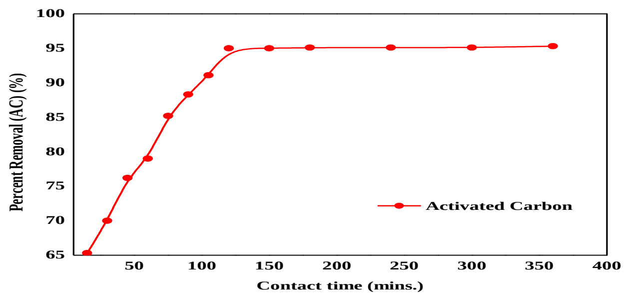

Fig. 4 Effect of contact time with regards to CR dye adsorption for AC

Effect of adsorbent dose on dye removal

The quantity of adsorbent plays important role in dye removal. Thus the experiments were carried out to optimize adsorbent dose by varying the adsorbent dosage from 0.05 g to 0.25 g. The results obtained were shown in fig.5. Increase in dye adsorption with increase in adsorbent dose was observed upto 0.2 g of adsorbent dose. Further increase in adsorbent dose did not improve dye removal. This may be due to the fact that maximum ads sorption has been achieved with respect to initial dye concentration.

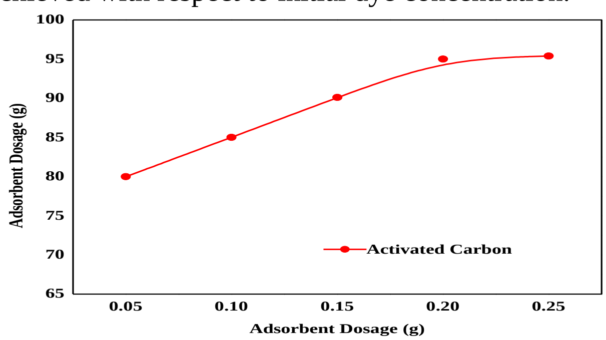

Fig. 4 Effect of adsorbent dosage with regards to CR dye adsorption for AC

Effect of Initial dye concentration on dye removal

The figure 5 shows the behavior of initial dye concentration to the percentage of dye removal. It leads to the outcome that as initial dye concentration increases removal percentage decreases. At 0.2 g of adsorbent dose optimum dye removal of 95% was noted. The adsorption sites on adsorbent was limiting factor for percent removal [15]. Hence, there was decrement in the percent removal for increase in the concentration of CR-dye.

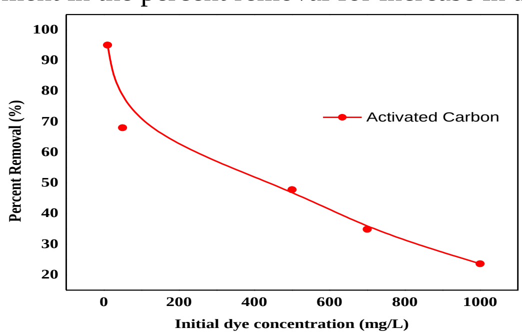

Fig. 5 Effect of initial concentration with regards to CR dye adsorption for AC

Effect of solution pH on dye removal

Adsorption process is greatly influenced by changing the pH of solution. The effect of pH on percent removal of CR dye is shown in fig 6. Increasing the pH from 5 to 7 there was increment in the removal percentage, on further increasing the pH decrement in the percentage removal was observed. The CR-dye being anionic in nature has better removal capacity around the 7 pH as observed. At pH above 7 the surface of adsorbent became surrounded by OH ions causing repulsive effect on anionic dye adsorption.

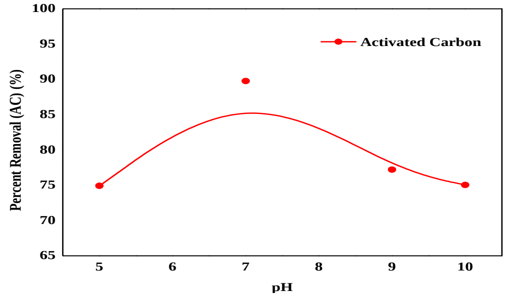

Fig. 6 Effect of pH with regards to CR dye adsorption for AC

3.3. Kinetics of adsorption

The criticality of adsorption was investigated by adsorption kinetics, which is major factor for process characteristics and efficiency of the adsorption mechanism. The two Kinetic models were fitted with experimental values i.e. the pseudo first order and second order kinetics study [16]. The pseudo first order was found to be better fitted in the analysis as shown in fig.8. The Adsorption parameters were recorded and shown in table 1. The best fitted R^2 was 0.9817 for first order kinetics applied for adsorbent-AC.

TABLE I. Adsorption Kinetics

Pseudo First Order		
K_F=0.051	**q_e= 1.22**	**R^2= 0.9817**
Pseudo Second Order		
q_e=558.6	**K_2= 0.0000051**	**R^2= 0.9799**

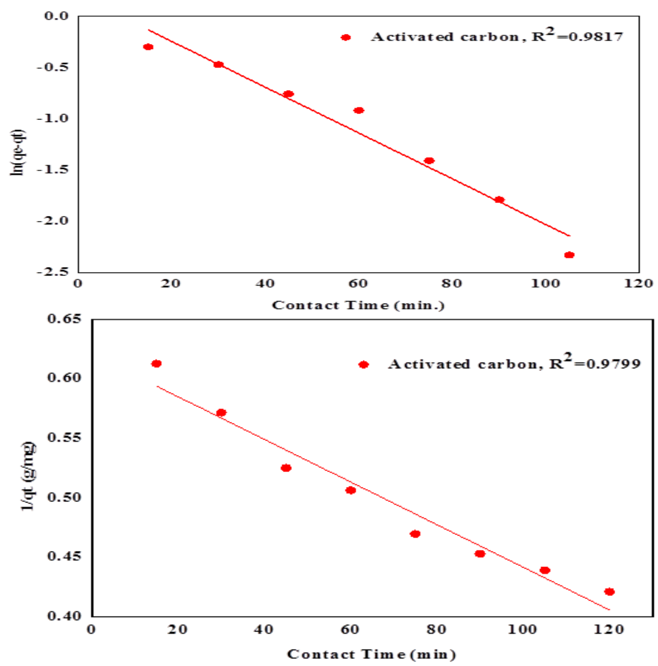

Fig. 8 Kinetic Adsorption study (a) pseudo first order kinetics, and (b) pseudo second order kinetics.

3.4. Adsorption Isotherm models

An adsorption isotherm provides the state of equilibrium in between synthesized adsorbent and adsorbate, which is the correlation of amount of dye adsorbed and the capacity of adsorbent to absorb the dye. The adsorption isotherm model, Langmuir, Freundlich, and Temkin were tried to fit with experimental results as shown in fig. 9. The Langmuir Isotherm model was found to be best fitted with R^2 = 0.9852 with the best adsorptive capacity of 64.14 mg/g for the synthesized activated carbon noted in the table 2.

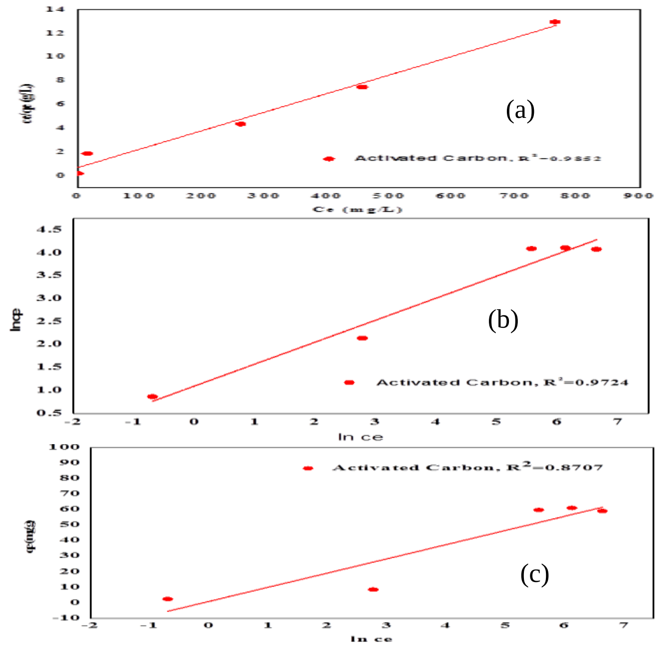

Fig. 9 Adsorption Isotherm Models (a) Langmuir Isotherm, (b) Freundlich Isotherm, and (c) Temkin Isotherm

TABLE II. Isotherm Model

	Langmuir Isotherm Model	**Freundlich Isotherm Model**	**Temkin Isotherm Model**
Muffle Furnace	K_L=0.022 , q_m=64.14 mg/g R^2= 0.9852	K_f=2.99, n=2.08 R^2= 0.9724	a= 0.8611, b=9.133 R^2=0.9331

Conclusion

Activated carbon (AC) was successfully synthesized from carbonization of walnut shell and it exhibited highly effective adsorbent for Congo red dye adsorption, which is mainly attributed to its high surface area of 256.66 m^2/g and confirming the presence of the abundant hydroxyl and carboxyl groups. Equilibrium data fitted well with Langmuir isotherm (maximum monolayer adsorption capability of 64.14 mg/g). The utilization of walnut shell as a precursor of AC not only lowers the cost of AC, but also offers a cost effective and environmental friendly way of recycling waste, reducing the environmental problems related to its disposal.

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