Adsorption of Dye Benzoazurin-G from synthetic wastewater by Activated Charcoal derived from *Eichhcornia* leaf (water weeds)

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Abstract -The major objective of this paper was to investigate the removal of Dye from synthetic wastewater using activated carbon prepared from leaves of Eichhcornia (water weed) as an adsorbent. The influence of pH, contact time, dye concentration, and adsorbent loading weight on the removal process was investigated. Batch adsorption studies were carried out at room temperature. The adsorption data plotted well with the Langmuir and Freundlich isotherm models. This research focuses on understanding adsorption process and developing a cost effective technology for treatment of dye-contaminated industrial wastewater. Comprehensive characterization of parameters indicates Eichhcornia to be a good material for adsorption of Benzoazurin-G to treat wastewaters containing low concentration of the dye.

Key words: Adsorption, Eichhcornia, Adsorption isotherms, Adsorption kinetics.

1.INTRODUCATION

The industries produce highly colored large volume of waste water, which is one of the major environmental problems. The reactive dye which represent the largest class of dyes used in textile processing industries are almost azo compound i.e. molecule with one or serval azo (N=N) bridges linking substituted aromatic structure. These dyes are designed to be chemically and photolytic ally stable, they exhibit high resistance to microbial degradation and are highly persistent in natural environment. Such dye effluent is toxic, mutagenic, carcinogenic, and difficult to remove by conventional waste water treatment methods. Adsorption has evolved into one of the most effective physical processes for removal of dyes. The most commonly used adsorbent for dye removal is activated carbon, because of its capability for efficiently adsorbing a broad range of different types of adsorb ate.

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The purpose of this work is to investigate the effectiveness of the adsorbent to removal of Benzoazurin-G from textile waste water using low cost adsorbents prepared from Eichhcornia. The adsorption of Dye Benzoazurin-G in aqueous solution on various low cost adsorbents was analyzed.

2. MATERIALS AND METHODS

2.1 Preparation of Activated Charcoal from Eichhcornia leaves:

The leaves of the plant Eichhcornia was obtained locally and dried them . Leaves were first subjected to heating process known as carbonization in which fixed carbon was formed, which was then activated by heat- leaves treatment (150-200oC). Washing with Phosphoric acid, Zinc chloride etc to activates it. It was cut into small pieces. The leaves were treated with concentrated sulphuric acid (five times its volume) and kept in oven at 150°C for 24 hours. It was filtered and washed with distilled water repeatedly to remove sulphuric acid (washing tested with two drops of barium chloride solution) and finally dried. The adsorbent was sieved to 40-60-mesh size and heated at 150 °C for 2 hours.

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2.2 Preparation of Stock Solution of Benzoazurin-G: In order to have wastes of uniform characteristics and to avoid interferences of other dyes the synthetic stock solution of waste water was prepared from AR Grade chemical. The stock solution of dye Benzoazurin-G was prepared by dissolving 1.000gram in 1000ml of double distilled water to give 1000ppm solution. The different range of test solution of different concentration of dye solutions was prepared from stock solution which varied between 40-150ppm.

2.3 Experimental methods and measurement:- The experiments were carried out in the batch mode for the measurement of the adsorption capacities the Bottles with 250ml were filled with wastewater and adsorbent. The bottles were capped and shaken at room temperature on an electric shaker at 500rpm for required time period. The separation of the adsorbent and solution was carried out by centrifugation. The concentration of the unabsorbed benzoazurin-G dye in the solution was determined spectrophotometrically. Bach adsorption studies were carried out to study the effect of pH (3, , 5, 8,10 & 12), contact time (15-150 min), adsorbent dose (2-10 g/l) and initial Dye concentration (40-150ppm) at room temperature using stopper bottles. The initial pH of solution was adjusted by using 0.05 N HCl or 0.1N NaOH without changing the volume of the sample. After agitating the sample for the required contact time, the contents were centrifuged and filtered through what man No.41 filter paper and filtrate was analyzed spectrophotometerically.The removal efficiency (E) of adsorbent was defined as:

$$E (\%) = [(Co - Ce) / Co] \times 100$$

Where Co and Ce is the initial and equilibrium concentration of dye solution (mg/l), respectively. Influence of each parameter (pH, initial dye concentration, and adsorbent particle size and carbon concentration) was evaluated in an experiment by varying parameter under evaluation while all the parameters in the experiments were maintained as constant.

3. Sorption isotherms

Equilibrium studies that give the capacity of the adsorbent and the equilibrium relationships between adsorbent and adsorb ate are described by adsorption isotherms which are usually the ratio between the quantity adsorbed and the remaining in solution at fixed temperature at equilibrium. Freundlich and Langmuir isotherms are the earliest and simplest known relationships describing the adsorption equation. These two isotherms model were used to assess the different isotherms and their ability to correlate experimental data.

3.1 Langmuir isotherm

The Langmuir equation was chosen for the estimation of maximum adsorption capacity corresponding to complete monolayer coverage on the adsorbent surface. This model is based on two assumptions that the forces of interaction between adsorbed molecules are negligible and once a molecule occupies a site and no further sorption takes place. The saturation value is reached beyond which no further sorption takes place. The saturation monolayer can then be represented by the expression:

$$Ce/qe = 1/Qob + Ce/Qo$$

Where, Ce is equilibrium concentration (mg/I), q is the amount at equilibrium time per unit adsorbent (mg/g) and Q and b are Langmuir constants related to adsorption capacity and energy of adsorption respectively. The essential characteristics of Langmuir isotherm can be described by a separation factor or equilibrium parameter, defined as follows by weber and chakravorti:-

$$R = 1/1 + b\,Co$$

Where Co is the initial adsorb ate concentration (mg/l) and b is the Langmuir constant (mg/l). The parameter indicate the shape of isotherm accordingly

R-value	Type of isotherm
R>1	Unfavorable
R=1	Linear
0<R<1	Favorable
R=0	Irreversible

Values of dimensionless equilibrium parameter RL (0.498755) show the adsorption to be favorable (0< RL<1). More ever the higher correlation coefficient value ($R2=0.9958$) confirmed the suitability of the modal.

3.2 Freundlich Adsorption Isotherms:

The Freundlich isotherm model was chosen to estimate the adsorption intensity of the sorbent towards the adsorbent. It is an empirical equation employed to describe the isotherm data given by:

$$qe = KF (Ce)\ 1/n$$

The linearized form of the Freundlich equation use for analysis and it is given as;

$$\text{Log } qe = \log KF + 1/n \log Ce$$

KF and n are Freundlich constants; n gives an indication of the favorability and KF the capacity of the adsorbent. The values of 1/n, less than unity is an indication that significant adsorption takes place at low concentration but the increase in the amount adsorbed with concentration becomes less significant at higher concentrations and vice verse. The higher the KF value, the greater the adsorption intensity. The value of 1/n, less than unity was obtained mostly for the AC-E. Also the KF value, the greater the adsorption intensity. Present study verifies value of 1/n (0.6541) & value of KF (1.24632) from table (1).

The equilibrium concentration was calculated using following formula

$$Ce = C0 – (\% \text{ adsorption } x\ C0 / 100)$$

The amount of dye adsorbed per unit weight of an adsorbent 'q' was calculated using following formula

$$q = (C0 – Ce) x V /m$$

Where Ce is the equilibrium concentration (mg/l) and qe the amount adsorbed (mg/g) at equilibrium time; C0 is the concentration (mg/l), m is the mass of the adsorbent (gm) and V is the volume of the solution (L).

The correlation coefficient (R2) for Freundlich and Langmuir isotherms are merely equal. The correlation coefficient (R2) for Freundlich (0.9953) & Langmuir (0.9958) were obtained from Table (2). Therefore for the present adsorption study it can be stated that Freundlich and Langmuir adsorption equations are found to be better fitted. ($R2 \approx 0.999$)

4. Result and Discussion:

4.1 Effect of contact time: In adsorption system, the contact time play a vital role irrespective of the other experimental parameters, affecting the adsorption kinetics. Figure 1 depicts that there was an appreciable increase in percent removal of dye Benzoazurin-G up to 105min. thereafter further increase in contact time the increase in removal was very small (at 105 min). Thus the effective contact time (equilibrium time) is taken as 105 min. and it is independent of initial concentration (40ppm).

4.2 Effect of pH: The adsorptive capacity of Eichhcornia was dependent on pH of benzoazurin-G solution. At lower pH values, the large number of H+ ions neutralizes the negatively charged adsorbent surfaces; there by reducing hindrance of the Benzoazurin-G, at the high pH values, the reduction in adsorption may be due to the abundance of OH- ions causing increased hindrance to diffusion of Benzoazurin-G. It was found that 82.4 % removal of dye Benzoazurin-G achieved at pH 8 and thereafter the percent removal decreases with increases in pH as 10and 12. Thus the optimum adsorption pH for removal of dye was found to be 8.(Shown in Fig-2)

4.3 Effect of adsorbent dose: The effect of dose on adsorption, with the dose of adsorbent increasing, the value of qe was decreased. But removal efficiency of the adsorbent generally improved with increasing dose. Increasing adsorbent dosage can be attributed to increased adsorbent surface area and the availability of more adsorption sites. Adsorbent dose was varied between 2-10g/l for adsorbents used. The percent removal of Benzoazurin-G increases at a faster rate initially with increases in adsorbent dose. The present study indicated that the amount of dye adsorbed on AC- Eic increase with increase in the Eichhcornia dose up to 8gm/l and thereafter further increase in dose the increase in removal was very small. Thus the effective dose is taken as 8 gm/l. (Shown in Fig-3)

4.4 Effect of Adsorption Capacity vary with dose: Effect of initial Benzoazurin-G concentration over the percent removal shows that, as the concentration of Benzoazurin-G in solution increases, the percent removal of Benzoazurin-G decreases for AC-Eic the adsorbents used. These results may be explained on the basis that the increase in the number of ions competing for the available binding sites and also because of the lack of active sites on the adsorbent at higher concentration. (Shown in Fig-4)

5. Conclusion:

Pollution of the aquatic environment with toxic valuable dye is widespread. Consideration of the modes of purifying these contaminations must be given to strategies that are designed to high thorough put methods while keeping cost at minimum. Adsorption readily provides an efficient alternative to traditional physiochemical means for removing dye. In conclusion, Eichhcornia could be used as potential adsorbent for the removal of dye from aqueous solutions. The optimum data were found from this adsorption studies is given below in Table:1

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TABLE-1

Sr No.	Particular	Optimium data (AC-Eic)
1	Time (min.)	105min
2	pH	8
3	Dose (gm/l)	8 gm/l
4	Max. % removal of Dye	82.4%

TABLE -2 Langmuir and Freundlich constants for adsorption of Benzoazurin-G:-

Dose (gm/l)	Freundlich isotherm (linear equation)	Langmuir isotherm (linear equation)	R2 Freundlich	R2 Langmuir
8	Y=0.6541X-0.0956	Y=0.0483x+2.455	0.9953	0.9958

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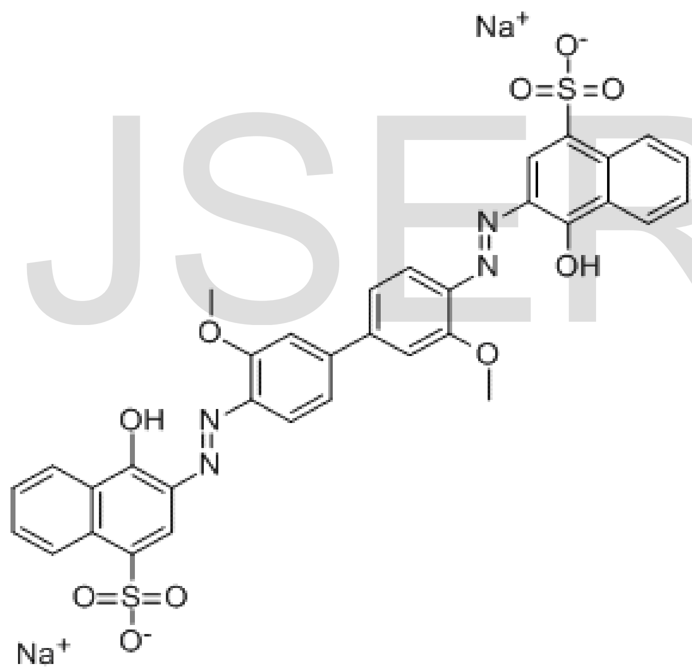
TABLE -3 Langmuir and Freundlich constants for adsorption of Benzoazurin-G:-

Dose (gm/l)	Freundlich constants			Langmuir constants		
	Kf	n	1/n	Qm (mg/g)	b (l/ mg)	RL
8	1.24632	1.528818	0.6541	20.70393	0. 025125	0.498755

Molecular Structure of Benzoazurine-G



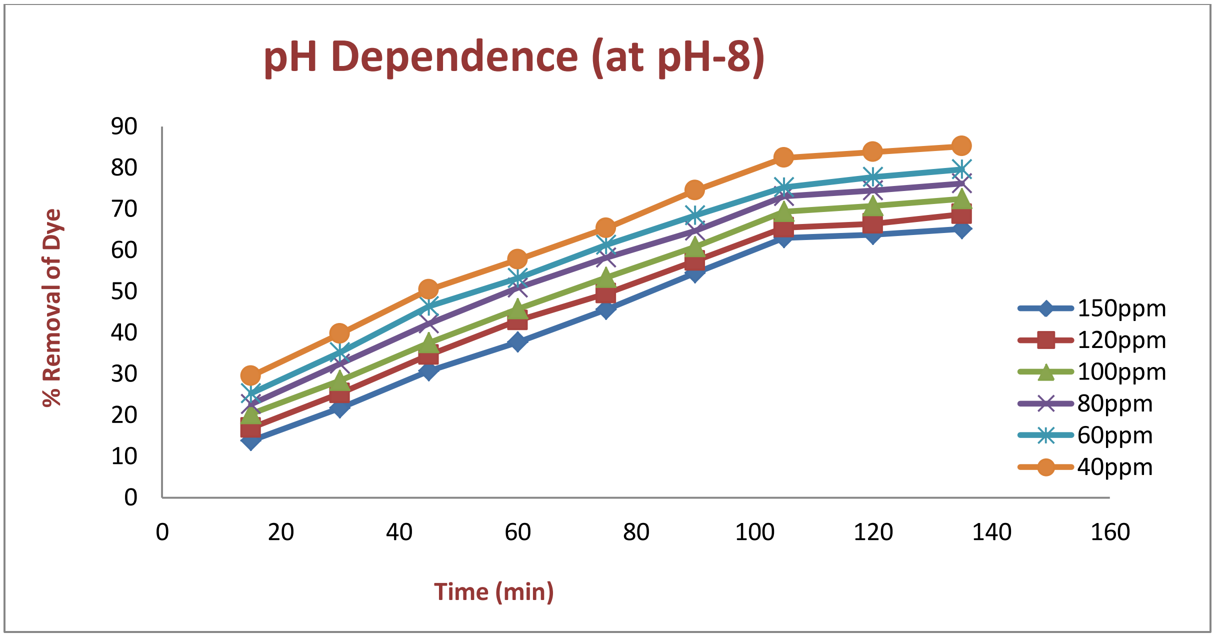


Figure 1: Effect of contact time on removal of Dye Benzoazurin-G at different concentration by AC-Eic. at pH 8

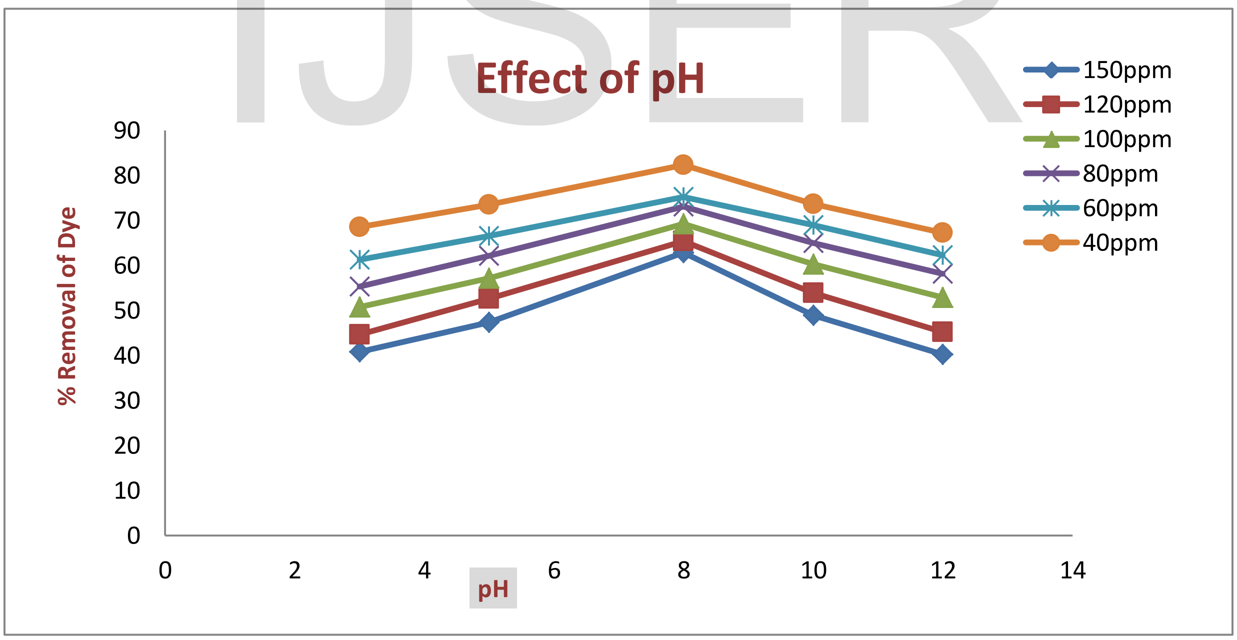


Figure 2: Effect of pH on removal of Dye Benzoazurin-G at different concentrations by 8gm/l of AC-Eic. at constant contact time 120 min.

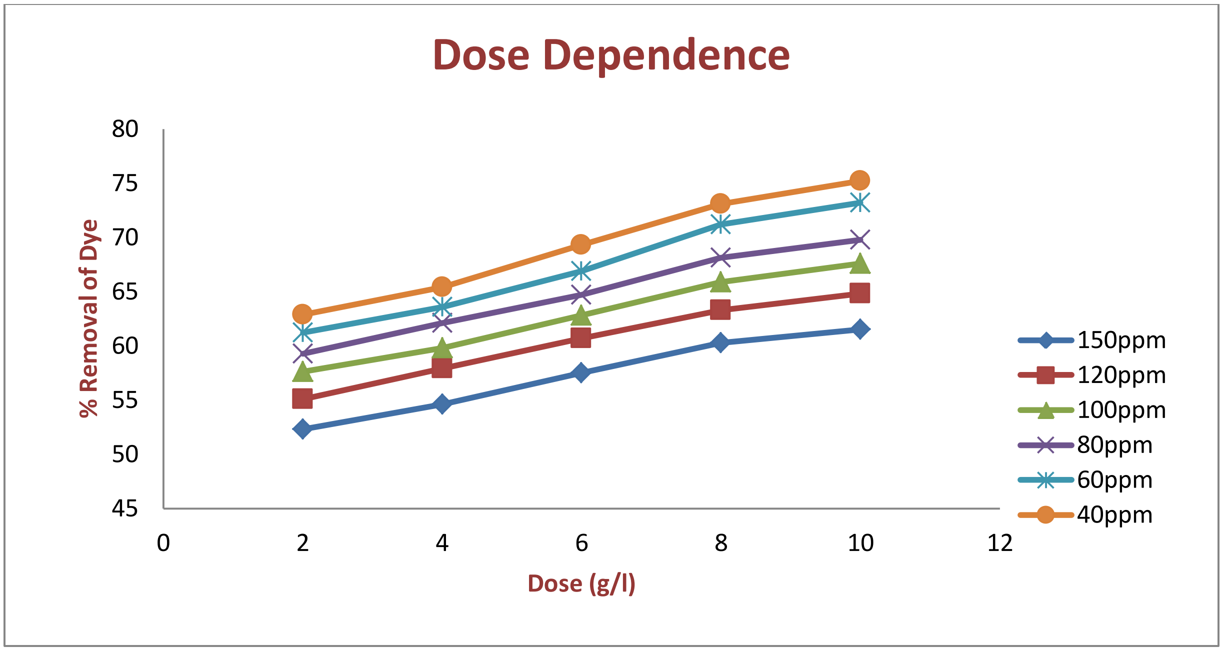


Figure 3 : Effect of AC-Eic. dose on percent removal of Dye at equilibrium contact time 120 min. and effective at pH 8.

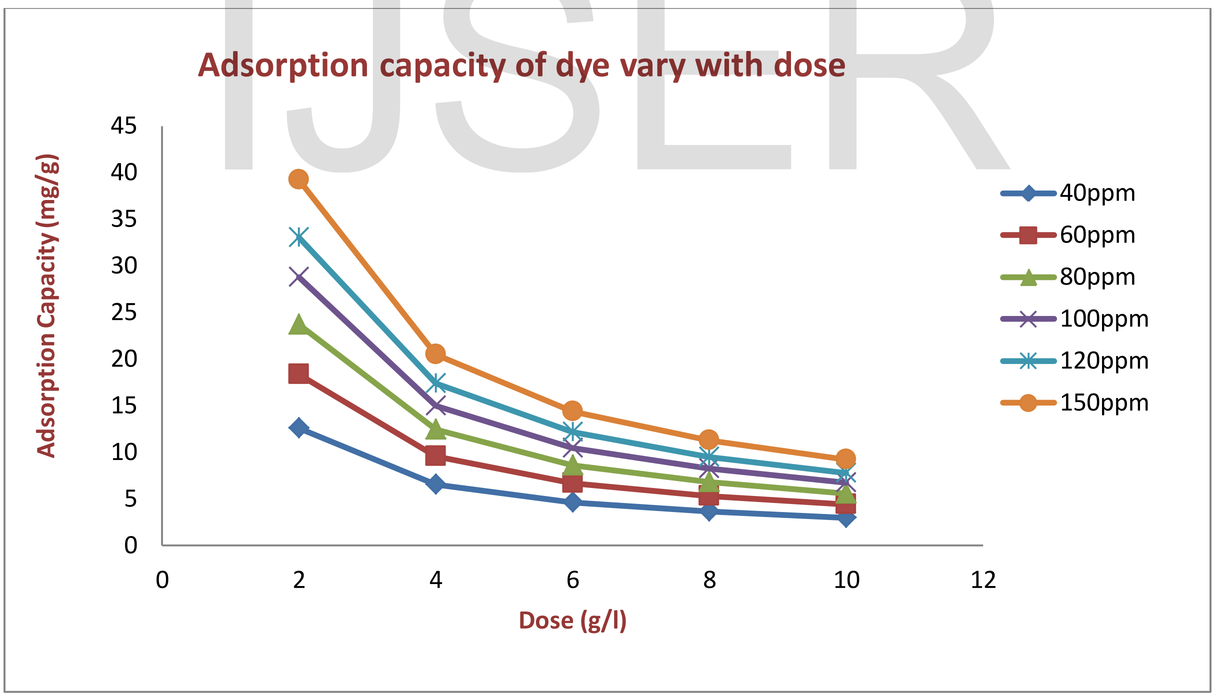


Figure 4: Effect of dose of adsorbent on adsorption capacity at equilibrium contact Time 120 min and effective pH 8

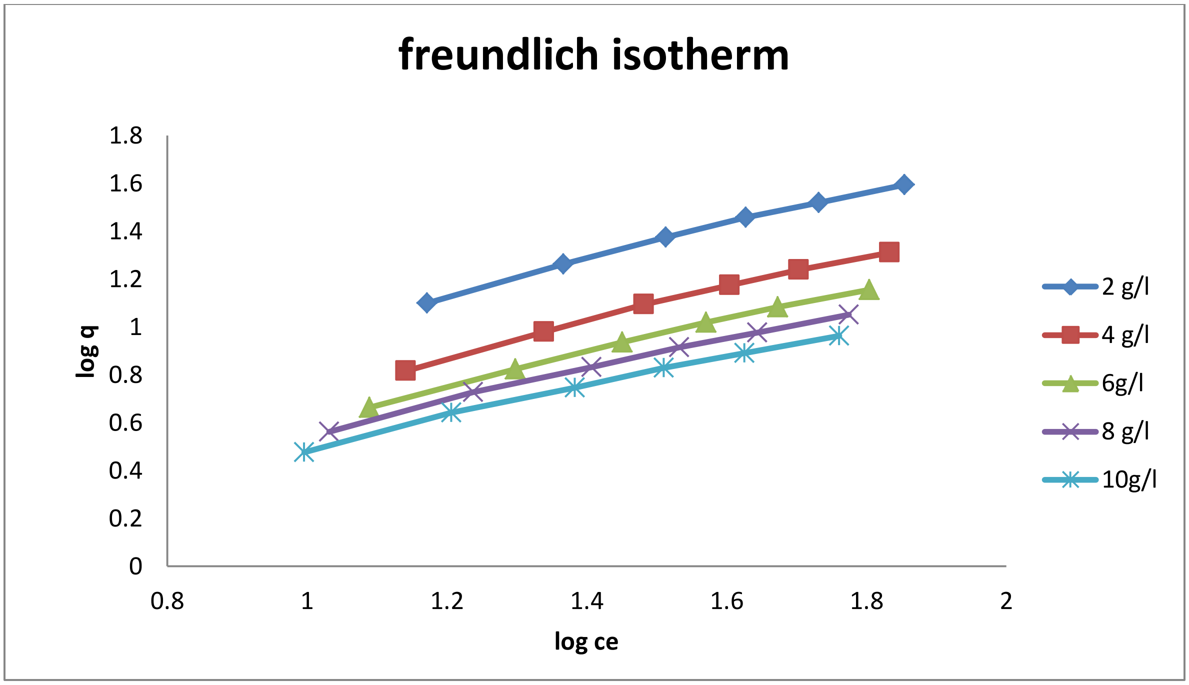


Figure 5: Freundlich Isotherm plot for Dye Benzoazurin-G adsorption by AC-Eic. at optimum conditions

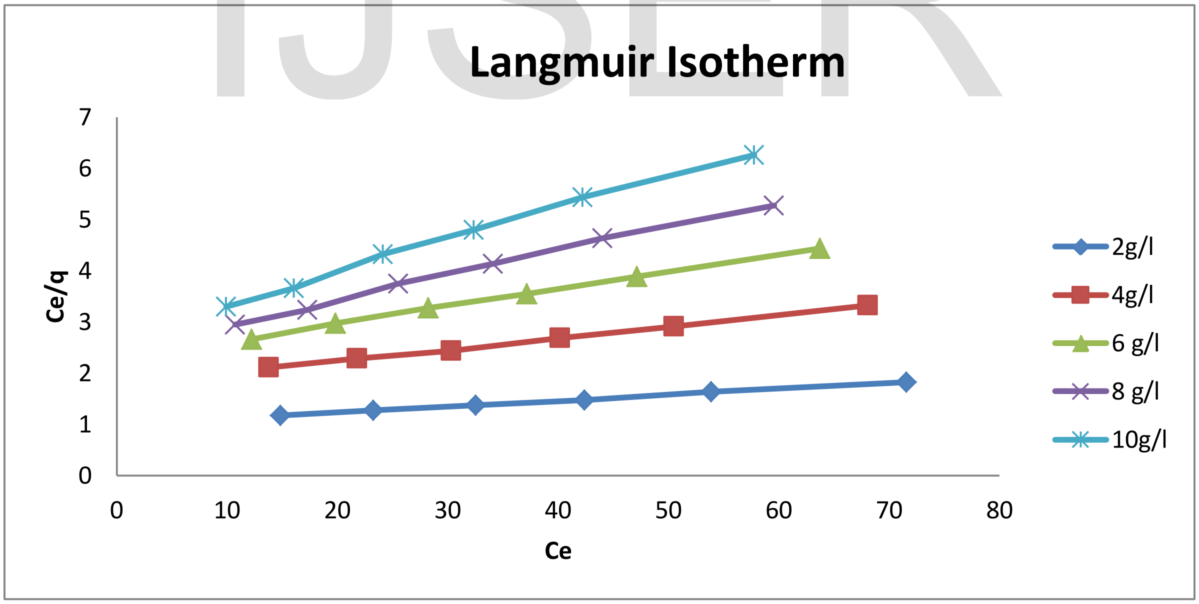


Figure 6: Langmuir Isotherm plot for dye Benzoazurin-G adsorption by AC-Eic. at optimum conditions.