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# Adsorption of Reactive Yellow-14 dye from aqueous solution using Psophocarpus tetragonalobus: Characterization and Adsorption Studies

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**Abstract :** In the present work, Psophocarpus tetragonalobus Leaf Powder has been studied to evaluate its adsorption capacity onto Reactive Yellow-14 dye from aqueous solution. The influence of experimental parameters such as sorption dose, contact time and pH has been studied. The adsorption process represented with Freundlich, Langmuir and Temkin isotherms. The isothermal experimental data fitted with Langmuir and Temkin isotherms. The results indicated that the dye, Reactive yellow-14 strongly interacts with a Biomass based adsorbent; the Psophocarpus tetragonalobus leaf powder.
**Keywords :** Reactive Yellow-14 dye, Psophocarpus tetragonalobus leaf powder, adsorption, biomass, Isotherm.

## 1. Introduction

At present most of the natural water sources are polluted by industrial waste. If we not save the water properly it would leads to loss of biodiversity[1]. Since the dyeing technique was invented, colour effluents are the important source of water pollution .Wastewater offer considerable resistance for the dye biodegradation due to the presence of these heat and light stable dyes.[2]

Dyes can be classified as anionic, cationic and non-ionic, dyes are usually high coloured polymer and they are low bio degradable substance.[3]Reactive dyes have been a great concern for protecting the water eco system because many azo dyes and their breakdown products have been found toxic to aquatic life,carcinogenic and genotoxic[4]. To remove dyes from wastewater several treatment like adsorption, coagulation, photocatalytic degradation, ultrafiltration and ozonation are available.[5]

In recent years adsorption techniques for wastewater treatment have become popular due to their efficiency in the removal of pollutants.[6]Adsorption is widely used in the removal of pollutants from wastewater. The major advantage of an adsorption treatment for the control of water pollution are less investment interms of initial development cost, simple design, easy operation and free from toxic substances.[7]

Winged bean (Psophocarpus tetragonalobus L.), also called as God-sent vegetable, four angled bean and princess pea, has assumed considerable importance as a protein rich multipurpose crop, originated in South-East Asia countries, like India, Burma, Sri Lanka, Thai- land and Philippine. Winged beans can be grown has a green vegetable, tuber crops or forage cover crops

In this paper, Adsorption of Reactive Yellow-14 dye were studied by using the leaves of winged bean. Adsorption was studied without activationand the removal of dye was examined by dried leaves of winged bean.

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## 2.Materials and methods

The Winged bean leaves were collected from local fields. It was dried under sunlight for 3 days and were extensively washed with water for several times untilthe colour of the water becomes clear. After removing dirt from the leaves it was sieved to 400 micron and washed once with dilute HCl and washed few times with water.The washed biomass were then dried under sunlight for 1 day and stored in air tight containers.

### 2.1.Preparation of dye solution

RY-14 dye analytical grade was used without further purification.The dye stock solution was prepared by dissolving accurately weighed dye in distilled water to concentration of 1000mg/L. The experimental solution were obtained by diluting the dye stock solutions in accurate proportions to different concentrations.

### 2.2.Batch experiments

Batch experiments were carried out in 250 mL stoppered reagent bottles. 100 mL of different concentration of dye solutions were taken in reagent bottle and the biomass were added to each reagent bottle. It was then equilibrated for 3 hours in a rotary shaker and it was filtered. The supernatant liquid was then taken and its absorbance were noted by using UV-Visible Spectrophotometer. Parameters like biomass dose, contact time and effect of pH were studied.Further the work was extended to study adsorption isotherms.

## 3.Result and Discussion

### 3.1.Effect of biomass

Figure 1 shows the Effect of the adsorbent dosage on the adsorption of RY-14 dye by varying the amount of PTLP from 0.1-1.9 g, the adsorption capacity was increased by increasing the amount of adsorbent dose and the % of dye removal was maximum at 1.9 g (80.91%). The increase in percentage of dye removal was due to the sorption surface and adsorption sites.

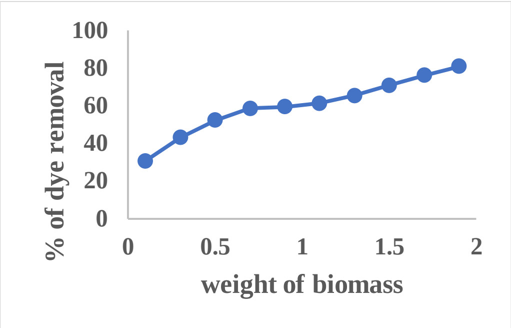


**Figure 1. Effect of sorbent dose on adsorption of RY-14 by PTLP(dye concentration: 100 mg/L; particle size: 400 µ; contact time: 4 hrs; pH: 7.0)**

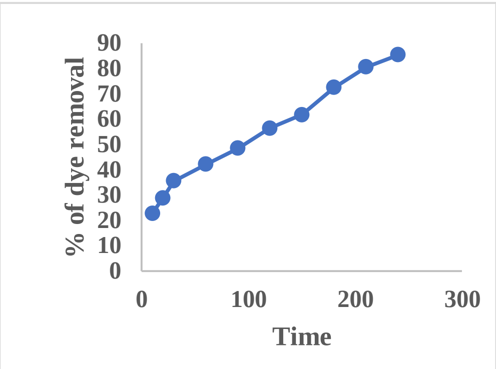


**Figure 2. Effect of equilibration period on adsorption of RY-14 by PTLP(sorbent dose: 1 g/100 mL; particle size: 400µ; contact time: 4hrs; pH: 7.0).**

### 3.2.Effect of contact time

The effect of contact time on the adsorption of RY-14 on PTLP is shown in Figure 2. The absorbance was noted at different time intervals (10-240 min) by taking 100 mL of 100 mg/L of dye solution.To this 1.0 gm of biomass powder is added separately.These bottles were agitated at regular time intervals.The contents were filtered and the filtrate is subjected for absorbance measurement.The result shows as the time increases the percentage of dye removal also increases.It was concluded that an equilibration period of 240 minutes were necessary for the maximum percentage of dye removal by PTLP and upto 85.34% of dyes were removed

### 3.3.Effect of pH

The Effect of pH on the dye removal was analysed over the range from 2-10. The pH was initially adjusted using 0.1N HCl and 0.1N NaOH solution. The dye adsorption on pH is shown in Figure 3, it can be observed that percentage adsorption was more (80.65%) at lower pH of 2 and decreased with increase in pH. This is due to high electrostatic attraction between positive charge of adsorbent and anionic adsorbate.

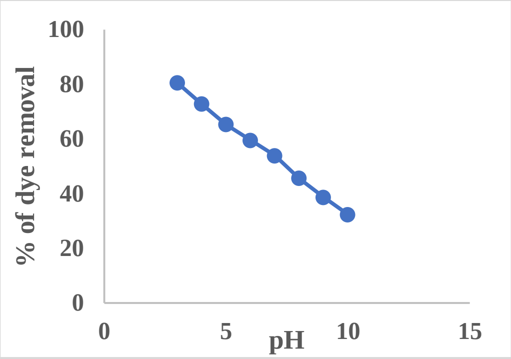


**Figure 3. Effect of initial pH on adsorption of RY-14 by PTLP(dye concentration: 100 mg/L; sorbent dose: 1 g/L; particle size: 400 µ, contact time: 4 hrs; Temperature 300 K).**

### 3.4.Adsorption isotherm

The equilibration data of RY-14 dye adsorption on PTLP was fitted with three isotherm models namely Freundlich, Langmuir and Temkin.Models with $R^2$ value close to unity is considered more appropriate to represent the experimental data.

### 3.4.1.Freundlich Adsorption Isotherm

Freundlich isotherm is an empirical equation which assumes that the adsorption process takes place on heterogeneous surface and adsorption capacity is related to the concentration of dye at equilibrium[8]. The linear form of Freundlich isotherm is expressed by the following equation,

$\log x/m = \log K_F + 1/n \log Ce$ ---------(1)

Where x-amount of dye adsorbed(mg), m-weight of adsorbent (mg), Ce-equilibrium dye concentration and $K_F$, 1/n are constants.A plot of log x/m versus log Ce was shown in Figure 4 . From the figure, it can be noted that the correlation coefficient value ($R^2$) obtained for RY-14 was 0.9059.

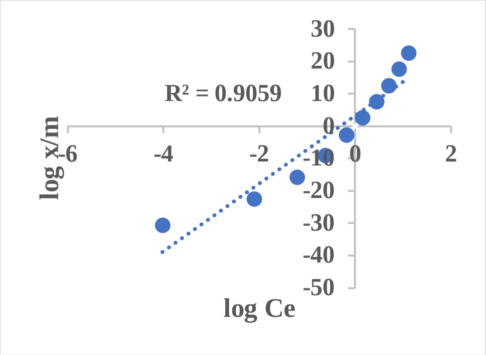


**Figure 4.Freundlich plot for the adsorption of RY-14**

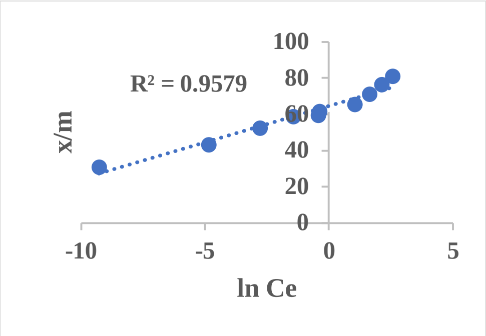


**Figure 5. Langmuir plot for the adsorption of RY-14**

### 3.4.2.Langmuir Adsorption Iostherm

Langmuir isotherm assumes that sorption occurs at specific homogeneous sites in the adsorbent and the adsorption capacity of the adsorbent is finite[8]. Langmuir adsorption isotherm is expressed by equation (2).

$$\frac{x}{m} = \frac{a\,.\,b\,.\,Ce}{1 + b\,.\,Ce} \qquad \text{---------}\ (2)$$

Where x-amount of dye adsorbed at equilibrium state, m-weight of adsorbent used, Ce-the equilibrium concentration of dye remaining, a-constant, b-Langmuir parameter

It was noted from the Figure 5 that the $R^2$ value for RY-14 dye was obtained as 0.9579,which is comparatively higher than Freundlich model and hence the model is applicable.

### 3.4.3.Temkin isotherm

Temkin isotherm was considered the effect of indirect adsorbate-adsorbent interactions and the layer should be increased linearly with coverage.[9]It can be seen from the Figure 6 that $R^2$ value for the adsorption of RY-14 dye was 0.9579, which is comparatively higher than Freundlich model and hence the model is applicable.

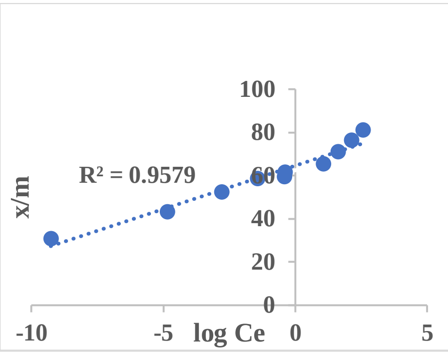


**Figure 6.Temkin plot for the adsorption of RY-14**

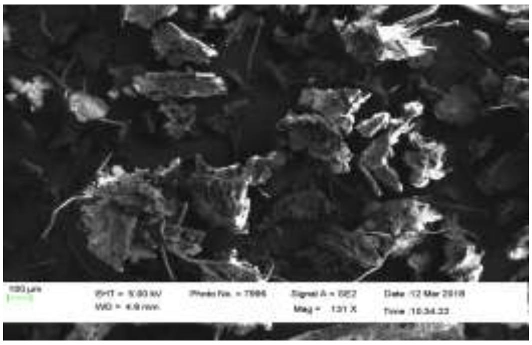

**Figure 7. SEM image of PTLP before adsorption of RY-14**

**3.5.SEM**

Figure 7 shows SEM micrograph of PTLP sample before adsorption.It shows that the PTLP possesses a rough surface morphology[10] with different pore sizes. It concludes that pores of different sizes are useful for RY-14 dye adsorption.

**Table 1. Effect of sorbent dose on adsorption of RY-14 by PTLP**

| S.No | Weight of biomass(g) | % of dye removal |
|---|---|---|
| 1 | 0.1 | 30.62 |
| 2 | 0.3 | 43.21 |
| 3 | 0.5 | 52.41 |
| 4 | 0.7 | 58.62 |
| 5 | 0.9 | 59.46 |
| 6 | 1.1 | 61.41 |
| 7 | 1.3 | 65.46 |
| 8 | 1.5 | 70.82 |
| 9 | 1.7 | 76.21 |
| 10 | 1.9 | 80.91 |

**Table 2. Effect of equilibration period on adsorption of RY-14 by PTLP**

| S.No | Time(min) | % of dye removal |
|---|---|---|
| 1 | 10 | 22.69 |
| 2 | 20 | 28.91 |
| 3 | 30 | 35.62 |
| 4 | 60 | 42.17 |
| 5 | 90 | 48.42 |
| 6 | 120 | 56.41 |
| 7 | 150 | 61.78 |
| 8 | 180 | 72.46 |
| 9 | 210 | 80.61 |
| 10 | 240 | 85.34 |

**Table 3. Effect of initial pH on adsorption of RY-14 by PTLP**

| S.No | pH | % of dye removal |
|---|---|---|
| 1 | 2 | 80.65 |
| 2 | 3 | 72.74 |
| 3 | 4 | 65.32 |
| 4 | 5 | 59.62 |
| 5 | 6 | 53.93 |
| 6 | 7 | 45.64 |
| 7 | 8 | 38.67 |
| 8 | 10 | 32.35 |

## Conclusion

The present study was carried out to evaluate the adsorption capacity of dye particles by using low cost PTLP.The study reveals that the parameters like sorption dose, contact time, pH have greater influence on the adsorption of RY-14 dye on PTLP. The optimum pH was found to be 2 for RY-14 dye[11].Freundlich, Langmuir and Temkin isotherm models were studied and it concludes that Langmuir and Temkin suitably fits experimental data and Freundlich becomes inapplicable. Hence, it can be concluded that, PTLP be a better adsorbent for removing RY-14 from aqueous solutions.

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