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# Biosorption of Eosin Yellow from an Aqueous Solution using *Lysiloma latisiliquum* seed powder: Kinetics and Isotherms

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**ABSTRACT:** Wild Tamarind (*Lysiloma latisiliquum*) Seed powder was used as adsorbent for removal of Eosin Yellow from aqueous solution. Experiments were carried out under various conditions like contact time, initial dye concentration, pH, dosage, temperature to evaluate the capability of the adsorbent for dye removal. The percentage of dye removal decreased with increase in initial dye concentration and increased with increase in biosorbent dosage. Kinetic studies were done using pseudo first order and second pseudo order models. The experimental data was well fitted for pseudo second order model. Langmuir, Freundlich and Tempkin models were used for analysing the equilibrium data. Maximum monolayer adsorption was observed to be 14.925 mg/g using Langmuir isotherm model.

**KEYWORDS:** *Lysiloma latisiliquum* (LL), Eosin Yellow (EY), Adsorption, Kinetic studies.

### I. INTRODUCTION

Textile industries consume massive volumes of water and chemicals for the wet process of textiles. The presence of very low concentrations of dyes in effluent discharged from these industries is highly visible and undesirable [1]. Dyes are widely used in industries including textile, printing, plastic, pharmaceutical, leather, paper and a food processing[2,3]. Most of the dyes are stable to light and oxidizing agents and non-biodegradable in nature[4]. Generally dyes are classified into three types (a) anionic: acid and reactive dyes (b) cationic: all basic dyes and (c) non-ionic: dispersed dyes. Eosin Yellow (EY) belongs to anionic dye that is used in wool and silk to give red color with a yellow fluorescence [5]. Eosin Yellow is a pink water soluble acid dye (anionic dye) which also displays yellow-green fluorescence and with wavelength of maximum absorbance of 517nm [6,7]. Even small amount of dye will harm not only marine but also human life. The majority of these dyes are of synthetic origin and toxic in nature with suspected carcinogenic and genotoxic effects [8-10]. Textile industries form the share of industries with the greatest problems associated with effluents due to their complex composition and elevated coloration [11]. Therefore, the dye content must be removed from the effluent water which is released from textile, paint industries. There are many conventional methods for removing dye content from industrial wastewater, for example adsorption, nano filtration, ozonation, and electro flotation [12-14]. Among these methods, adsorption has been found to be the best technique for waste water purification [15-17] because of its ease of operation, non-sensitivity to toxic substances and cost efficient. Carbon is used as adsorbent but the cost of the process increases due to the cost involved in the regeneration therefore the natural adsorbents are used in the process. The natural adsorbents main sourced from agricultural waste such as rice husk [18-24], Mango seeds [23], peanut husk [22], Moringaoliefera seeds[25], Coffee grounds [26]. Consequently, various types of biosorbent, which are able to bind dye molecules and be easily regenerated, have been extensively searched and tested [27,28].

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## II. MATERIALS AND METHODS

### 1. Chemicals:

Eosin Yellow is an anionic dye and is used in the present study. The dye is purchased from a local vendor. Stock solutions were prepared by dissolving 1.0g of EY in 1L of distilled water to form a 1g/L dye solution. Further, this solution is diluted in a serial manner to obtain required concentrations for the experiment. The pH of the solutions were adjusted using 0.1N NaOH and 0.1N HNO<sub>3</sub>.

### 2. Preparation of Biosorbent:

The seeds of *Lysiloma latisiliquum* are collected near Kolkata in West Bengal. The plant was rinsed with tap water to remove sand and fine dust particles. Later, it is washed several times with distilled water and dried in an oven drier at 65°C for about 72h. The dried seeds are then ground with a grinder and the powder obtain is stored in an air tight glass container and used for experimental purpose without any further pre-treatment.

### 3. Biosorption Studies:

Biosorption studies were performed in batch mode and were carried out in a 250mL conical flasks with 100mL of dye solution. The flasks were agitated using an orbital shaker for 2h for different time intervals at temperature of 30°C. The effect of contact time (1,3,5,10,15,20,25,30,40,50,60,,90,120,150, 180 mins), initial dye concentration (20, 50, 100, 150 mg/L), pH (2, 3, 4, 5, 6, 7, 8, 9), biosorbent dosage (0.5, 1.5, 2.0, 2.5 g) and temperature (25,30, 35, 40, 45 °C) was examined in the present study. Samples were taken at pre-determined intervals for measuring the final dye concentration in the solution. These samples were centrifuged to separate solid and liquid phases. The residual dye concentration was measured using a UV Spectrometer at an absorbance of 516.5nm. The amount of dye adsorbed onto the biosorbent was estimated using the following equations:

$$q = \frac{C_i - C_e}{m} V$$
$$\% \text{ removal} = \frac{C_i - C_e}{C_i} \times 100$$

where  $C_i$  is the initial dye concentration,  $C_e$  is the equilibrium dye concentration in solution (mg/L),  $V$  is the volume of solution (L) and  $m$  is mass of adsorbent (g).

### 4. Biosorption equilibrium & Kinetics:

The equilibrium and kinetic experiments were performed by adding 1.0g of biosorbent to 100mL of the Eosin Y dye solution with different initial concentration of 25mg/L, 50mg/L, 100mg/L, 150 mg/L at room temperature (30°C). The solutions were agitated at 180rpm using an orbital shaker for 120 mins which is sufficient to reach the equilibrium time. The samples were then subjected to centrifugation and were analyzed.

## III. RESULTS AND DISCUSSIONS

### 1. Effect of Contact Time:

The effect of contact time has been studied at temperature 303K, pH 5.5 and dye concentration of 50 mg/L. The results are represented in Fig 1 and it revealed that the adsorption rate was high initially till 30mins and reached constant rate at 60mins. Hence, the equilibrium time was taken as 60mins. This could be due to availability of active sites initially on the surface of biosorbent. Further experiments were carried out based on this equilibrium time.

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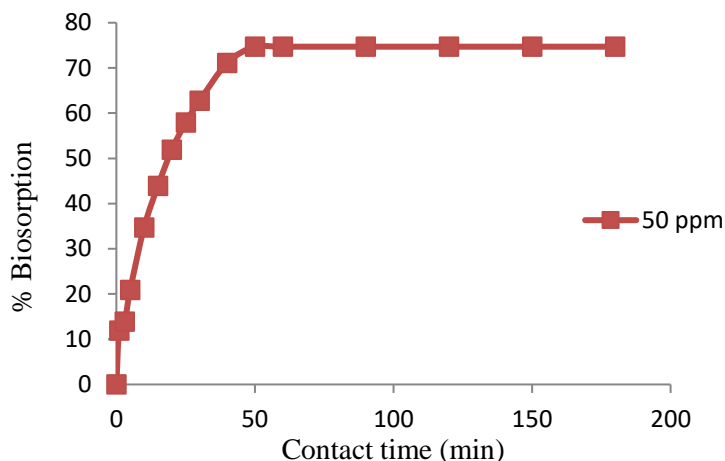


Figure 1. Effect of contact time on the adsorption of Eosin Yellow onto LL seed powder.

### 2. Effect of initial dye concentration and pH:

The dye uptake is mainly based on the initial dye concentration. The effects of initial dye concentration on removal of MG were shown in Fig 2. It was observed that biosorption capacity decreased from 79.71% to 61.33% as the initial concentration of MG increased from 20mg/L to 150mg/L.

The pH of the solution affects the binding sites present on the surface of the adsorbent. It also affects the adsorption process through dissociation of functional groups onto surface of the adsorbent. The effect of pH was studied with the initial concentration, contact time, amount of adsorbent and temperature were fixed at 20mg/L, 60mins, 1.0g and 303K respectively. The effects were illustrated in Fig 3. The pH were studies in the range of 2-9. The adsorption capacity increased from 71.58% to 83.98% in the pH range of 2-6 and decreased from 83.98% to 61.58% within the of 6-9.

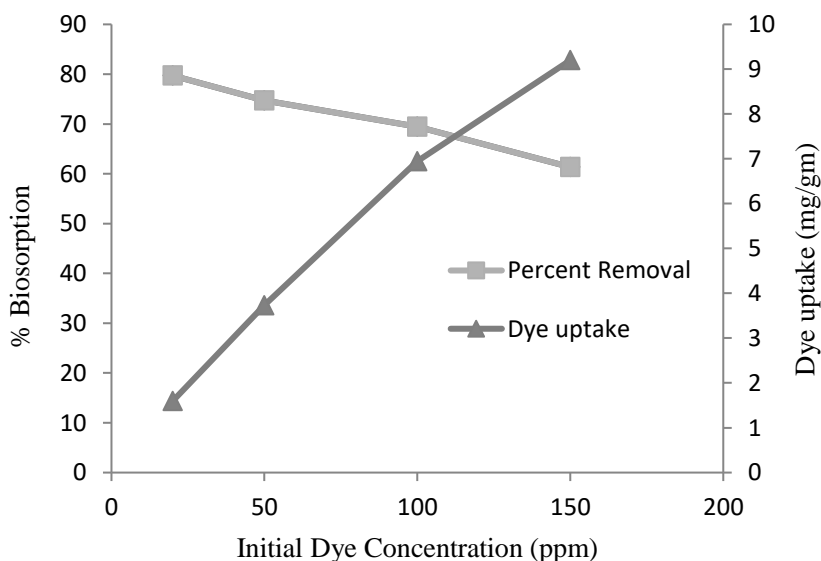


Figure 2. Effect of initial concentration on the adsorption of Eosin Yellow onto LL seed powder. (Experimental Data: Adsorbent Dosage = 1g/100mL, Contact time = 60 mins, Temperature = 303K).

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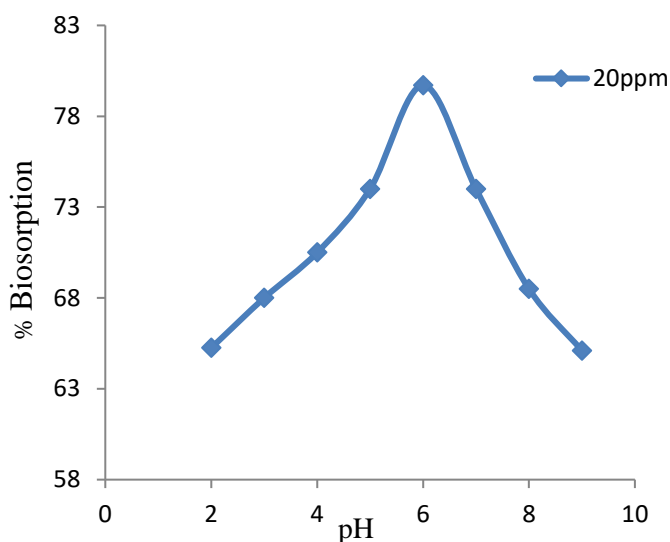


Figure 3. Effect of pH on the adsorption of Eosin Yellow onto LL seed powder.

### 3. Effect of adsorbent dosage:

Adsorbent dose is a vital parameter controlling adsorption process as it determines the adsorption capacity of an adsorbent. The effect of TO was studied in the range of 0.5g-2.5g. Fig 4 shows that the adsorption capacity increased 68% to 83% with increase in dose of adsorbent from 0.5g to 1.5g. This increase can be attributed to an increase in availability of sites available for adsorption. Further increase showed no significant rise in % biosorption. So, for further experiments, adsorbent dose was chosen as 1.5g.

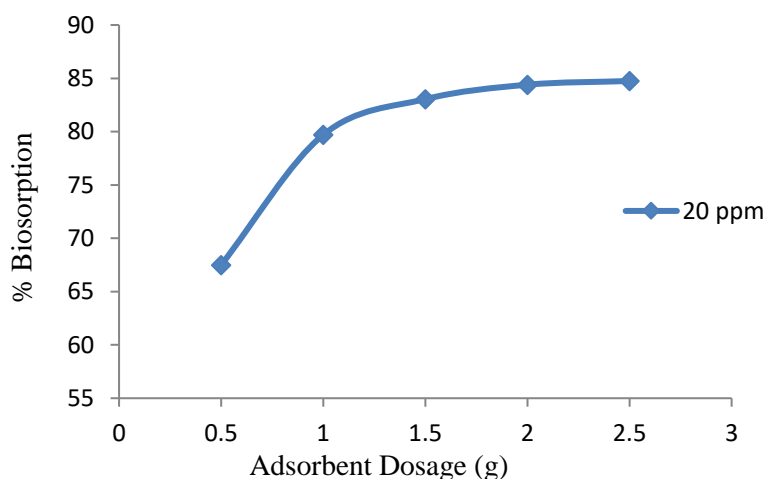


Figure 4. Effect of Adsorbent Dosage on the adsorption of Eosin Yellow onto WTS. (Experimental Data: Initial concentration = 20mg/L, Contact time = 60 mins, pH=6).

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#### 4. Effect of Temperature:

Temperature is one of the vital factors which affects the adsorption process. For a specific adsorbent dosage, increasing the temperature alters the equilibrium adsorption capacity. The investigations were illustrated in the Fig 5. It shows that with increase in temperature from 293K to 318K, biosorption capacity also increases from 75.25% to 86.6%.

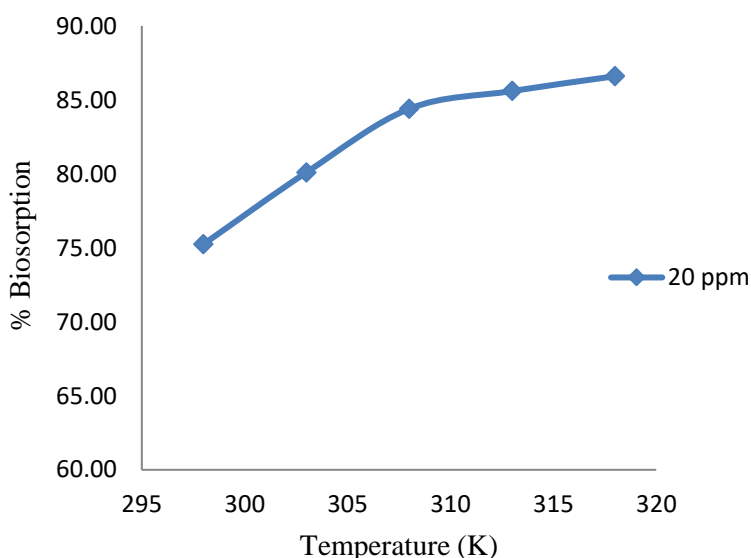


Figure 5. Effect of Temperature on the adsorption of Eosin Yellow onto WTS.

(Experimental Data: Adsorbent Dosage = 1.5g/100mL, initial concentration = 20mg/L, Contact time = 60mins, pH =6).

#### 5. Biosorption Kinetic Studies:

The kinetic studies provide vital information about the adsorption process mechanism. The two commonly used models are Lagergren's pseudo-first-order, Ho's pseudo-second-order models. The kinetics are thus investigated with the help of these two models and experimental data was analysed.

##### 5.1 Pseudo-first-order kinetic model:

The underlying assumption in the Pseudo-first-order kinetic model is that the rate of adsorption is directly proportional to the number of active sites available. The linear form of pseudo-first-order model is represented in the form:

$$\log(q_e - q_t) = \log q_e - K_1 t / 2.303$$

where  $q_e$ ,  $q_t$  are the amounts of dye adsorbed at equilibrium and time  $t$  (mg/g) and  $K_1$  ( $\text{min}^{-1}$ ) is the adsorption rate constant. From Fig 6.1, the correlation coefficient is low and thus suggest that the adsorption kinetics did not follow first-order kinetics.

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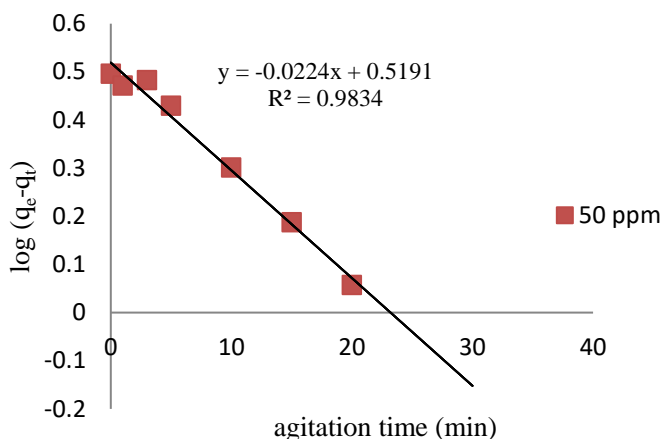


Fig 6.1. First Order plots for the adsorption of EY onto LL seed powder

### 5.2 Pseudo-second-order kinetic model:

This model is based on the assumption that the adsorption process follows chemisorption of second-order. The linear form of Pseudo-second-order model is of the form:

$$t/q_t = 1/K_2q_e^2 + t/q_e$$

where,  $K_2$  is the adsorption rate constant (g/ mg min),  $q_e, q_t$  are the amounts of dye adsorbed (mg/g) at equilibrium and time  $t$  (min), respectively. From Fig 6.2, the correlation coefficient has a higher value compared to first order and hence suggests that Pseudo-second-order kinetics is applicable for adsorption of MG onto LL seed powder. The parameters of the two kinetic models are represented in Table 1.

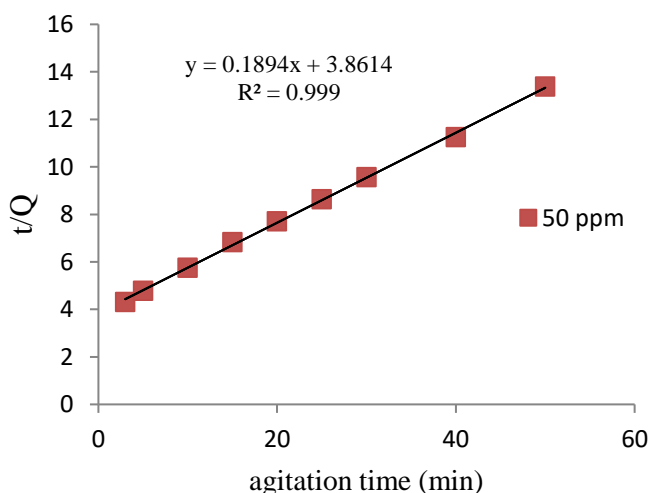


Fig 6.2. Pseudo Second Order plots for the adsorption of EY onto LL seed powder.

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**Table 1.**

Kinetic Parameters for adsorption of EY onto *Lysiloma latisiliquum* seed powder.

Conc MG (mg/L)	$q_e^{exp}$ (mg/g)	Pseudo-first-order			Pseudo-second-order		
		$q_e^{cal}$ (mg/g)	$K_1$ (min <sup>-1</sup> )	$R^2$	$q_e^{cal}$ (mg/g)	$K_2$ (min <sup>-1</sup> )	$R^2$
50	3.735	3.3044	0.051587	0.9869	5.279	0.0093	0.9993

### 6. Analysis of Isotherms:

Equilibrium isotherm equations are helpful in evaluating experimental data. The parameters obtained from these isotherm models gives us essential details about mechanism of adsorption process and surface characteristics of the adsorbent.

In this study, Langmuir, Freundlich, Temkin isotherm models were used for fitting the experimental data of adsorption of MG onto TO. Biosorption isotherm studies were performed by contacting 1.0g of Wild Tamarind Seeds powder with 100mL MG solutions of 20 mg/L concentration at pH 5.5 and temperature of 303K. The solution is agitated using orbital shaker at constant rpm of 180 for equilibrium time. Entire procedure is repeated for temperatures in the range of 298K to 318K.

#### 6.1 Langmuir Isotherm:

The underlying assumption in this model is that the adsorption process is homogenous and valid for adsorption of a solute from a liquid solution as monolayer adsorption on a surface containing a finite number of identical sites. The Langmuir isotherm is represented by the following equation:

$$C_e/q_e = 1/q_0b + C_e/q_0$$

where,  $C_e$  (mg/L) is the equilibrium concentration of MG,  $q_e$  (mg/g) is the amount of MG adsorbed at equilibrium time, and  $Q_0$  and  $b$  are Langmuir constants related to adsorption capacity and energy of adsorption, respectively. Results are presented in Fig 7.1

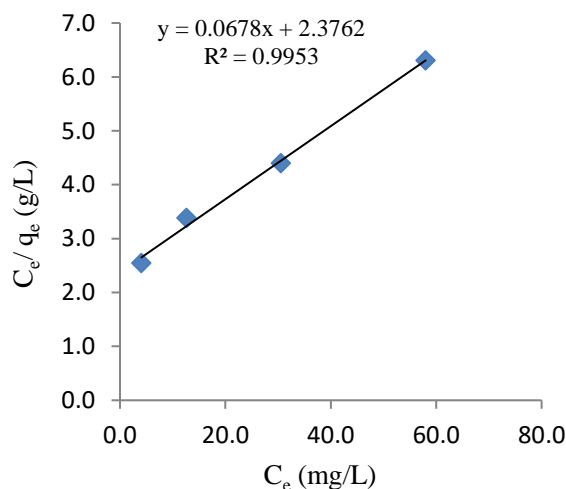


Fig 7.1 Langmuir adsorption isotherm for adsorption of EY onto LL seed powder.

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### 6.2 Freundlich Isotherm:

This is an exponential equation suggested for adsorption onto heterogeneous surfaces. It's expressed in the linear form as:

$$\ln q = \ln K + \frac{1}{n} \ln C_{eq}$$

where 'q' is the equilibrium biosorption capacity (mg/g),  $C_{eq}$  is the equilibrium concentration of the adsorbate in the solution. 'K' and 'n' are constants related to biosorption process such as biosorption capacity and intensity capacity. Fig 7.2 illustrates the experimental results.

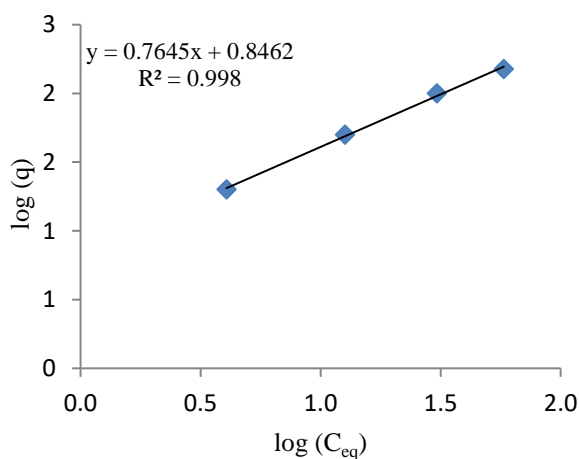


Fig 7.2 Freundlich adsorption isotherm for adsorption of EY onto WTS.

### 6.3 Temkin Isotherm:

It is based on the assumption that the heat of adsorption of all molecules in the layer decreases linearly due to indirect interactions between adsorbate and biosorbent. This model is expressed as:

$$q = \frac{RT}{b} \ln(A_T C_{eq})$$

where  $A_T$  (L/mg) and  $b$  are Temkin isotherm constants. 'T' is the absolute temperature in Kelvin and 'R' is the universal gas constant (J/mol.K).  $C_{eq}$  is the equilibrium concentration of the adsorbate. Fig 7.3 depicts Temkin isotherm plot. Various parameters obtained for different isotherm models were listed in Table 2.

**Table 2.**

Isotherm Parameters

Isotherm	Parameter	Values
Langmuir	$q_0$ (mg/g)	14.925
	$b$	0.028
	$R^2$	0.9953
Freundlich	$K$	7.0145
	$n$	1.308
	$R^2$	0.998
Temkin	$A_T$ (L/g)	1.176
	$B$ (KJ/mg)	14.906
	$R^2$	0.9759



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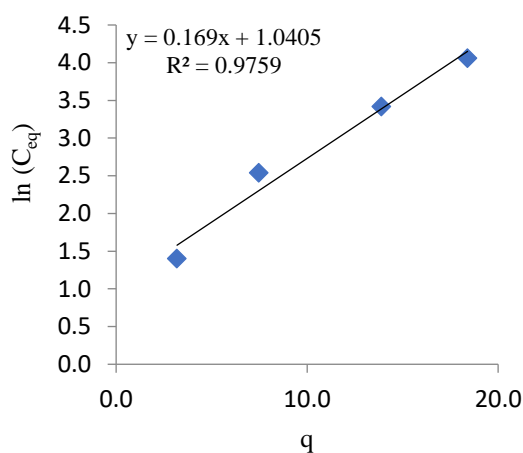


Fig 7.3 Tempkin adsorption isotherm for adsorption of EY onto WTS

#### IV. CONCLUSIONS

*Lysiloma latisiliquum* seed powder was effective for adsorption of Eosin Yellow under suitable conditions and thus serves as a useful adsorbent. The *Lysiloma latisiliquum* seeds are available conveniently in the open environment and are of negligible costs. The adsorption capacity was found to be optimum at pH 6 and the process followed Pseudo Second Order Kinetics. The experimental data were analysed using Langmuir, Freundlich and Tempkin isotherms. The Freundlich model fitted the best among the three and maximum adsorption capacity was found to be 14.925 mg/g.

#### REFERENCES

- [1] P. Nigam, G. Armour, I.M. Banat, D. Singh, R. Marchant, Physical removal of textile dyes from effluents and solid-state fermentation of dye-adsorbed agricultural residues, *Biores. Technol.* 72 (2000) 219–226.
- [2] Arzani Kaveh, Ashtiani BG and Kashi AHA. Equilibrium and Kinetic Adsorption Study of the Removal of Orange-G Dye Using Carbon Mesoporous Material. *Journal of inorganic materials.* 2012;27(6):660-666.
- [3] Li YH, Liu T, Du Q, Sun J, Xia Y, Wang Z and Wu D. Adsorption of cationic red X-GRL from aqueous solutions by graphene: equilibrium, kinetics and thermodynamics study. *Chemical and Biochemical Engineering Quarterly.* 2012;25(4):483-491.
- [4] Wang L, Zhang J, Zhao R, Li C, Li Y and Zhang C. Adsorption of basic dyes on activated carbon prepared from *Polygonum orientale* Linn: equilibrium, kinetic and thermodynamic studies. *Desalination.* 2010;254(1):68-74.
- [5] M.K.Purkait, S.DasGupta, S.De; *J.Envir.Manage.* 76, 135 (2005).
- [6] Ugbe, F. Audu, Ikudayisi, and V. Abiola, "Renewable energy: Wastewater nexus," *Edorium J. Waste Manag.*, vol. 2, pp. 5–11, Oct. 2017.
- [7] S. Chatterjee, S. Chatterjee, B. P. Chatterjee, A. R. Das, and A. K. Guha, "Adsorption of a model anionic dye, eosin Y, from aqueous solution by chitosan hydrobeads," *J. Colloid Interface Sci.*, vol. 288, no. 1, pp. 30–35, Aug. 2005.
- [8] P.C. Vandevivere, R. Bianchi, W. Verstraete, *J. Chem. Technol. Biotechnol.* 72 (1998) 289.
- [9] W.K. Walthall, J.D. Stark, *Environ. Pollut.* 104 (1999) 207.
- [10] K. Al-sabti, K. Ecotoxicol. *Environ. Saf.* 47 (2000) 149.
- [11] Iqbal M and Nisar J (2015) Cytotoxicity and mutagenicity evaluation of gamma radiation and hydrogen peroxide treated textile effluents using bioassays. *Journal of Environmental Chemical Engineering* 3: 1912–1917.
- [12] U. Rott, "Multiple use of water in industry—the textile industry case," *Journal of Environmental Science and Health Part A*, vol.38, no. 8, pp. 1629–1639, 2003.
- [13] Z. Houshyar, A. B. Khoshfetrat, and E. Fatehifar, "Influence of ozonation process on characteristics of pre-alkalized tannery effluents," *Chemical Engineering Journal*, vol. 191, pp. 59–65, 2012.

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Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 4, April 2019

- [14] D. Ghernaout, C. Benblidia, and F. Khemici, "Microalgae removal from Ghrib Dam (Ain Defla, Algeria) water by electroflotation using stainless steel electrodes," *Desalination and Water Treatment*, vol. 54, no. 12, pp. 3328–3337, 2015.
- [15] A. Aouni, C. Fersi, M. Ben Sik Ali, and M. Dhahbi, "Treatment of textile wastewater by a hybrid electrocoagulation/nanofiltration process," *Journal of Hazardous Materials*, vol. 168, no. 2-3, pp. 868–874, 2009.
- [16] A. Maljaei, M. Arami, and N. M. Mahmoodi, "Decolorization and aromatic ring degradation of colored textile wastewater using indirect electrochemical oxidation method," *Desalination*, vol. 249, no. 3, pp. 1074–1078, 2009.
- [17] M. Rafatullah, O. Sulaiman, R. Hashim, and A. Ahmad, "Adsorption of methylene blue on low-cost adsorbents: a review," *Journal of Hazardous Materials*, vol. 177, no. 1, pp. 70–80, 2010.
- [18] Rajeev jain, meghamathur and shalinisikarwar, "Removal of indigo carmine from industrial effluents using low cost adsorbent," *Environmental Progress & Sustainable Energy*. Vol.31: pp 258-263 2012.
- [19] Maghri, A. Kenz, M. Elkouali, O. Tanane and M. Talbi, "Textile Dyes removal from industrial waste water by mytilusedulis shells," *J. Mater. Environ. Sci.* Vol. 3: pp121-136 2012.
- [20] Chang SookKeng, ZulkarnainZainal and Abdul Halim Abdullah, "Removal of Cationic and Anionic Dyes by Immobilised Titanium Dioxide Loaded Activated Carbon," *The Malaysian Journal of Analytical Sciences*. Vol. 12: pp 451 – 457 2008.
- [21] Beltra'n-Heredia, J. Sa'nchez-Marti'n, and A. Delgado-Regalado, "Removal of Carmine Indigo Dye with *Moringaoleifera* Seed Extract," *Ind. Eng. Chem. Res.* Vol.48: pp 6512–6520 2009.
- [22] Ivo Safarika and MirkaSafarikova, "Magnetic fluid modified peanut husks as an adsorbent for organic dyes removal," *Physics Procedia*. Vol. 9: pp 274–278 2010.
- [23] Mohamad RasoolMalekbala, Salman MasoudiSoltani, Sara KazemiYazdi, and SorayaHosseini, "Equilibrium and Kinetic Studies of Safranin Adsorption on Alkali-Treated Mango Seed Integuments," *International Journal of Chemical Engineering and Applications*. Vol. 3: pp 160-166 2012.
- [24] Papita Das Saha and Rahul Mishra, "Adsorption of safranin onto chemically modified rice husk in a upward flow packed bed reactor: artificial neural network modeling," *Elixir Pollution*. Vol. 44: pp 7579-7583 2012.
- [25] Beltra'n-Heredia, J. Sa'nchez-Marti'n, and A. Delgado-Regalado, "Removal of Carmine Indigo Dye with *Moringaoleifera* Seed Extract," *Ind. Eng. Chem. Res.* Vol.48: pp 6512–6520 2009.
- [26] Ivo Safarik, Katerina Horska, BarboraSvobodova and MirkaSafarikova, "Magnetically modified spent coffee grounds for dyes removal," *Eur Food Res Technol.* Vol. 234: pp 345–350 2012.
- [27] S.W. Won, S.B. Choi, B.W. Chung, D. Park, J.M. Park, Y.-S. Yun, Biosorptive decolorization of Reactive Orange 16 using the waste biomass of *Corynebacterium glutamicum*, *Ind. Eng. Chem. Res.* 43 (2004) 7865–7869.
- [28] S. Karcher, A. Kornmüller, M. Jekel, Screening of commercial sorbents for the removal of reactive dyes, *Dyes Pigments* 51 (2001) 111–125.