Dosage of sugar mill sludge activated carbon on dye removal

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Abstract

Industrial effluents with color are to be treated before its disposal in to the environment. So, the treatment technology is focused on using the natural and waste materials. This research is focusing on preparing and using the sugar mill sludge activated carbon for the removal of dye. The adsorption of dye by sugar mill sludge activated carbon (SSAC) was studied through batch experiments and the optimum dosage of carbon was found to be 3.0 g for treating 250 ml of dye solution at equilibrium stage of 120 min. Equilibrium study on initial dye concentration was investigated and the percentage of dye removal observed was 100%, 100%, 99.34%, 98%, 95.84% and 88.93% for the concentrations of 10, 20, 30, 40, 50, and 60 mg/L respectively. Dye removal efficiency of carbon decreased from 100% to 83.53% when pH increased from 2 to 11. Equilibrium study of SSAC on particle size of carbon and temperature of dye solution for the removal of dye and post equilibrium studies have been performed.

Key words*:* adsorbtion, carbon, dye, equilibrium, sludge, waste.

1. Introduction

Investigations on using the natural materials and waste materials as base material to produce activated carbon were carried out by the researchers. Hamad Noori Hamad et al (1) have reviewed on recent developments in the application of bio-waste-derived adsorbents for the removal of methylene blue from Wastewater. Tadele Assefa Aragaw et al (2) reviewed on biomass-based adsorbents for removal of dyes from wastewater.

Seyyed Alireza Mousavi et al (3) carried out **s**tatistical modeling and kinetic studies on the adsorption of reactive red II by a low-cost adsorbent (Grape Waste-Based ctivated Carbon). Ali Soltani et al (4) reviewed adsorbent parameters for removal of dye products from industrial wastewater. Syieluing Wong et al **(5)** investigated effective removal of anionic textile dyes using adsorbent synthesized from coffee waste. Ouissal Assila et al (6) carried out adsorption studies on the removal of textile effluent over two natural eco-friendly adsorbents. Moussa Abbas (7) prepared activated carbon from apricot stones material (ASM) for removal of malachite green (MG) from aqueous solution. Huifang Wu et al (8) studied synthesis of activated carbon from peanut shell as dye adsorbents for wastewater treatment. Radia Labied et al (9) carried out experiments on adsorption of hexavalent chromium by activated carbon obtained from a waste lignocellulosic material. Jaime Lo´pez-Cervantes (10) studied adsorption of an azo dye from an aqueous medium using a chitosan– glutaraldehyde biosorbent. Fatemeh Gorzin et al (11) studied adsorption of Cr(VI) from aqueous solution by adsorbent prepared from paper mill sludge. Shahul Hameed K et al (12) investigated on adsorption of chromotrope dye onto activated carbons obtained from the seeds of various plants. Mohammad R et al (13) carried out breakthrough curve analysis for fixed-bed adsorption of azo dyes using novel pine cone–derived active carbon**.** Mambo Moyo et al (14) carried out batch studies on the removal of Pb (II) using maize tassel based activated carbon. So this research focussed on evaluating the adsorption capacity of SSAC on adsorbing reactive red dye through equilibrium studies and its dependancy on time and concentration of dye solution.

2. Experimental investigation

2.1. Preparation of activated carbon

Raw sludge was air-dried for three days, kept in muffle furnace air tightly and heated up to 850^0C with time duration of 8 hours at the rate of 100^0C increase per hour. Thus the sludge was turned in to activated carbon. The prepared activated carbon was taken out from the container, washed thoroughly with distilled water and air-dried. The carbon was sieved through a set of sieves and 425-600 micron size of carbon was used in this investigation.

2.2. Characteristics of activated carbon

The characteristics of sludge based activated carbon are presented in Table 1.

Table1. Characteristics of sugar mill sludge activated carbon

Parameter	Characteristic value
P^H	8.95
Ash content (%)	3.44
Moisture content (%)	4
Bulk density (g/cm^3)	0.67
Porosity	0.90
Matter soluble in water (%)	1
Matter soluble in acid (%)	15
Surface area (m^2/g)	1103

2.3. Methodology

To study the effect of digested sugar mill sludge activated carbon on dye removal, initially 10 mg/ L concentrated reactive red dye solution was prepared and 250 ml of solution was taken in each of 24 flasks (heavy rotary shaker assembly has a platform with rubber bushes to accommodate 24 flasks) and 1.0 g of activated carbon was added in each flask. The flasks containing solution with adsorbent were kept in heavy rotary shaker mechanism with timer and agitated. At every 15 min interval, one flask was taken out from the shaking mechanism and residual concentration of dye solution was analyzed by UV—VIS 150 spectrophotometer. Similar procedure was adopted for different concentrations and different dosages. The pH of the dye solution was not adjusted by using any acid or bases for all investigations except for the equilibrium study on pH of dye solution. Effect of pH of dye solution was investigated by adjusting the pH using sodium hydroxide and hydrochloric acid. Temperature of the solution was raised by an instrument of magnetic stirrer with temperature control arrangements.

3. Discussion of test results

3.1. Equilibrium study of SSAC on dye adsorption

Adsorption of reactive red dye by SSAC was studied by increasing adsorbent dose from 1.0 g to 4.0 g for treating 250 ml of dye solution of 10 mg/L concentration. Figure 1 depicts that the equilibrium was attained at 120 min and the maximum percentage of dye removal was 89.33%, 90.12%, 92.09%, 94.07%, 100%, 100% & 100% for the dosages of 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 & 4.0 g respectively. It was found that 3.0 g of carbon was sufficient for complete dye removal. The percentage of dye removal increased with increase in adsorbent dosage and similar results were obtained by the researchers [3]; [4]; [11] and [12].

3.2. Equilibrium study of SSAC on initial dye concentration

Batch experiment was conducted on concentrations of 10, 20, 30, 40, 50 & 60 mg/L with a constant dosage of 3.0 g for treating 250 ml of dye solution. Figure 2 shows that the initial rate of adsorption was higher on all concentrations. Initially the amount of dye adsorbed on to the carbon surface increased rapidly, but then the process slowed down. The equilibrium was attained at 120 min and the percentage of dye removal observed was 100%, 100%, 99.34%, 98%, 95.84% and 88.93% for the concentrations of 10, 20, 30, 40, 50, and 60 mg/L respectively. The percentage of dye removal decreased with increase in dye concentration and similar results were obtained by the researchers [3]; [4]; [11]; [12] and [14].

3.3. Equilibrium study of SSAC on particle size of carbon

In this series of experiments, four different particle sizes of carbon such as 150-300, 300-425, 425-600 and 600-1000 micron and an adsorbent dose of 3.0 g were used. A solution of 50 mg/ L concentration of 250 ml quantity was taken up for the study. The percentage of adsorption was 100%, 100%, 95.84% and 78.66% for 150-300, 300-425, 425-600 and 600-1000 micron size respectively at the equilibrium stage of 120 min. Figure 3 shows that adsorption increased when particle size decreased and this effect has been studied by [7]; [8]; [9] and [12].

3.4. Equilibrium study of SSAC on pH of dye solution

Batch studies were conducted for treating 250 ml of dye solution with 3.0 g of carbon by varying the pH from 2 to 11 on 50 mg/L dye concentrated solution. Figure 4 shows that the percentage removal of dye was 100%, 100%, 96.08%, 85.85%, 84.97% and 83.53% for the pH of 2, 3, 6, 8, 10 and 11 respectively at equilibrium stage of 120 min. It was observed that the adsorption capacity of carbon decreased when pH of dye solution increased. The effect of P^H was studied by the researchers [3]; [4]; [11]; [12] and [14].

3.5. Equilibrium study of SSAC on temperature of dye solution

Four temperatures have been chosen for conducting experiments on removal of dye. They were 30^0C, 40^0C, 50^0C and 60^0C. The other test parameters were 3.0 g of dosage of adsorbent, 50 mg/L of concentration of solution, and carbon size of 425-600 micron. The maximum percentage of dye removal observed was 95.84%, 86.49%, 77.94%, 73.06% for the temperatures of 30^0C, 40^0C, 50^0C and 60^0C respectively at the equilibrium stage of 120 min. It can be observed from Figure 5 that, at a given temperature, the percentage of dye removal increased with increase in contact time but with increase in temperature the dye removal decreased for a given contact time. Hence, the process is exothermic. Temperature studies have been carried out by researchers [4]; [6] and [11].

4. Conclusions

Based on the experimental results the sugar mill sludge activated carbon was found to be effective on removing reactive red dye from textile industry effluents. Optimum dosage of carbon was found to be 3.0 g at equilibrium stage of 120 min for treating 250 ml of dye solution. The adsorbed amount of dye increased with increase in contact time on all concentrations. The percentage of adsorption was 100%, 100%, 95.84% and 78.66% for 150-300, 300-425, 425-600 and 600-1000 micron carbon size respectively and shows that adsorption increased when particle size decreased. Dye removal efficiency of carbon decreased from 100% to 83.53% when pH increased from 2 to 11. The maximum percentage of dye removal observed was 95.84%, 86.49%, 77.94%, 73.06% for the temperatures of 30^0C, 40^0C, 50^0C and 60^0 C respectively. Further, 3.0 g dosage of carbon was just sufficient to treat 250 ml of reactive red dye solution at all concentrations of 10, 20, 30, 40, 50 and 60 mg/L at equilibrium stage to result in a dye removal efficiency of 100%, 100%, 99.34%, 98%, 95.84% and 88.93% respectively.

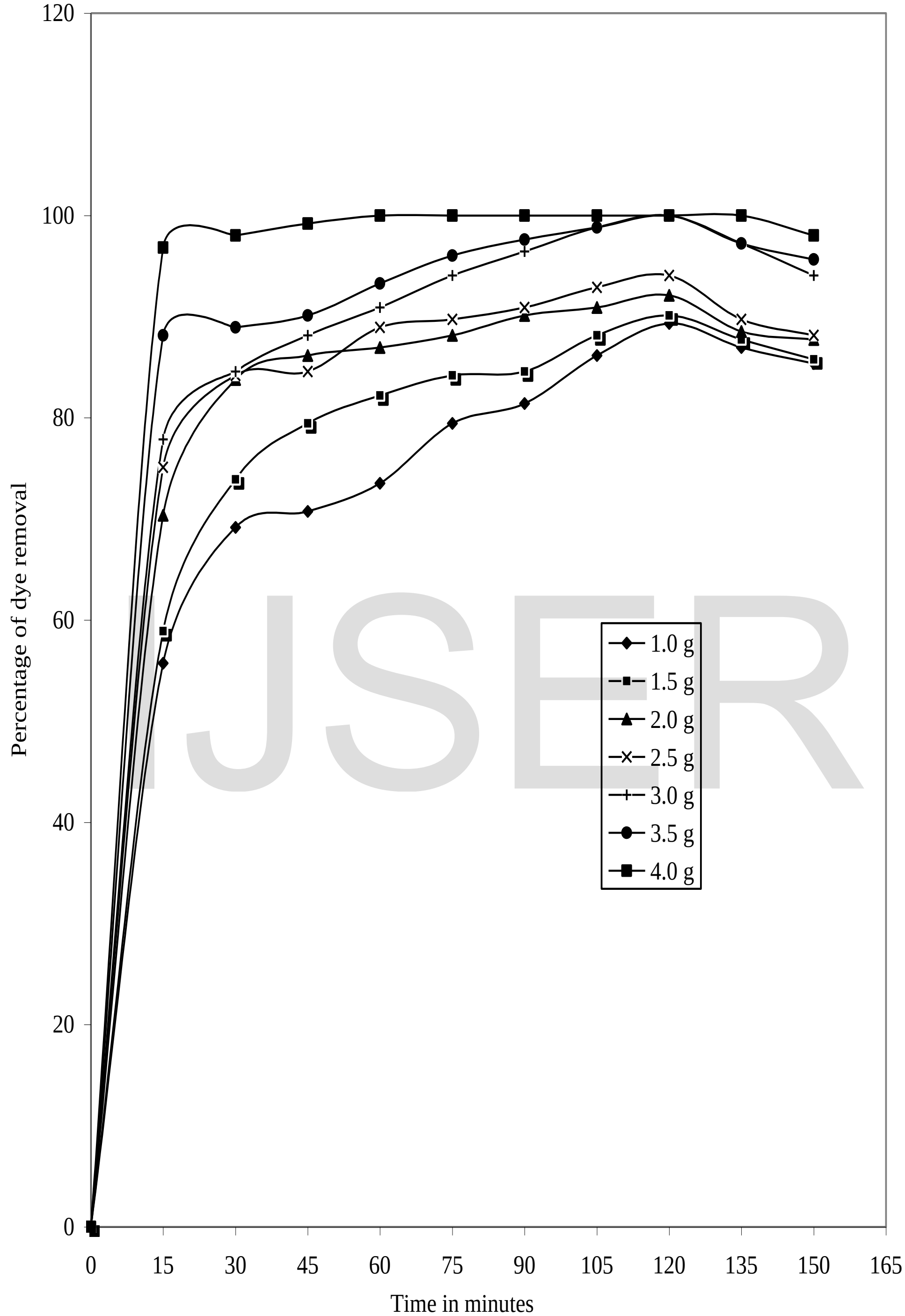

Fig 1. Equilibrium study of SSAC on dye adsorption
(initial dye concentration=10 mg/L)

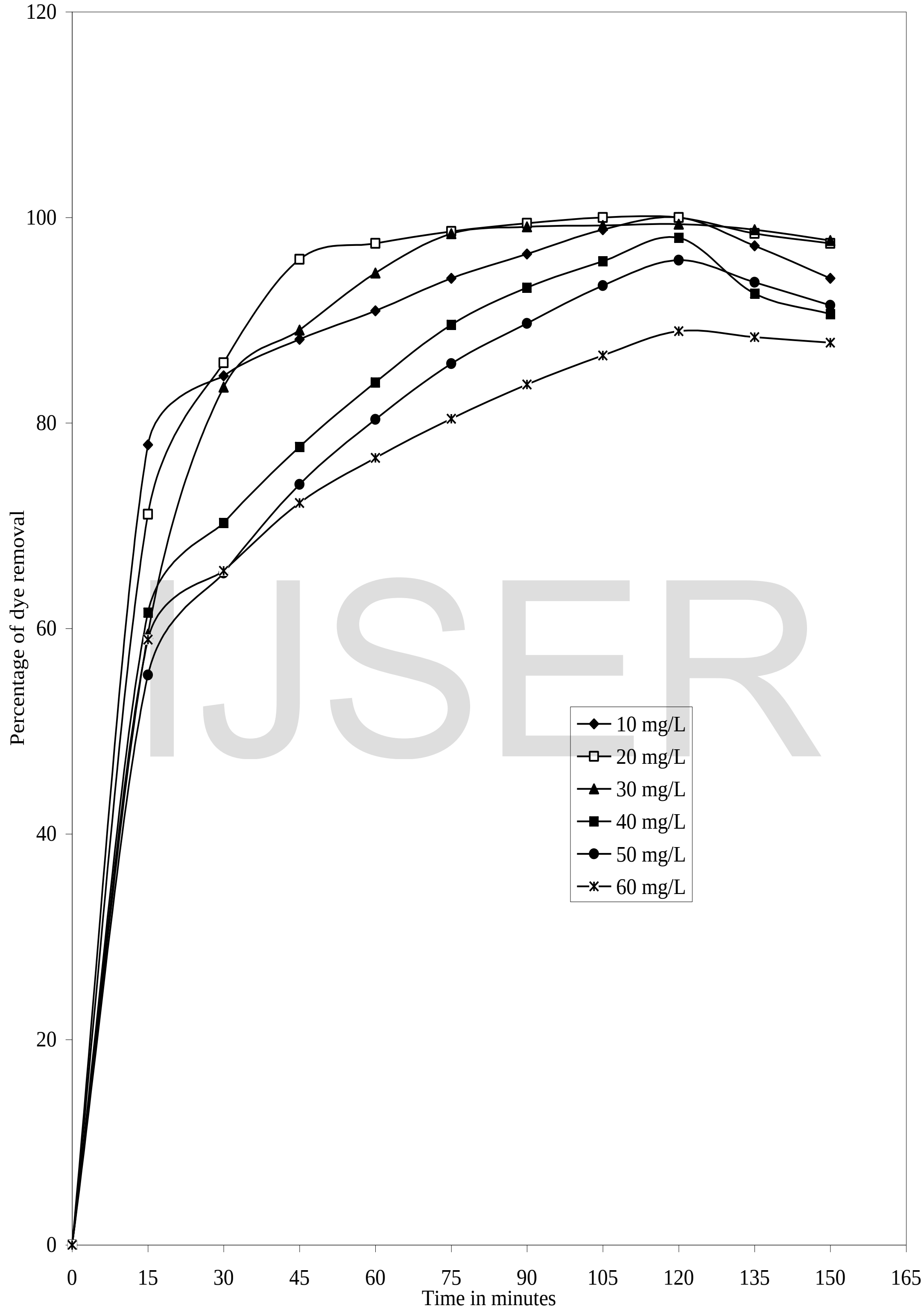

Fig 2. Equilibrium study of SSAC on initial dye concentration
(dosage of carbon=3.0 g)

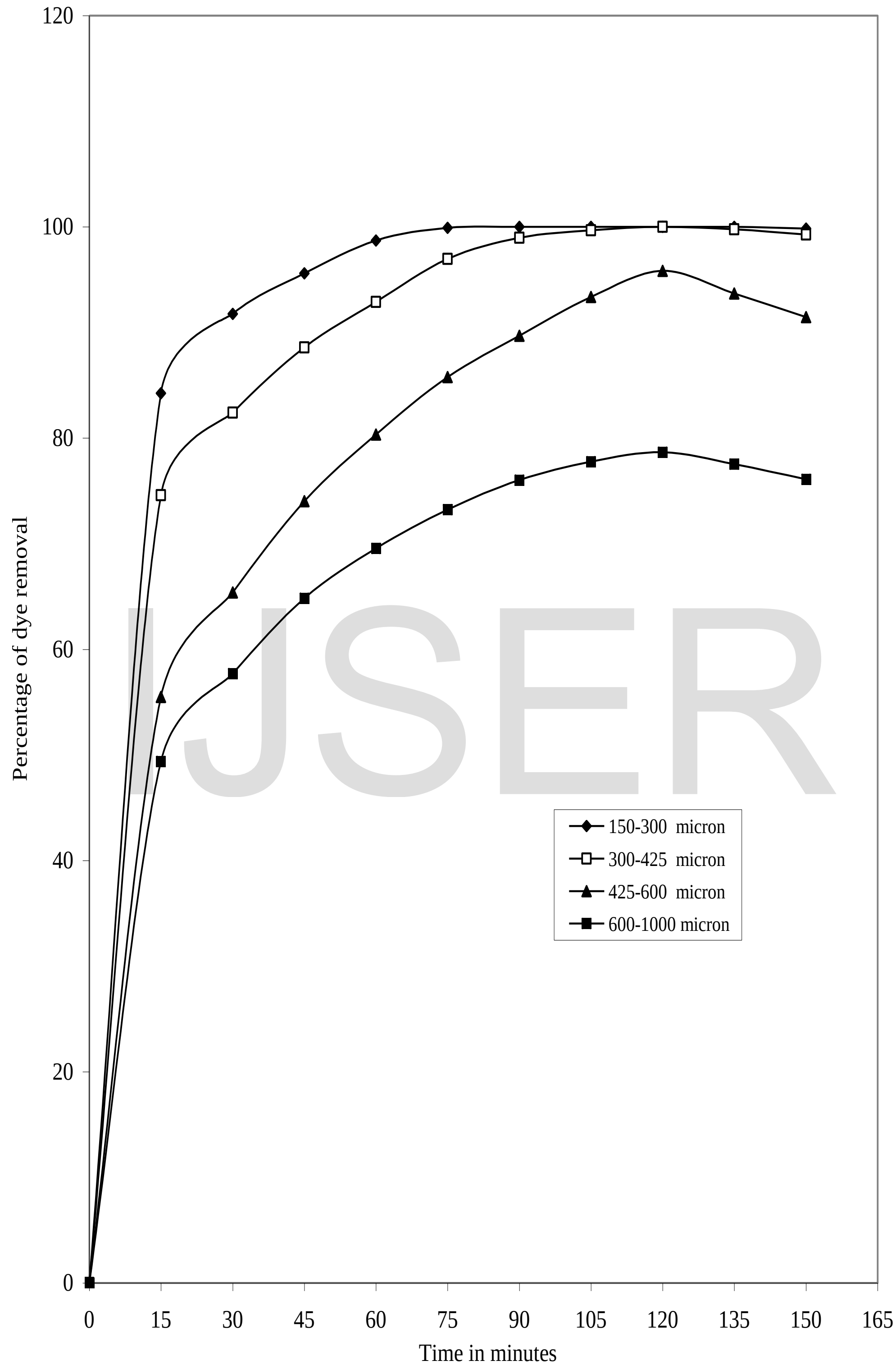

Fig 3. Equilibrium study of SSAC on particle size of carbon
(initial dye concentration=50 mg/L, dosage of carbon=3.0 g)

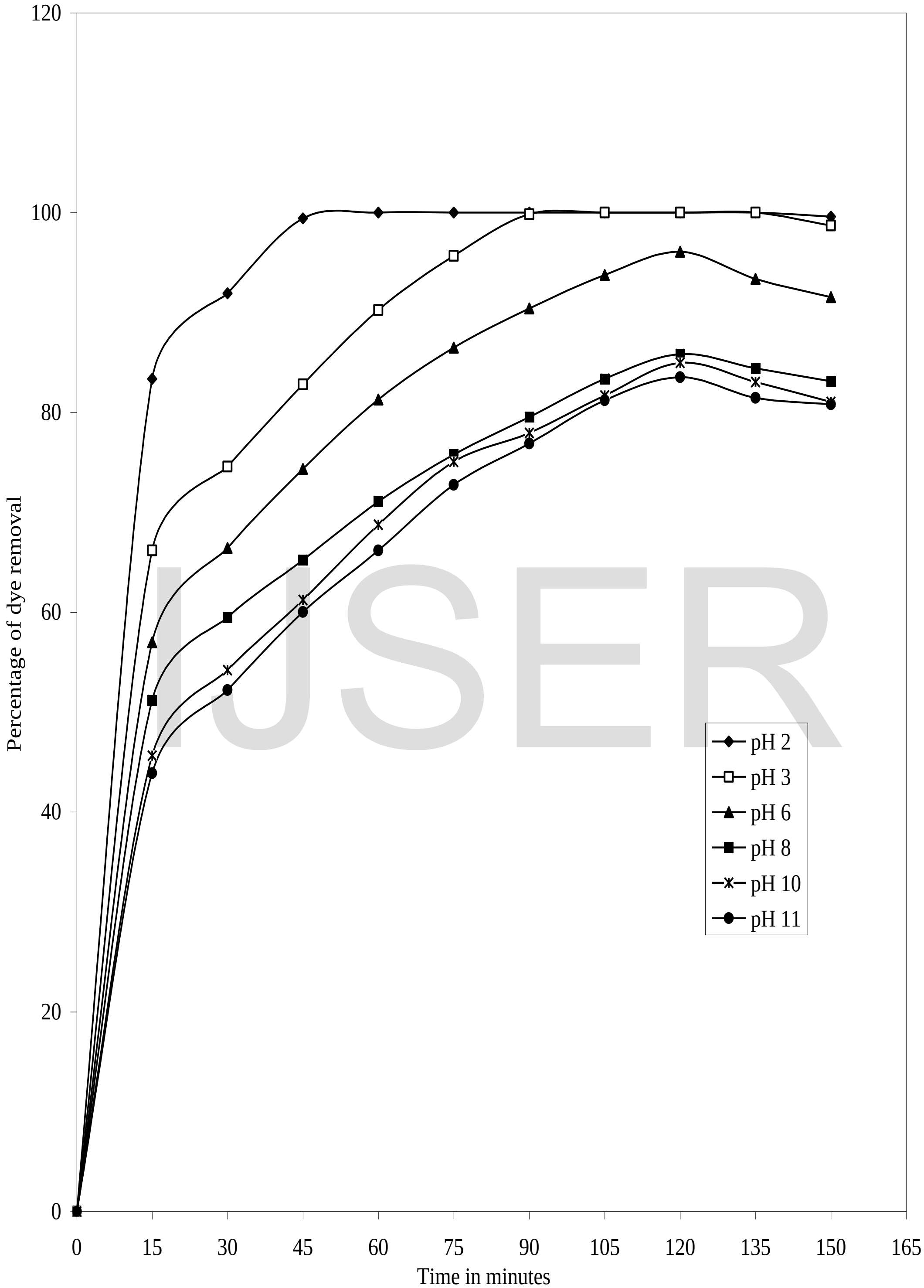

Fig 4. Equilibrium study of SSAC on pH of dye solution
(initial dye concentration=50 mg/L, dosage of carbon=3.0 g)

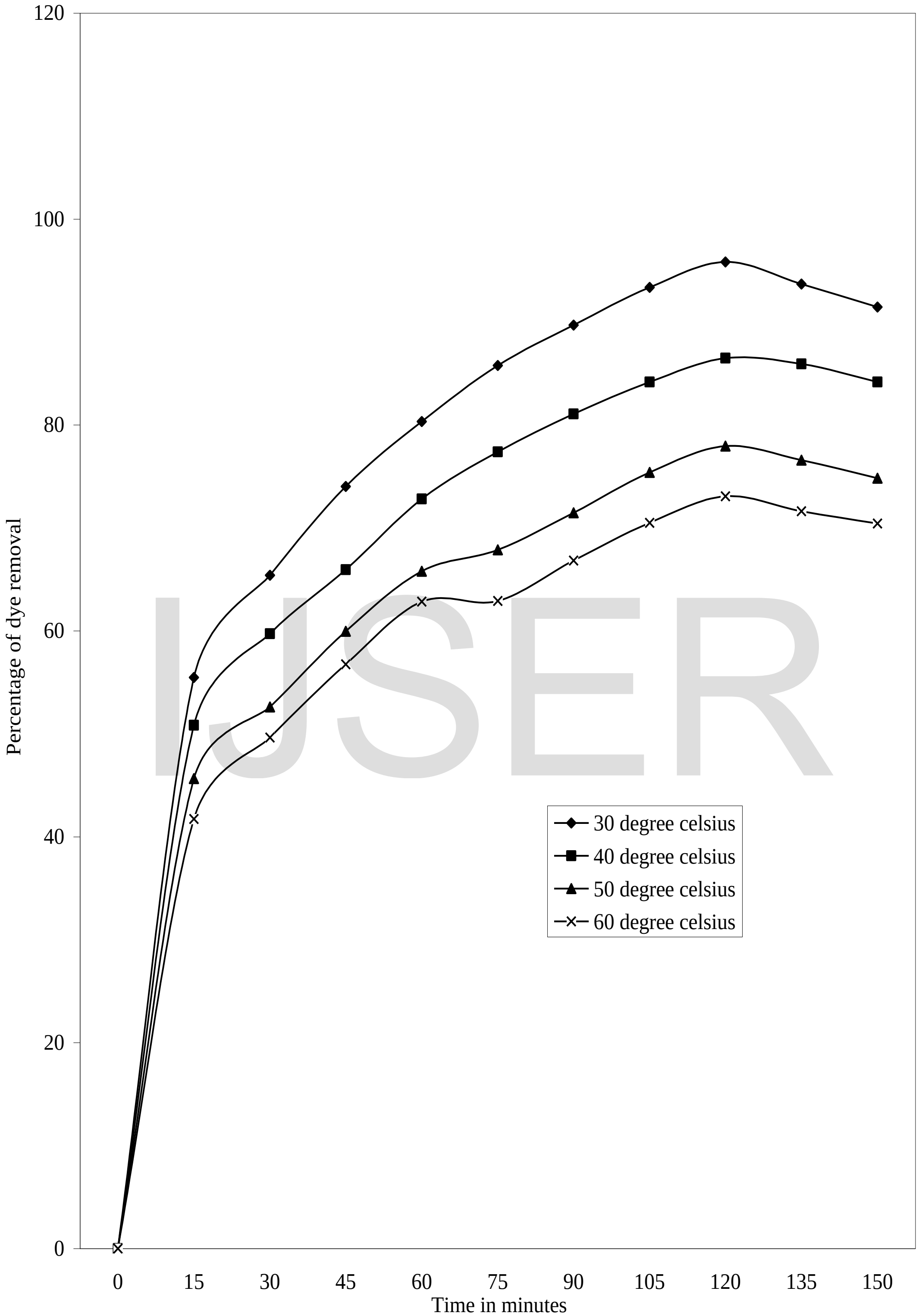

Fig 5. Equilibrium study of SSAC on temperature of dye solution
(initial dye concentration-50 mg/L, dosage of carbon=3.0 g)

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