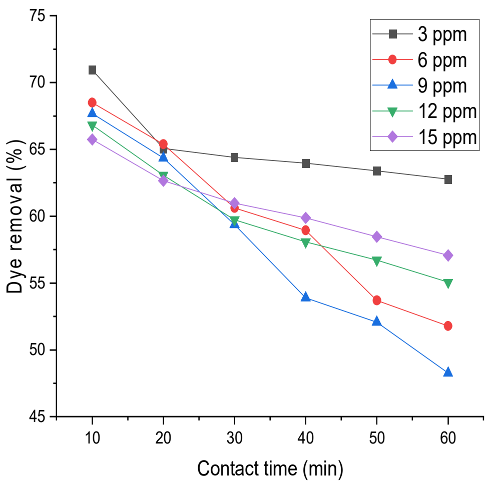

Fig.3 Impact of initial concentration and contact time

3.4 Impact of pH

To determine the adsorbent's removal capability, the dye's pH was adjusted between 4 and 8.

The maximum adsorbent capacity for dye removal occurred at pH 8 (Fig. 4). In contrast to lower pH, it was found that high pH enhanced the adsorption process.

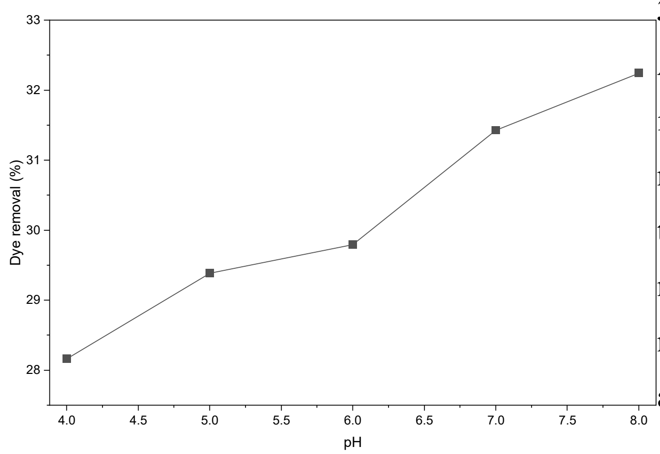

Fig 4 Impact of pH

3.5 Impact of dosage of adsorbent

The dose of the adsorbent ranged from 0.4 to 2.4 g. As adsorbent quantity rose, so did the clearance % of malachite green dye. Because there were more adsorption sites available, there was a greater chance of higher adsorption, increasing the dye removal from 45% to 75%.

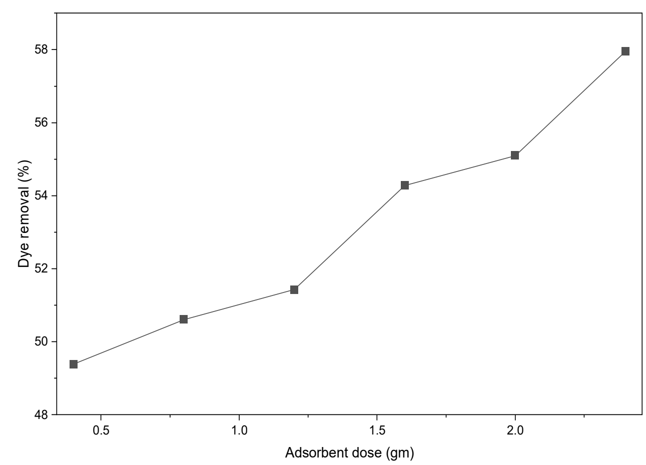

Fig.4 Impact of dosage of adsorbent

3.6 Impact of temperature

Adsorption is said to be endothermic when its rate rises as temperatures rise. This could result from the fact that when the temperature rises, more dye molecules migrate and the adsorbent's active sites multiply showed the greatest dye clearance at 40 ^{o}C.

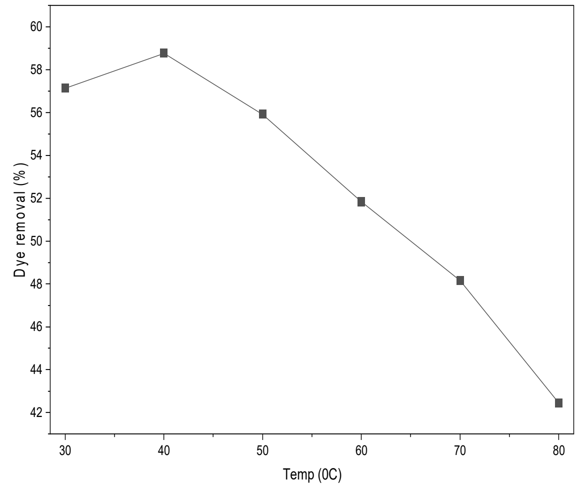

Fig.5 Impact of Impact of temperature

3.7 Impact of rotation per minute

To investigate the impact of rotation per minute (rpm) on adsorption, five distinct rpm values between 120 and 200 were used in the experiment. The effectiveness of dye removal increased with an increase in rpm. As rpm was raised, minimization in the resistance to boundary layer was noted, which aided in the transfer of the adsorbate molecule from the solution bulk to the adsorbent outer surface. As a result, the adsorbate is driven in the direction of adsorbent surface, intensifying adsorbent-adsorbate reaction and raising the two adsorbents capacity to remove dye at 200 rpm.

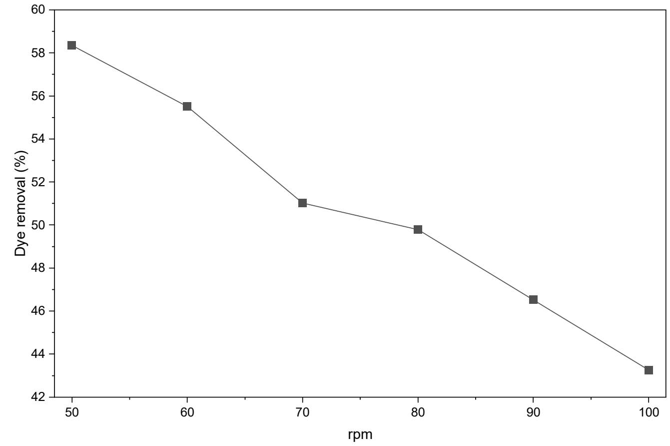

Fig.6 Impact of Impact of rotation per minute

4.Adsorption isotherms

The experimental data has been analyzed using isotherm study: the Langmuir isotherm model, the Freundlich isotherm model, and the Temkin isotherm model.The definition of a Langmuir isotherm is as follows:where Ce shows equilibrium concentration, At equilibrium, qe is number of moles adsorbed. The maximal adsorption capacity is given by aL/KL, where KL = Langmuir constants.The Langmuir isotherm's correlation coefficient was determined to be 0.404. The factor of separation Another crucial factor that determines the process's favorability is RL.Adsorption is irreversible when RL is zero, a favorable adsorption process is shown when $0 < RL < 1$, and no adsorption is seen when RL > 1. The dye adsorption's RL value of 0.078 indicated that the adsorption was favorable.

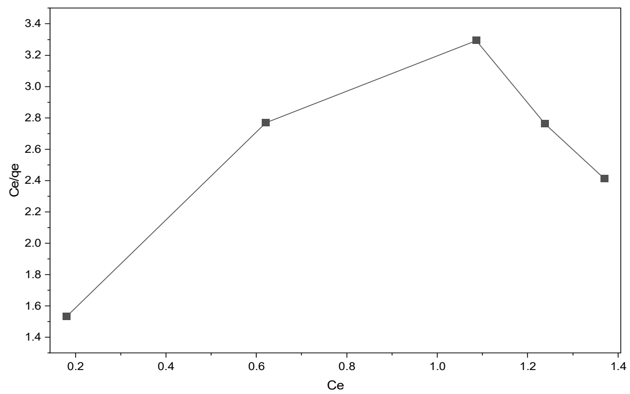

Fig.7 Langmuir Isotherm model

The definition of the Freundlich constant is as follows:

where 1/n is factor of heterogeneity, k_f is the Freundlich constant, and C_e and q_e are the values at equilibrium. The adsorption process Tridax procumbens was shown to have a correlation coefficient of 0.93174 for the Freundlich model.

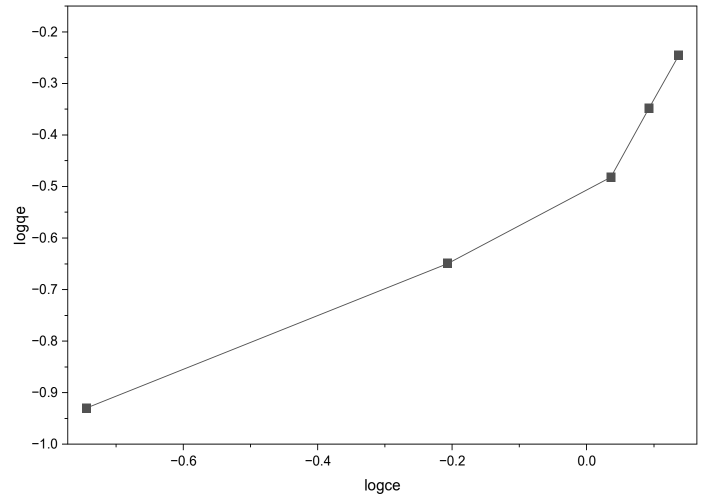

Fig.8 Freundlich Isotherm model

When degree of fulfillment of area of sorption of a bioadsorbent increases, Temkin isotherm expression shows linear decline in sorption energy. This model provides details on interaction between adsorbate and adsorbent and suggests that adsorption heat of all molecules will decrease linearly as a result of these intermolecular interactions. Here is a representation of the Temkin isotherm:

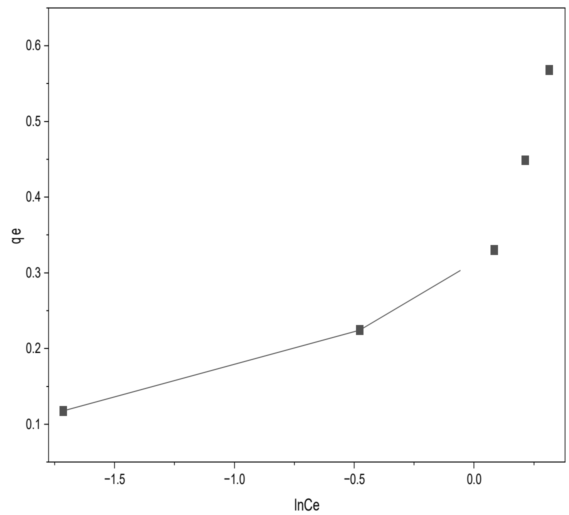

Fig.9 Temkin Isotherm model

It was discovered that correlation coefficient for dye adsorption process was 0.777. This model was shown to be appropriate for the process in comparison to the Langmuir isotherm. Kinetic study Pseudo first and pseudo second order: Kinetic studies can be used to examine the rate and mechanism of the adsorption process. The results of malachite green dye Tridax procumbens demonstrated that the adsorption rate of the dye molecules increased with increasing agitation time and speed. where qt is the dye concentration at time t and qe is the equilibrium concentration; the pseudo first and second order rate constants are denoted by k1 (min)-1 and k2 (g/mg min), respectively. The plot of ln (qe-qt) against contact time (t) displays a straight line if the adsorption process is characterized by first-order kinetics.

4. Kinetic Study

The following is a representation of the pseudo second order model:

where the pseudo second order model's rate constant is denoted by k2 (g/mg min). The applicability to the process would be verified by a linear plot of t/qt vs t. As a result, Tridax procumbens, the sorption process may be better suited by a pseudo second order kinetic model than a pseudo first order one.

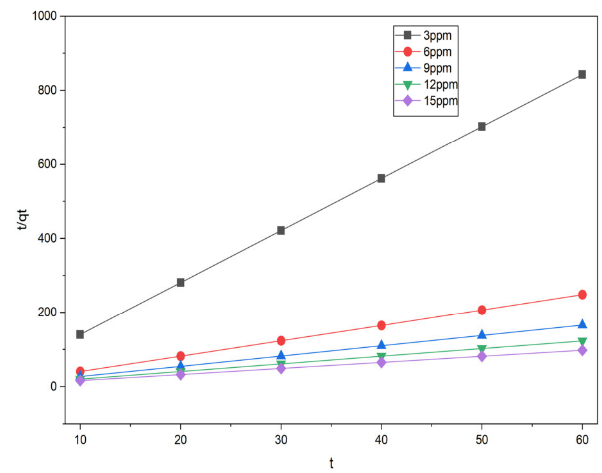

Fig.10 Pseudo second order model

Conclusion: Using inexpensive Tridax procumbens, the adsorption process of malachite green dye was investigated under ideal conditions. At 40 oC, the highest percentage of malachite green dye removal was attained. The Freundlich isotherm demonstrated a good fit to the kinetic data of the adsorption process, and the kinetic data was appropriate for pseudo second order for the bioadsorbent.

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