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REMOVAL OF MALACHITE GREEN DYE FROM AQUEOUS SOLUTION USING SAW DUST AS AN ABSORBENT

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ABSTRACT
Many textile industries always use dyes and pigments to colour their product. Colour removal from textile effluent is a major environmental problem. The colored effluent have an inhibitory effect on the processes of photosynthesis which are disturbing aquatic ecosystem. Malachite Green dye is selected because it is not easily degradable and is toxic in nature. The effect of different parameters like pH, contact time, adsorbent dose, and temperature were studied. The Freundlich and Langmuir adsorption isotherm were studied. The amount of adsorption increases with increasing adsorption dose, contact time, p^H and temperature. The ultrasonic velocity of the dye solution was also studied. The result showed that, the velocity increases with adsorption. The kinetic study shows that pseudo second order model is more fitted than pseudo first order model. This effect is observed due to swelling of the structure of the adsorbent which enables large number of dye molecules adsorbed on adsorbent body. The result showed that 80%dye was removed when p^H is 9 and contact time is 120 minutes. When the temperature increases from 298K to 308K the adsorption capacity also increases.

KEY WORDS: adsorption, adsorption isotherms, adsorption kinetics, dye, Malachite Green, Saw dust.

INTRODUCTION

Textile industries always use dyes and pigments to color their products. Color removal from textile effluent is a major environmental problem(Namasivayam *et. al*., 1993).Many dyes and their break down products are toxic for living organisms (Nigam *et. al*.,2000)and thus affecting aquatic ecosystem. Dyes have a tendency to produce metal ions in textile water produces micro toxicity in the life of fish. There are many physical and chemical methods for the removal of dyes like co-agulation, precipitation, filtration, oxidation, and flocculation. But these methods are not widely used due to their high cost. Adsorption technique (Sarioglu *et. al*., 2006) is the best versatile method over all other treatments. Therefore the proposed work will undertake using agriculture waste like corncob forremoving dye material (Singh *et. al*., 1994) (Mckay *et. al*., 1986) (Khare *et. al*., 1987) (Joung et. *al*., 1977) from aqueous solution.

MATERIALS AND METHODS

Saw dust was washed with distilled water and dried in an oven at 120^0 C. It was then sieved through sieve no. 100 (150µm). The BET surface area of Saw dust was 41.m^2/gm. obtained from BET technique. Malachite Green dye used was from Finer chemicals Ltd. Molecular Formula: $C_{23}H_{25}Cl N_2$ .The X-ray diffraction study of saw dust was carried out by X-ray Fluorescence Spectrometer (Philip model PW 2400) as shown in (figure1).The morphological and XRD study clearly indicates that the adsorbent is porous and amorphous in nature.

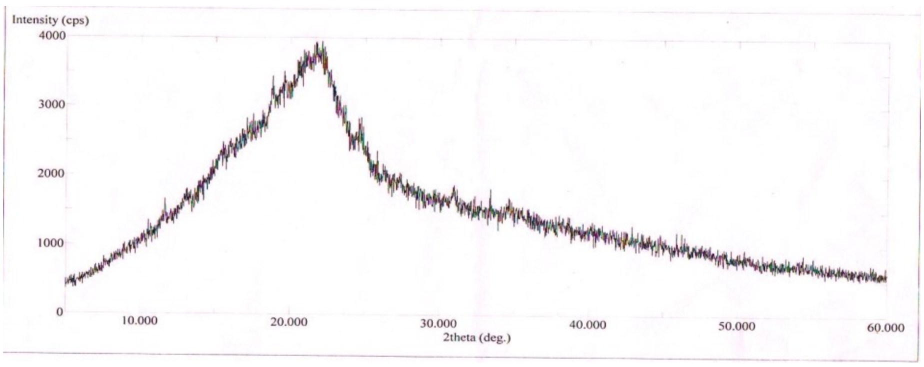

Figure 1: X-ray diffraction pattern of Saw dust

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The IR spectrum of Saw dust was also studied as shown in (figure 2).

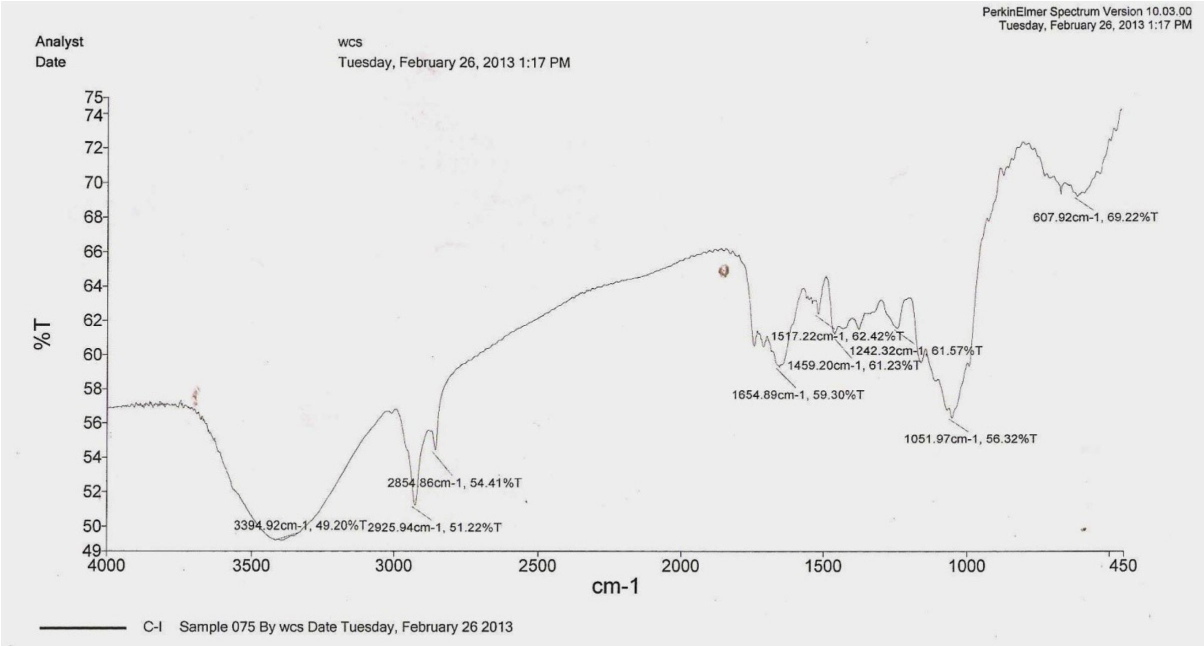
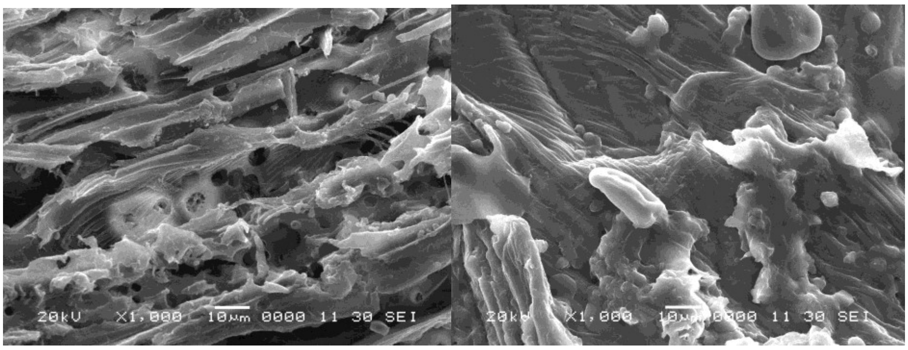


Figure 2: IR spectrum of Saw dust

From the **SEM** analysis it was found that there were holes and cave type openings on the surface of adsorbent which would have more surface area available for adsorption (Khatri *et. al.*, 1999) as shown in (figure 3).



(Before adsorption) (After adsorption)

Figure 3 : Scanning electron micrograph (SEM) of the Saw dust adsorbent

Experimental Procedure

Batch adsorption experiments were conducted by shaking 150 ml of dye solution having concentration (50mg/l) i.e. 50 ppm with different amount of adsorbent and having different p^H values, at different temperatures as well as different time intervals. The adsorbent was then removed by filtration and the concentration of dye was estimated spectrophotometrically at λ_{max}= 600 nm. The amount of dye adsorbed was then calculated by mass balance relationship equation,

$$q_e = \frac{C_0 - C_e}{X}$$

Where,

C_o= Initial dye concentration

C_e= Equilibrium dye concentration

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q_e= Amount of dye adsorbed per unit mass of adsorbent.
X = Dose of adsorbent.

RESULTS AND DISCUSSIONS

For getting highest amount of dye removal various factors were optimized.

Effect of contact time:

In order to know minimum amount of adsorbent for the removal of maximum amount of dye, the contact time was optimized. The results showed that the extent of adsorption is rapid at the initial stage after 120 minutes the rate of adsorption is constant. About 80% dye was removed. (Figure 4).

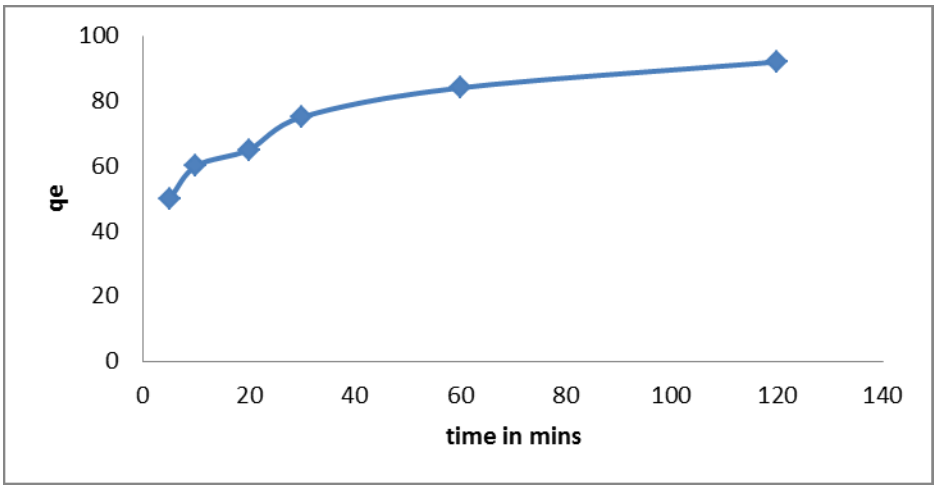

Figure 4: Effect of contact time on removal of Malachite green by saw dust

Effect of p^H:

From (figure 5), it reveals that when p^H of the dye solution increases from 3 to 9 the percentage of dye removal also increases. At p^H= 9, adsorption is maximum. By further increase in p^H adsorption decreases slightly. (Nimkar *et. al.*, 2014)

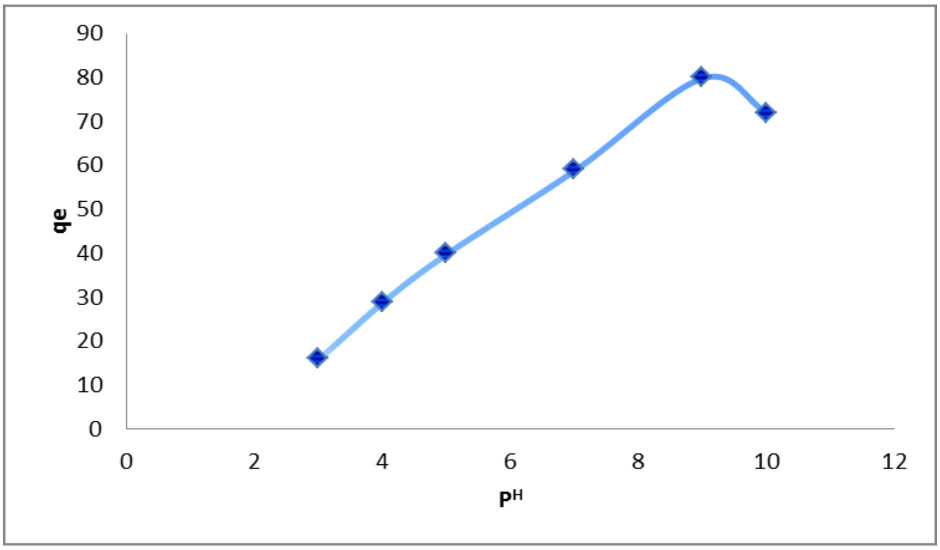

Figure 5: Effect of p^H on removal of Malachite green by saw dust.

Effect of adsorbent dose:

The different adsorbent doses were studied from the range 0.5gm to 7.0 gm from the results, it is clear that the optimum dose is 1gm/150ml. (Figure 6). By further increase of adsorbent dose, the removal of adsorbent decreases due to some of the adsorption sites remains unsaturated during the process (Ferrero; 2007) (Asma *et.al.;* 2011) (Theng *et. al*., 1955) (Garg *et. al*., 2004).

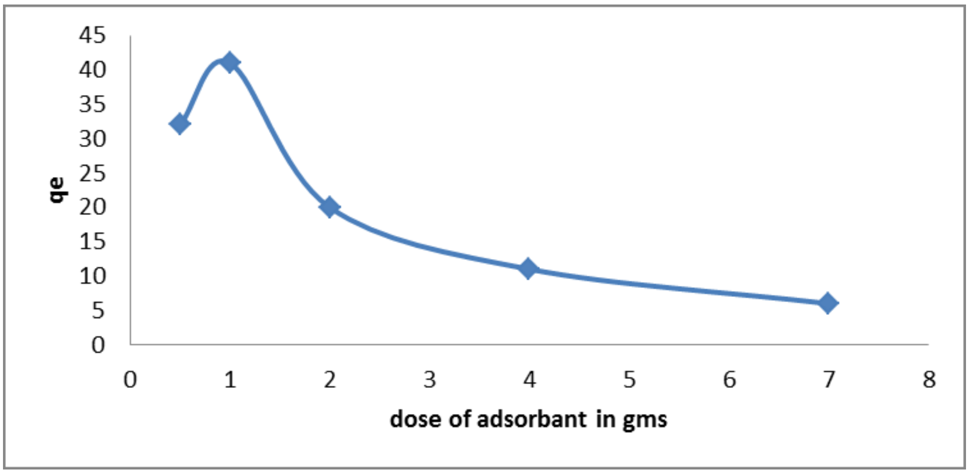

Figure 6: Effect of adsorbent dose on removal of Malachite green by saw dust

Effect of temperature:

The perusal of (figure 7) it is clear that adsorption capacity of adsorbent increases with increase in temperature, due to increase in the mobility of dye ions. Increasing temperature also causes a swelling effect within the internal structure of adsorbent. So that large number of dye molecules can easily penetrate through it (Yamin *et. al*., 2007) (Mane *et. al*., 2012).

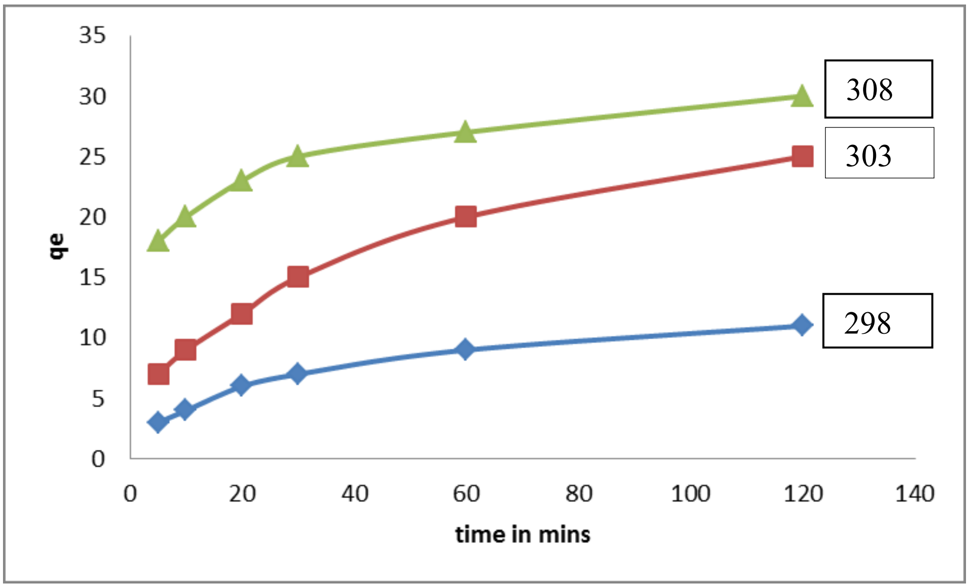

Figure 7: Effect of contact time on removal of Malachite green by saw dust

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Adsorption Isotherm:

Langmuir Isotherm:

In order to study the adsorption of dye according to Langmuir isotherm, following equation was used

$$\frac{C_e}{q_e} = \frac{1}{Q_m \times b} \times \frac{C_e}{Q_m}$$

Where

C_e =Dye concentration at equilibrium (mg/ L)

q_e =Amount of dye adsorbed on the adsorbent (mg/g)

b =Langmuir constant

A graph of C_e/ q_e against C_e was plotted as shown in (figure 8)

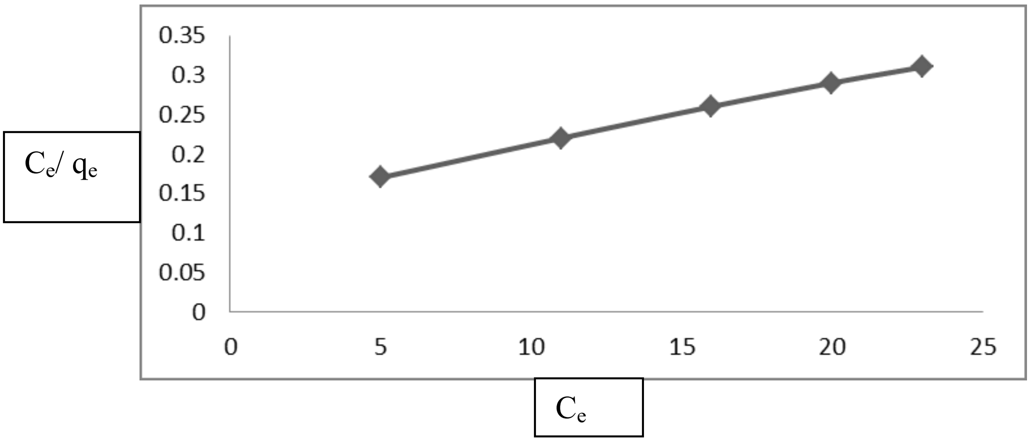

Figure 8: Langmuir Isotherm for adsorption of Malachite green on saw dust.

The correlation factor is closely related to unity, which indicates that the Langmuir isotherm model is applicable (Sen *et. al*., 1987) (Mallipudi S.*et al*., 2013) (Parvathi *et. al*., 2009). The formation of monolayer takes place on the surface of the adsorbent (Arivoli *et. al*., 2007) (Thievarasu *et. al*., 2011)

Freundlich isotherm:

To study the Freundlichisotherm the following equation was used. (Karabulut *et. al*., 2000)

$$\log \quad q_e = \log \quad K_f + \log \frac{C_e}{n}$$

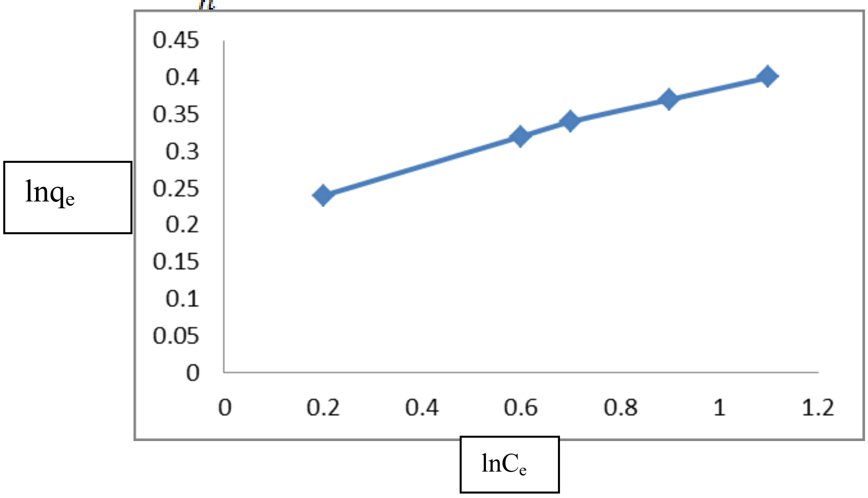

Figure 9: Freundlich Isotherm of Malachite green on saw dust.

The graph of ln q_e against ln C_e was plotted. From the slope, the value of n and correlation factor can be calculated. The value of correlation factor is closely related to one as shown in (figure 9) So it indicates that the Freundlich isotherm also satisfied. The value of n is greater than 1. So the Freundlich adsorption develops appropriately. But Langmuir model is more fitted than Freundlich model.

Adsorption kinetics:

Pseudo 1st order model:

The pseudo 1st order kinetics model is used to understand the kinetic behavior of the system (Paul *et. al.*, 2011) (Nagada *et. al.*, 2007)(Sarioglu *et. al.*,2006) It is given by the equation.

$$\frac{dq}{dt} = k_i\,(q_e - q_t)$$

A graph of ln (q_e- q_t) vs time was plotted as shown in (figure 10).

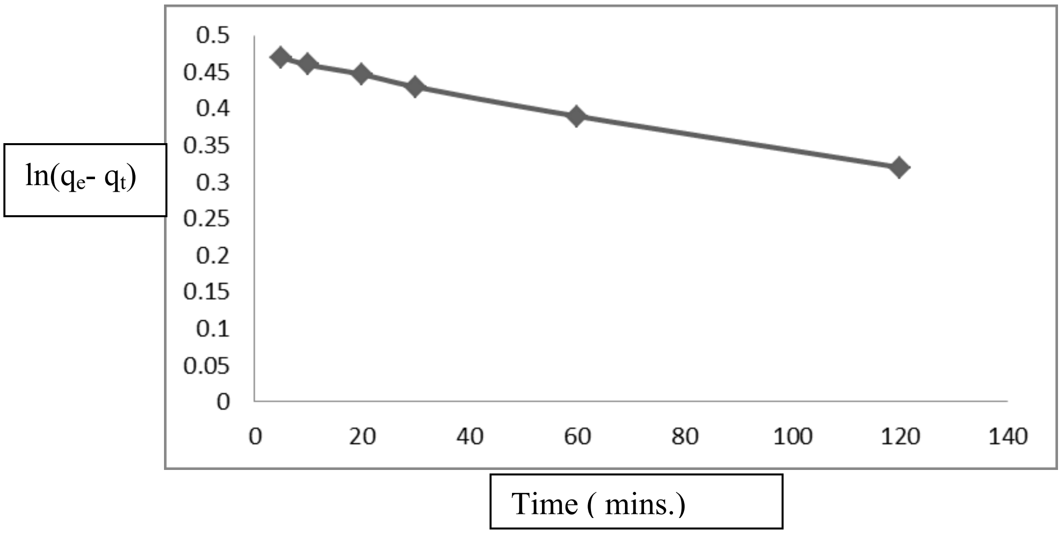

Figure 10 : Plot of pseudo 1st order for adsorption of Malachite green on saw dust.

Table 1.

Slope (K_i) (correlation coefficient)	Intercept (q_e) (Max. adsorption capacity)	Correlation Factor
-0.00129	0.45	-0.92

Pseudo 2nd order kinetics:

The pseudo 2nd order kinetic model was studied using equation

$$\frac{t}{q_e} = \frac{q^2_e}{k_2} + \frac{t}{q_e}$$

Where q_e = dye adsorbed at equilibrium.
q_t = dye adsorbed at time t
A graph t/q_t of against time was plotted as shown in (figure 11)

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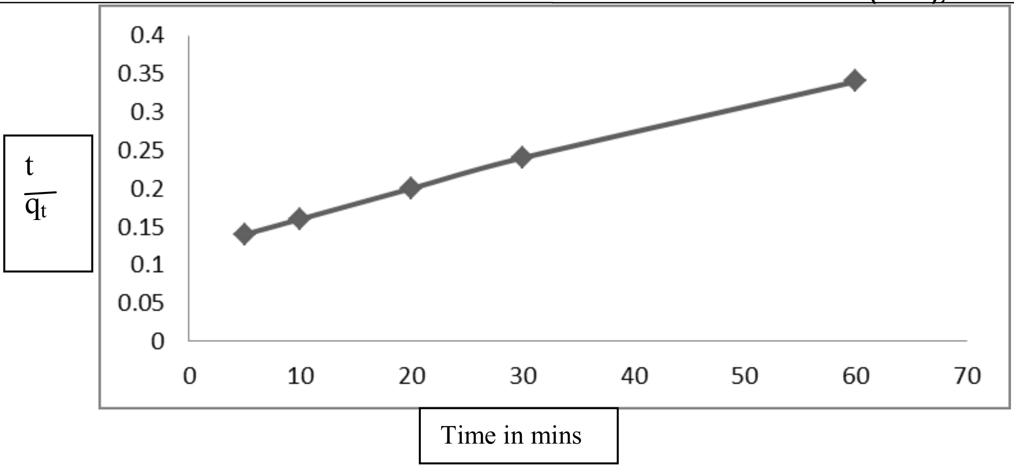

Figure 11: Plot of pseudo 2nd order of Malachite green on saw dust.

Table no 2

Slope (K_2)	Intercept (q_e)	Correlation factor
0.00353	0.127	0.99

In case of pseudo 1st order kinetic model,(Table no.1) the value of slope and correlation factor are negative. While in case of pseudo 2nd order kinetic model,(Table no 2)the value of slope and correlation factors are positive. Which implies that, the system is more fevourable for pseudo 2nd order kinetics.

Conclusion:

Saw dust acts as abetter effective low cost adsorbent for the removal of basic dye like Malachite Green.Batch adsorption was shown that yield of adsorption increases by increasing adsorbent dose, contact time,p^H,and temperature.The fittness of Langmuir model shows that there is a formation of monolayer on the adsorbent surfaces. Similarly Freundlich isotherm also develop appropriety.

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REFERENCES

Arivoli S. and Hema N.(2007).Comparative study on the adsorption kinetics and thermo dynamics of dyes on the activated low cast carbon. *Int. J. Phys. Sci.* 2: 10-17.

Asma khan and Nadeem Feroze .(2011).kinetics and equilibrium studies of Zn-II and Cu-IIMetal ions removal using Biomass (Rise husk)Ash. *J. Chem. Soc. Pak.*.33(2): 139-146.

Ferrero F. (2007). Dye removal by low cost adsorbent:Hazelnut shells in comparison with wood saw dust. *J. Hazardous Material*.142(2):144-152.

Garg V. K., Kumar Rakesh andGupta Renuka. **(2004**). Basic dye (methylene blue) removal from simulated waste water using Indian Rose wood saw dust. *J. Waste Dyes and Pigments*.63 :243-250.

Juang R. S., Wu F. C. and Tsang R. L.(1997). The ability of activated clay for the adsorption of dyes from aquous solutions. *Environ. Technol*. 18 : 525-531.

Karabulut S.(2000). Comparitive study on the adsorption kinetics and thermodynamics of dyes on the activated low cost carbon .*Sep. purif. Tech*. 18 :177-187.

Khare S. K., Panday K. K;Srivastava R. M. and Singh V.(1987). Removal of Victoria Blue from aquous solution by fly ash. *J. Chem. Technol. Biotechnol*. 38 :99-104.

ISSN: 2277-5536 (Print); 2277-5641 (Online)

Khatri S. D. and Singh M .(1999). Adsorption of basic dyes from aquous solution by natural adsorbent .*Ind. Chem. Technol*. 6 :112-116.
Mallipudi S.(2013). Removal of Two Azo and Two Anthra –Quinone Dyes from the textile effluent using an activated carbon of Tunic of Allium Cepa. *Int. J. Engineering Research and Technology*. 2(10) :4054-4059.
Mane R. S. and Bhusari V. N.(2012). Removal of colour (dyes) from textile effluent by adsorption using orange and Banana Peel. *Int. J. Engineering research and applications*. 2(3) :1997-2004.
McKay G., Prasad G. R. and Mowli P. R. (1986). Equilibrium studies for the adsorption of dye stuff from aquous solution by fly ash. *Water Air Soil Pollut*. 29 :273-283.
Nagada G. K., Diwan A. M. and Ghole V. S.(2009). Biosorption of Congo Red by hydrogen peroxide treated Tendue waste. *Iran J.Environ. Health Sci.Engg*.6(3) :195-200.
Namasivayam C. and Kanchanna N .(1993). Removal of congo red from aquous solution by waste banana pith. *Peranika J. Sci. and Technol*. 1(1) :33-42
Nigam P., Armour G., Singh D. and Merchant R.(2000). Physical removal of textile dyes from effluent and solid waste fermentation of dye adsorbed agricultural residue.*Bioresour Technol*.72 :219-226.
Nimkar D. A. and Chavan S. K.(2014). Removal of Congo red Dye from aquous solution by using Saw dust as an adsorbent. *Int. J. Engineering Research and Applications*.4(1) : 47-51.
Nimkar D. A.and Chavan S. K.(2014). Removal of Methylene BlueDye (basic Dye) from aquous solution using Saw Dust as an adsorbent. *Int. J. Engineering Research and Technology*.3(4) :1579-1583.
Parvathi C. Sivamani S. and Prakash C.(2009). Bioadsorption studies on Malachite Green dye Colourage . *Colourage Environmental Solution*. 10 (1):54-56.
Paul S. A. and Chavan S. K.(2011). Waste Tendu leaves from Beedi Industry utilised for removal of Sulphur Dye from Textile waste water .*Oriental J. Chem*. 28 (1):47-51.
Sarioglu M. and Atay U. (2006). Removal of Methylene Blue Dye by using biosolid *Global Nest. J.* 8(2) : 113-120.
Sen A. K. and De. A. K. (1987). Adsorption of Mercury (II) by coal fly ash . *Water Res.* 21 :885.
Singh B. K. and Rawat N. S.(1994). Comparitive adsorption studies for the adsorption of dye stuff from aquous solution by low cost material .*J. Chem. Technol. Biotechnol*.61 :307-317.
Theng B. K. G. and Wells N.(1995). Assessing the capacity of some Newzeland clays for decolourizing vegetable oil and butter .*Appl. Clay. Sci*. 9 :321-326.
Thievarasu C., Mylsamy S. and Sivakumar N. (2011). Coca shell as adsorbent for removal of Methylene Blue from aquous solution Kinetics and Equlibrium studies. *Universal J. Env. Research and Tech.* 1 :70-78.
Yamin Yasin, Mohd. Zobir Hussein. and Faujan Hj Ahmad. (2007). Adsorption of Methylene Blue on to treated Activated carbon . *Malaysian J. Analytical Sciences.*11 : 400-406.