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# Removal of Reactive Blue 82 dye from Aqueous Solution with Adsorption Technique using Organic Adsorbents

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***Abstract*—This study was aimed to use Gigantia Leaves (GL), Curcuma Longa Leaves (CLL), Morienga Oleifera (MO) and Citrus Sinensis (CS) as a potential adsorbents to remove C.I. Reactive Blue 82 dye from aqueous solution. The adsorption of Reactive Blue 82 on adsorbents was studied as a functions of dose (50-300 g/L), pH solution (2-12), contact time (30 min). The influence of these parameters on the adsorption capacity was studied using the batch process. The corresponding results showed that excellent colour removal of Reactive Blue 82 can be achieved with adsorbents at optimum pH of 2. The maximum colour of Gigantia Leaves, Curcuma Longa Leaves, Morienga Oleifera and Citrus Sinensis was 90.36%, 80%, 75.81% and 70.90% respectively.The experimental data were analyzed by the Langmuir, Freundlich isotherms, Kinetic studies, and Interruption studies. Results show that the data fitted well with the Freundlich isotherm. The kinetics of Reactive Blue 82 adsorption onto adsorbents was examined using the pseudo-first and pseudo-second order.The adsorption kinetics followed the pseudo-second order kinetic modelwhich implies that chemisorption is the rate limiting step. Pore diffusion seems to be the rate controlling in the sorption process as indicated by interruption studies.**

***Keywords*— Adsorption, C.I.Reactive Blue 82, Gigantia Leaves, Curcuma Longa Leaves, Moringa Oleifera, Citrus Sinensis**

## I. INTRODUCTION

Synthetic dyes are widely used in industries, producing a large amount of toxic, carcinogenic, mutagenic, bio-accumulative wastewaters that pollute the environment [1].Their discharges into effluents involve a significant source of pollution dueto their recalcitrance nature. Furthermore dyes may impart toxicityto aquatic and plants biota and may be mutagenic and carcinogenic,causing severe damage to human life; such as disfunction of kidneys, reproductive system, liver, brain, and central nervous system [2]-[3]-[4]. A majority of the used dyes are azo dyes which are bright in colour due to the presence of one or several azo (–N=N–) groups associated with substituted aromatic structures [5]. Therefore, efficient and effective treatment approaches are necessary to overcome these problems.

At present, many treatment technologies, such as adsorption, flocculation, super filter film, oxidation and electrolysis, have been employed for dye removal from wastewaters. Amongthem,adsorptionis considered tobesuperiorbecauseofthehighefficiency and subsequently economical value [6]. Activated carbon, the prevalent adsorbent, is effective for dye removal. However, because of its high price and hard regeneration the wide applications of activated carbon were limited [7]-[8]-[9]-[10]. Thus, more economic, efficient and practical adsorbents are necessary for the dye removal.

Inrecentyears,manyplantmaterialshavebeentestedaslow-costadsorbentsforvarious dyes. Forinstance, wheat straw [11], barleystraw [12], ricestraw [13], ricehusks [14], sawdust [15], teawaste [16], peanuthusks [17], spentcoffeegrounds [18], coffeehusks [19], spentgrain [20], fruitpeels [21] andsugarcane bagasse [22] havebeen successfully usedfordyesremoval.

The present investigation was conducted to remove C.I. Reactive Blue 82 dye colour employing Gigantia Leaves, Curcuma Longa Leaves, Morienga Oleifera and Citrus Sinensis. Scope of the study includes kinetics and isothermal equilibrium studies, effect of adsorption process parameters such as pH, contact time and adsorbent dose on colour removal. Interruption studies were carried in order to know the sorption mechanism involved in the adsorption process.

## II. MATERIALS AND METHODS

### *A. Adsorbent*

Adsorbents like Gigantia Leaves, Curcuma Longa Leaves, Morienga Oleifera and Citrus Sinensis collected from the local areas are used in the present study. The four organic adsorbents were washed with distilled water to remove dirt and other particulate matter. The washed peels and leaves are dried at low temperature (<105˚C) to remove moisture content. After drying process, peels and leaves were grounded to finepowder and sieved through 75µ size. Adsorbents size of 75µ is used in the study.

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### B. Adsorbate

C.I. Reactive Blue 82 was used as adsorbate. Chemical structure of the dye:

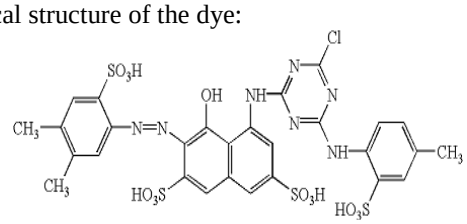

*Fig.1. Chemical structure of C.I. Reactive Blue 82*

### C. Analysis and Characterization

The maximum wavelength of C.I. Reactive Blue 82 (570 nm) was observed using Thermo make UV VIS Spectrophotometer of Evolution 201 Model. All the analyses were done in accordance with standard methods [23].

## III. BATCH ADSORPTION EXPERIMENT

Experiments were conducted for dye solution of pH from 2 to 12. The adsorbent dose and pH at which maximum colour removal of dye were determined, which was adopted as favourable dose and favourable pH. Agitated, non-flow batch sorption studies were conducted by bottle point method using reagent bottles of 250 mL capacity. To a 100 mL of test dye solution (optimum pH) of 50 mg/L concentration taken in the reagent bottle, premeasured quantity of adsorbent was added and the resultant mixture was agitated in a horizontal shaker at a rate of 125 rpm for varying time intervals of 1, 3, 5, 7, 9, 12, 15, 30, 45 and 60 minutes. The bottles were withdrawn from the shaker at designated time intervals and the reagent bottles were kept undisturbed for 4 hours for sedimentation, at the end of which, samples were withdrawn by carefully pipetting out 10 ml portion and are analyzed for colour content remaining in the test dye solution. The time at which maximum removal of colour takes place and no further significant difference in colour removal occurs from that time, was taken as the equilibrium contact time and used in all further studies. Equilibrium Isothermal studies were conducted by adding varying doses of adsorbents such as 50, 100, 150, 200, 250, and 300 mg/L to the test dye solution and contacted for equilibrium time. The residual colour was analyzed with a Spectrophotometer by measuring OD/%T at respective maximum wavelength (570 nm) of dye solution and computing concentrations from the calibration curve.

## IV. RESULTS AND DISCUSSION

### A. Effect of pH

The effect of initial pH on adsorption of dye was studied from pH 2 to 12, at dye concentration of 50 mg/L, contact time 30 min and 300 mg/L dosage. The percentage of colour removal of dye at different pH is as shown in Fig.2.

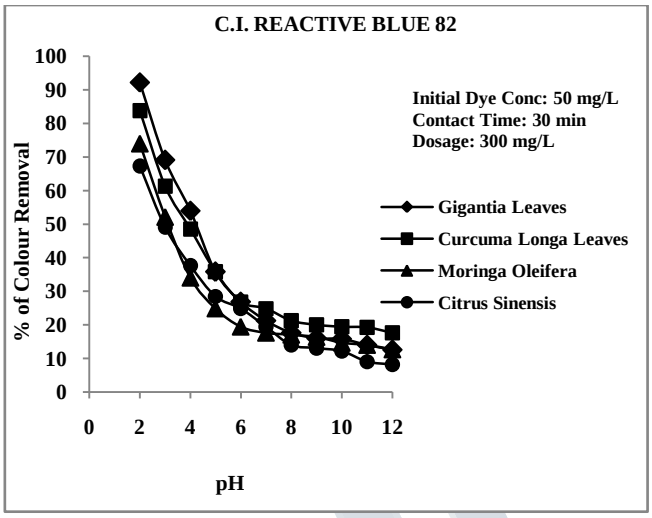


*Fig.2. Response of C.I. Reactive Blue 82 onto Adsorbents at Different pH*

From Fig.2, it was observed that maximum colour removal of C.I. Reactive Blue 82 with all adsorbents was obtained at pH of 2. Hence favourable pH of 2 was considered to the dye C.I. Reactive Blue 82.

### B. Effect of Adsorbent Dosage

Equilibrium isothermal adsorption studies were conducted by varying the amount of adsorbent dose from 50 to 300 mg/L and the results are presented graphically as % colour removal at different doses for C.I. Reactive Blue 82, at pH 2 as shown in Fig.3.

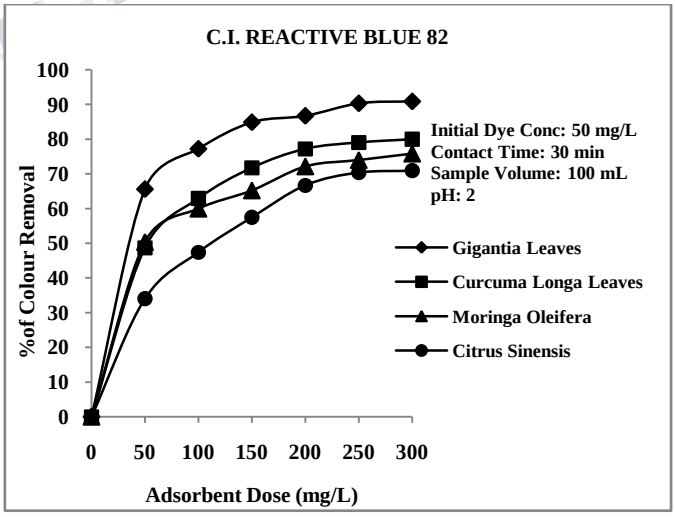


*Fig.3. Response of C.I. Reactive Blue 82 to adsorbents at different dosages (pH=2)*

From Fig.3, it was observed that C.I. Reactive Blue 82responded favourablyto all adsorbents investigated, exhibited Excellent colour removal of 90.36% with Gigantia Leaves, Good colourremoval of 80%, 75.81%, and 70.90% with Curcuma Longa Leaves, MoringaOleiferaand Citrus Sinensisat pH of 2.

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### C. *Effect of contact time*

The influences of contact time vis-à-vis kinetics of colour removal by adsorbents are presented in Fig.4. It may be observed from figures that the rate of colour removal was rapid initially. The rate leveled off gradually and then attained a more or less constant value (equilibrium) beyond which there was no significant increase in colour removal. The time required to attain equilibrium was 30 minutes.

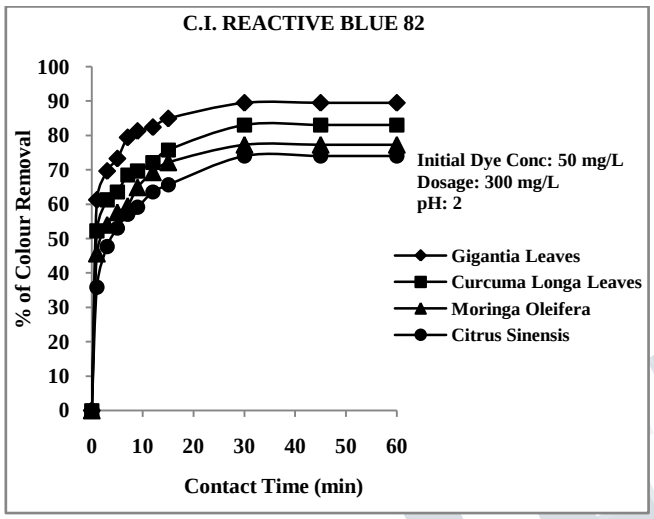


*Fig.4.Kinetics of Sorption of C.I. Reactive Blue 82 onto Adsorbents at Different Contact Times (pH=2).*

It follows from the experimental results that percentage removal of colour increased with an increase in mixing time; however, the difference is not much beyond a mixing time of 30 min. Therefore, an equilibrium mixing time of 30 min was adopted in all subsequent experiments.

## V. EQUILIBRIUM STUDY

Adsorption isotherms are mathematical models that describe the distribution of the adsorbate species among liquid and adsorbent, based on a set of assumptions that are mainly related to the homogeneity/ heterogeneity of adsorbents, the type of coverage and possibility of interaction between the adsorbate species. Adsorption data are usually described by adsorption isotherms, such as Langmuir, Freundlich isotherms. These isotherms relate dye uptake per unit mass of adsorbent, $q_e$, to the equilibrium adsorbate concentration in the bulk fluid phase $C_e$.

### A. *The Langmuir isotherm*

The **Langmuir model (1918)** is based on the assumption that the maximum adsorption occurs when a saturated monolayer of solute molecules is present on the adsorbent surface, the energy of adsorption is constant and there is no migration of adsorbate molecules in the surface plane.

The linear form of Langmuir isotherm is given as;

$$\frac{1}{q_e} = \frac{1}{q_m} + \frac{1}{q_m K_L}\frac{1}{C_e}$$

Where $K_L$ is the energy constant of the sorption, $q_m$ is the maximum value of sorption capacity (mg $g^{-1}$), $C_e$ is the equilibrium conc. of sorbate in solution after adsorption (mg $L^{-1}$),$q_e$ is the mass of sorbate adsorbed per unit mass of sorbent (mg $g^{-1}$).The plot between $1/q_e$ and $1/C_e$ is as shown in the Fig.5.

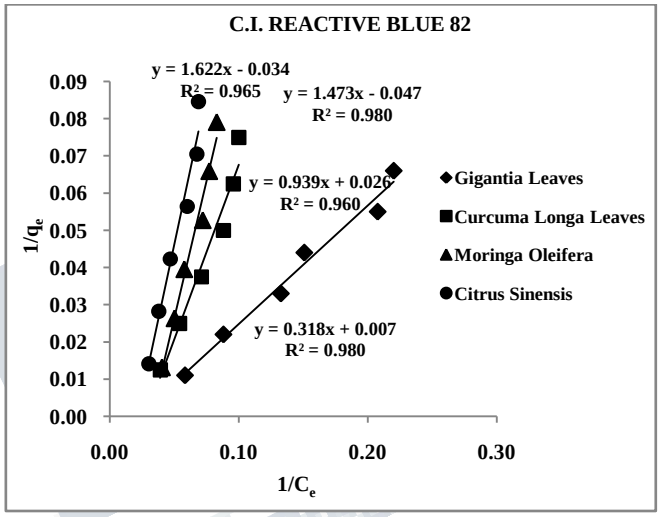


*Fig.5.Linearised Plot of Sorption Isotherm of Langmuir Model for Various Adsorbents*

The values of sorption capacities and coefficient of correlation of Langmuir Isothermare presented in TableI.

Table I.Langmuir Adsorption Isotherm Constantsand Coefficient of Correlation ($R^2$) for all the Adsorbents

| Dye | Langmuir Isotherm | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient of Correlation ($R^2$) | | | | $q_m$(mg/g) | | | | $K_L$(L/mg) | | | |
| | GL | CLL | MO | CS | GL | CLL | MO | CS | GL | CLL | MO | CS |
| C.I. Reactive Blue 82 | 0.998 | 0.996 | 0.998 | 0.996 | 142.85 | 38.46 | 29.41 | 21.27 | 0.02 | 0.02 | 0.02 | 0.02 |

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### B. *The Freundlich isotherm*

***Freundlich isotherm mode (1906)*** is applicable for non-ideal sorption on heterogeneous surfaces and multilayer sorption.

The nonlinear and linearised forms of the equation are as follows:

$$logq_e = \log(K_F + \frac{1}{n} logC_e)$$

where $C_e$ is the equilibrium conc. of sorbate in solution after adsorption (mg $L^{-1}$), $q_e$ is the mass of sorbate adsorbed per unit mass of sorbent (mg $g^{-1}$).The constants in the Freundlich isotherms can be determined by plotting $logq_e$ versus $logC_e$ which gives a straight line with slope of 1/n and a intercept equal to the value of log $K_F$, where $K_F$ (L $g^{-1}$) is the Freundlich constant related to the adsorption capacity and *n* is the constant for intensity.Plot between log $C_e$ and log $q_e$ was drawn to generate the intercept value of $K_F$ and the slope of n as shown in the Fig.6.

The values of n<1 indicate a favourable adsorption comparable with other researches. It is observed that all the adsorbents satisfy the condition of heterogeneity.

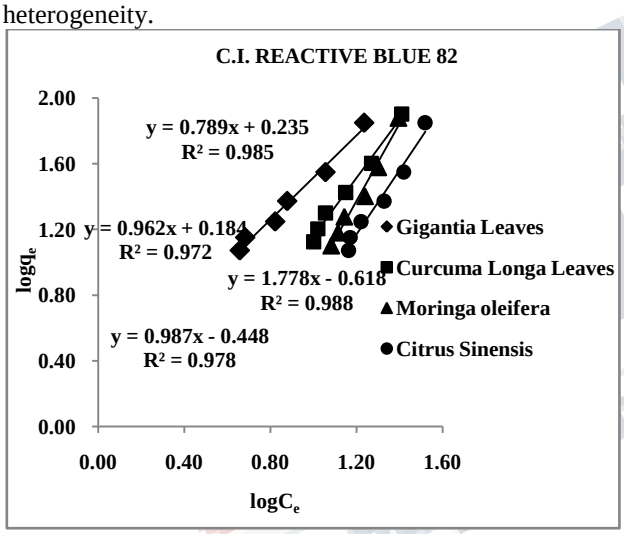


***Fig.6. Linearised Plot of Sorption Isotherm of Freundlich Model for Various Adsorbents***

The isothermal equilibrium sorption data were fitted into linearised Freundlich equation and the values of sorption capacities and coefficient of correlation are presented in Table II.

***Table II: Isotherm model constants and correlation coefficients for adsorption of dye from aqueous solution***

| Dye | Freundlich isotherm | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient of Correlation ($R^2$) | | | | $K_f$ (L/g) | | | | Slope (n) | | | |
| | GL | CL | MO | CS | GL | CL | MO | CS | GL | CL | MO | CS |
| C.I. Reactive Blue 82 | 0.98 | 0.98 | 0.97 | 0.97 | 1.26 | 1.85 | 1.56 | 1.20 | 1.26 | 1.28 | 1.01 | 1.03 |

From Table II, the value of coefficient of correlation ($R^2$) obtained was nearly equal to one for all adsorbents giving a best fit for Freundlich equation compared to Langmuir Isotherm. It follows from the data that equilibrium adsorption of colour on to all adsorbents follows Freundlich isotherm model, which implies multilayer sorption, with lateral interactions between the adsorbed molecules or ions in the case of Freundlich models; the energetic distribution of sites is heterogeneous due to the diversity of sorption sites.

### C. *Kinetic study*

In order to investigate the controlling mechanism of adsorption processes such as mass transfer and chemical reaction, the pseudo-first-order and pseudo-second-order equations are applied to model the kinetics of dye adsorption on to the adosorbents.

The **Pseudo-First-Order (1898)** rate equation is given as:

$$\log(q_e - q_t) = logq_e - (\frac{K}{2.303})$$

where $q_e$ is the amount of adsorbed adsorbate on the adsorbent at equilibrium (mg adsorbate $g^{-1}$ adsorbent),$q_t$ is the amount of adsorbed adsorbate on the adsorbent at time t,$K_1$ is the adsorption rate constant for pseudo first-order. To determine the correlation coefficients, graph was drawn between log ($q_e$-$q_t$) and time as shown in the Fig.7.

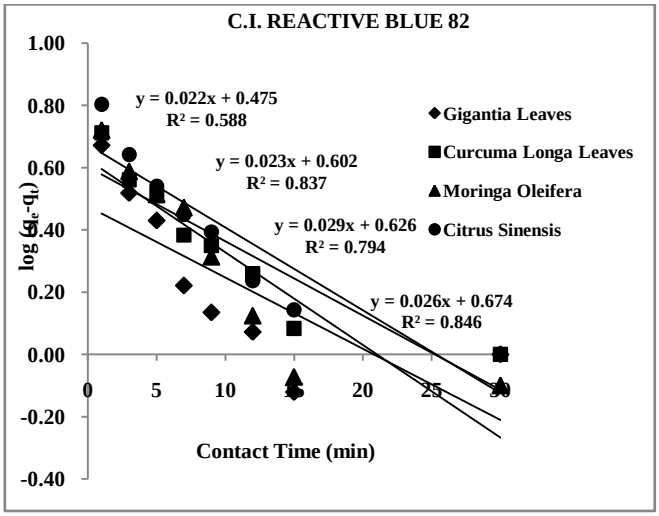


***Fig.7.Pseudo-First–Order plot for C.I. Reactive Blue 82 Adsorbed onto Different Adsorbents.***

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Calculated values of $K_1$ and $q_e$ along with correlation coefficient ($R^2$) are summarized in Table III.

***Table III: The Adsorption Rate Constants, $q_e$ and Coefficient of Correlation ($R^2$) for Pseudo-First-Order Kinetic Model***

| Dye | Pseudo-First-Order Kinetic Model | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient of Correlation ($R^2$) | | | | $q_e$cal(mg/g) | | | | Rate Constant $K_1$(min$^{-1}$) | | | | $q_e$exp (mg/g) | | | |
| | GL | CLL | MO | CS | GL | CLL | MO | CS | GL | CLL | MO | CS | GL | CLL | MO | CS |
| C.I. Reactive Blue 82 | 0.58 | 0.83 | 0.79 | 0.84 | 2.98 | 3.99 | 4.22 | 4.72 | 0.05 | 0.05 | 0.06 | 0.05 | 14.90 | 13.85 | 12.88 | 12.33 |

The pseudo first-order kinetic model of Lagergren was not fitted well with the experimental data of $q_e$.

The **Pseudo-Second Order ((Ho, 1995)** kinetics is expressed as:

$$\frac{t}{q_t} = \frac{1}{h} + \frac{t}{q_e}$$

The initial adsorption rate, h, (mg g$^{-1}$ min) is expressed as $h = k_2 q^2_e$, Where $k_2$ is the rate constant of Pseudo-second-order adsorption (min$^{-1}$) and$q_e$ is the equilibrium adsorption capacity (mg g$^{-1}$).The graph between $t/q_t$ versus t was drawn as shown in the Fig.8, to determine the values of qe, k and h from the slope and intercept of the plot.

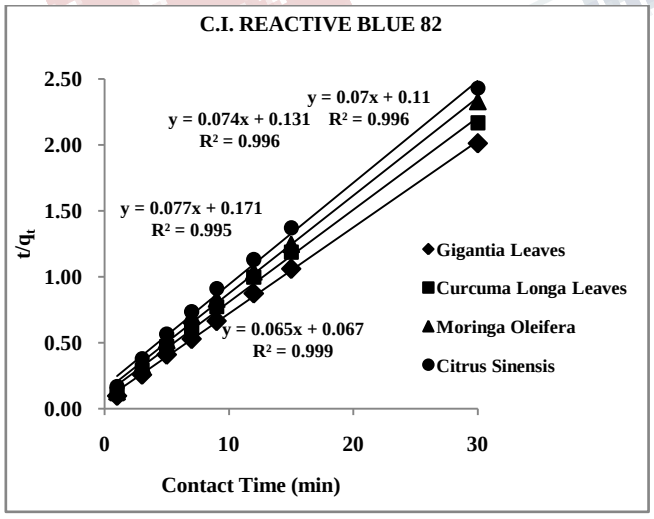


***Fig.8. Pseudo-Second-Order Plot for C.I. Reactive Blue 82 Adsorbed onto Different Adsorbents.***

***Table IV: The Adsorption Rate Constants, $q_e$ andCoefficient of Correlation and ($R^2$) for Pseudo-Second-Order Kinetic Model.***

| Dye | Pseudo-First-Order Kinetic Model | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient of Correlation ($R^2$) | | | | $q_e$cal (mg/g) | | | | Rate Constant($K_2$) (min$^{-1}$) | | | | h (mg/g min) | | | | $q_e$exp (mg/g) | | | |
| | GL | CLL | MO | CS | GL | CLL | MO | CS | GL | CLL | MO | CS | GL | CLL | MO | CS | GL | CLL | MO | CS |
| C.I. Reactive Blue 82 | 0.99 | 0.99 | 0.99 | 0.99 | 155.38 | 142.88 | 135.51 | 122.98 | 0.06 | 0.04 | 0.04 | 0.03 | 14.91 | 8.97 | 7.48 | 5.72 | 14.90 | 13.85 | 12.88 | 12.33 |

From Table IV, it was observed that $R^2$ is equal to 1.0 with respect to pseudo-second-order, moreover the experimental values of $q_e$ is nearer to the values obtained in pseudo-second -order , indicating that pseudo-second-order model is well fitted to the data than pseudo – first-order model, which implies that chemisorption is the rate limiting step.

## VI. INTERRUPTION STUDIES

In order to probe into the nature of the sorptive uptake of dye colour by the adsorbents, interruption studies were conducted by interrupting the ongoing process of adsorption for 30min in a batch system. For film diffusion controlled process, the interruption does not affect the rate of uptake, since there is no increase in concentration gradient on the sorbent after the interruption.

However, in the case of pore diffusion to be rate controlling step, the concentration gradient increases immediately after interruption compared to that of before interruption and this may result in a higher uptake. Result of interruption tests are presented in Fig.9, for various dyes using different adsorbents.

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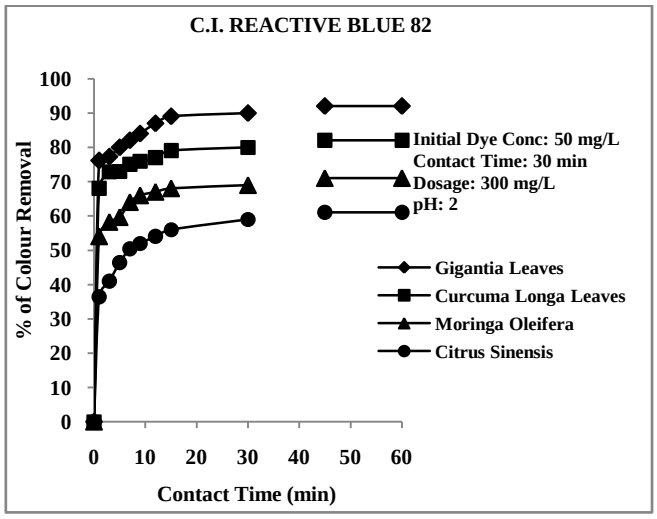


***Fig.9.Interruption Kinetic Plot of C.I. Reactive Blue 82***

It is evident from the Fig.9, that there is slight increase in the slope of the concentration gradient curve after interruption and hence it indicates the possibility of pore diffusion to be the rate controlling in the sorption process.

## CONCLUSIONS

The present investigation shows that organic adsorbents can be effectively used as an adsorbent for the removal of C.I. Reactive Blue 82 from aqueous solutions. The amount of dye uptake was found to increase with increase in dose from 50 to 300 $mg^{-1}$L.Excellent colour removal can be achieved with adsorbent of Gigantia Leaves, Curcuma Longa Leaves, Moringa Oleifera and Citrus Sinensis at pH of 2.The maximum colour of Gigantia Leaves, Curcuma Longa Leaves, Morienga Oleifera and Citrus Sinensis was 90.36%, 80%, 75.81% and 70.90% respectively.The data fitted well to Freundlich model, which implies that the possibility of multilayer adsorption with a heterogeneous energy distribution of the active sites, accompanied by interaction between the adsorbed molecules. Kinetic studies data of all the sorbents are fitted well to pseudo-second-order, which implies that chemisorption is the rate limiting step. Further Interruption Studies implies that pore diffusion to be the rate controlling one in the adsorption process.

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## REFERENCES

[1]. Chen, S., Zhang, J., Zhang, C., Yue, Q., Li, Y., Li, C.“Equilibrium and kinetic studies of methyl orange and methyl violet adsorption on activated carbon derived from phragmites australis”. Desalination 252, 149e156. 2010.

[2]. Dinc¸er, A.R., Günes¸, Y., Karakaya, N., Günes¸, E. “Comparison of activatedcarbon and bottom ash for removal of reactive dye from aqueous solution”.Bioresour. Technol. 98, 834–839. 2007.

[3]. Kadirvelu, K., Kavipriya, M., Karthika, C., Radhika, M., Vennilamani, N., Pattabhi, S. “Utilization of various agricultural wastes for activated carbonpreparation and application for the removal of dyes and metal ions fromaqueous solutions. Bioresour”. Technol. 87, 129–132. 2003.

[4]. Shen, D., Fan, J., Zhou, W., Gao, B., Yue, Q., Kang, Q. Adsorption kinetics andisotherm of anionic dyes onto organo-bentonite from single and multisolutesystems. J. Hazard. Mater. 172, 99–107. 2009.

[5]. Vinoth M., Lim H. Y., Xavier R., Marimuthu K., Sreeramanan S., Rosemal M. H. M. H. and Kathiresan S., “Removal of Methyl Orange from Solutions Using Yam Leaf Fibres”, *International Journal of Chem Tech Research*, Vol. 2, No. 4, pp 1892 – 1900. 2010.

[6]. W.S.W.Ngah,L.C.Teong,M.A.K.M.Hanafiah, Adsorptionofdyesandheavy metal ionsbychitosancomposites:areview,Carbohydr.Polym.83 1446–1456. 2013.

[7]. Santhi T., Manonmani S. and Smitha T.,“Removal ofMethyl Red from Aqueous Solution by Activated CarbonPrepared from the *Annona squmosa* Seed by Adsorption”,*Chemical Engineering Research Bulletin*, Vol. 14,pp 11 – 18. 2010.

[8]. Fathi M. R. and Asfaram A., “Investigation of Kineticsand Equilibrium Isotherms of Direct Red 12B Dye Adsorption on Hazelnut Shells”, *Journal of Chemical Health Risks*, Vol. 1, No. 2, pp 1 – 12. 2011.

[9]. Kartik J. P. M., Swathik H, Baskar U. S., Sivamani S., “Removal of Direct Red Dye Using Neem Leaf Litter”,Helix, Vol. 1, No. 2, pp 129 – 133. 2012.

[10]. Voudrias E., Fytianos K. and Bozani E., “Sorption-Desorption Isotherms of Dyes from Aqueous Solutions andWastewaters with Different Sorbent Materials”, *GlobalNest: the International Journal*, Vol. 4, No.1, pp. 75 – 83. 2002.

[11]. R.Gong,R.Guan,J.Zhao,X.Liu,S.Ni,Citricacidfunctionalizingwheatstra was sorbent forcopperremovalfromaqueoussolution,J.HealthSci. 54 174–178. 2008

[12]. E.Pehlivan,T.Altun,S.Parlayici,Modifiedbarleystrawasapotentialbiosorbentforremovalofcopperionsfromaqueoussolution,Food Chem. 1352229–2234. 2012.

[13]. S.Chowdhury,S.Chakraborty,P.Das, “Adsorptionofcrystalvioletfrom aqueoussolutionbycitricacidmodified ricestraw” equilibrium, kinetics, and thermodynamics, Sep.Sci.Technol.481339–1348. 2013.

[14]. B.Ramaraju,P.M.K.Reddy,C.Subrahmanyam,Low-costadsorbentsfrom agricultural

 

wasteforremovalofdyes,Environ. Prog. Sustain.Energy33 38–46. 2014.
[15]. S.Hashemian, M.Salimi, Nano composite apotentiallow-costadsorbentfor removal of cyanineacid,Chem.Eng.J.18857–63. 2012.
[16]. T.Madrakian,A.Afkhami,M.Ahmadi,Adsorptiona ndkineticstudiesofseven different organicdyesontomagnetitenanoparticlesloadedteaw asteand removalofthemfrom wastewater samples,Spectrochim.ActaPartA-Mol. Biomol. Spectrosc. 99102–109. 2012.
[17]. I. Safarik,M.Safarikova,Magnetic fluid modified peanuthusksasanadsorbent for organicdyesremoval, Phys.Proc.9274–278. 2010.
[18]. I.Safarik,K.Horska,B.Svobodova,M.Safarikova, Magneticallymodified spent coffee groundsfordyesremoval,Eur.FoodRes. Technol.234345–350. 2012.
[19]. L.S.Oliveira,A.S.Franca,T.M.Alves,S.D.F.Rocha, Evaluationofuntreatedcoffee husksaspotentialbiosorbentsfortreatmentofdyeconta minatedwaters, J. Hazard.Mater .155507–512. 2008.
[20]. I.Safarik,K.Horska,M.Safarikova,Magneticallym odified spentgrainfordye removal,J. CerealSci.5378–80. 2011.
[21]. S.T.Ong,P.S.Keng,S.T.Ooi,Y.T.Hung,S.L.Lee,Ut ilizationoffruitspeelasa sorbent forremovalofmethyleneblue,AsianJ. Chem.24 398–402. 2012.
[22]. C.B.Chandran,D.Singh,P.Nigam,Remediationofte xtileeffluent using agricultural residues,Appl.Biochem.Biotechnol.102207–212. 2002.
[23]. Clescerl L.S., A.E. Greenberg, A.D. Eaton (1998), APHA, Standard Methods for the Examination of Water and Wastewater. 20th ed., American Public Health Association/American water works Association/Water Environment Federation,Washington, DC.

 