Heavy metal copper uptake by adsorption using *Crotalaria burhia* as an adsorbent

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ABSTRACT-The wastewater containing bivalent copper was treated with adsorbent prepared from Crotalaria burhia (a plant of western Rajasthan) was investigated in batch experiments. The results showed removal of 74.8% of copper in the 60 mgl-1 copper solutions. The adsorptive capacity of the Crotalaria burhia was dependent on the pH of the copper solution, with pH 6 being optimal. The adsorption data fit well with the adsorption isotherm models. Comprehensive characterization of parameters indicates Crotalaria burhia to be an excellent material for adsorption of Cu(II) to treat wastewaters containing low concentration of the metal

Key words- Adsorption, Heavy metals, adsorption Isotherm, Crotalaria burhia, Wastewater

1 INTRODUCTION

IN the recent years, increasing awareness of water pollution and its far reaching effects has prompted concerted efforts towards pollution abatement. Among the different heavy metals from toxic pollutant introduced into natural waters . There are two major sources of heavy metals contamination waste water metal finishing industries (bivalent copper).

Cu(II) is a common pollutant introduced into natural waters from a variety of industrial wastewaters including those from the textile dyeing, leather tanning, electroplating and metal finishing industries. Most of the methods very often present problems such as secondary polluting effects, excessive use of reagents or high operating cost. There is need of low cost, easily available adsorbent materials which can adsorb heavy metal ions economically.

Adsorption of heavy metal ions on to activated carbon has been widely applied as a unit operation in the treatment industrial wastewater. The use of commercial activated carbon is not suitable for developing countries because of its high cost. Therefore, there is a need to produce activated carbon from cheaper and readily available materials, which can be used economically on a large scale. In recent years, adsorption has emerged as a cost-effective and efficient alternative for the removal of heavy metals from low strength wastewaters.

In this study, activated carbons prepared from Crotalaria burhia are used to removal of Cu (II) ions from aqueous solution. Various parameters affecting adsorption like contact time ,adsorbent dose, pH of the sample, initial concentration have been investigated and data on adsorption isotherms have been presented.

2 MATERIALS AND METHODS

2.1Preparation of activated carbon from Crotalaria burhia (AC-CB):

The complete plant Crotalaria burhia was obtained locally. It was cut into small pieces. The small pieces was treated with sulphuric acid (2% v/v) in 1:1 ratio and was kept in an oven at 150°C for 24 hours. It was filtered and washed with distilled water repeatedly to remove sulphuric acid (washings tested with two drops of barium chloride solution) and finally dried.

Chemical activation using sulphuric acid produces a high surface area and high degree of microporosity. The adsorbent was sieved to 40-60 mesh size and heated at 110 °C for 2 hours. This material was used as an adsorbent to study adsorption of metal ions at different pH.

2.2Preparation of stock solution (Synthetic wastewater)

0.393gm of AR grade copper sulphate was dissolved in 1000ml of distilled deionized water and acidified with acetic acid. This solution was stored in dark brown glass bottle and used as stock solution.

3 Adsorption studies

Batch adsorption studies were carried out to study the effect of pH (3, 4 ,5, 6,7 and 8), contact time (30-135 min), adsorbent dose (3-18 g/l) and initial metal ion concentration (60-150 mg/l) at room temperature using stopper bottles. The initial pH of solution was adjusted by using 0.1 M sodium hydroxide and /or 0.1 M nitric acid, without changing the volume of the sample.

After agitating the sample for the required contact time, the contents were centrifuged and filtered through whatman No.41 filter paper and unreacted Copper in the filtrate was analyzed .

The removal efficiency (E) of adsorbent was defined as:

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

Where Co and Ce are the initial and equilibrium concentration of metal ion solution (mg/ l), respectively.

4 Adsorption Isotherm Models For Cu (II)

4.1Freundlich isotherm:

It has the general form of

(X/m) or $q_e = Kf\, C_e\, 1/n$

The linearised Freundlich adsorption isotherm, which is of the form

$\text{Log } q_e = \log Kf + 1/n \text{ Log } C_e$

where:

q_e = the amount of the adsorbate adsorbed per unit mass of adsorbent (mg adsorbate/g adsorbent)

X = the amount of the adsorbate

m = mass of adsorbent used (g)

Kf = adsorption capacity

n = adsorption intensity (the empirical constants)

C_e = equilibrium concentration of adsorbate (mg/L)

Linear plots of log $q_e(x/m)$ v/s log C_e at different adsorbent doses are applied to confirm the applicability of Freundlich models as shown in Fig.4

4.2Langmuir isotherm:

$$C_e/q_e = 1/Q_m b + C_e/Q_m$$

Q_m and b is Langmuir constants related to adsorption capacity (maximum specific uptake corresponding to the site saturation) and energy (intensity) of adsorption (l of adsorbent /mg of adsorbate) respectively. The essential characteristics of the Langmuir Isotherm can be expressed in terms of a dimensionless constant, Separation factor or equilibrium parameter R_L that defined as

$$R_L = 1/(1+b\, C0)$$

Where Co (mg/1) is the initial concentration of the metal.

Values of dimensionless equilibrium parameter R_L show the adsorption to be favorable ($0< R_L<1$).

5 Results and discussion

The data obtained during the adsorption studies made here to evaluate the effect of contact time, pH of solution, adsorbent doses and isotherms on the removal of bivalent copper from the synthetic wastewater have been analyzed and discussed under the following head.

5.1Effect of contact time:

In adsorption system, the contact time play a vital role irrespective of the other experimental parameters. Figure:1 depicts that there was an appreciable increase in percent removal of copper up to105 minutes and thereafter further increase in contact time the increase in removal was very small. Thus the effective contact time is taken as105 minute.

5.2Effect of pH:

The removal of metal ions from solution by adsorption is highly dependent on the pH of the solution. It was found that 74.8% and 63.8 % removal of Cu (II) achieved at pH6 and 7 respectively. Thus the optimum adsorption pH for Cu (II) is 6. (Figure: 2) Due to strong adsorption of hydrogen ions from the solution and hydroxyl ions, the adsorption of other ions is strongly influenced

.

5.3Effect of adsorbent dose:

The effect of adsorbent dose on percent removal of copper is shown in fig.3. Adsorbent dose was varied (3,6,9,12,15,18g/L) and performing the adsorption studies at pH 6. The present study indicated that the amount of Cu (II) adsorbed on AC-CB increase with increase in the AC-CB dose up to 15 g/l and thereafter further increase in dose the increase in removal was very small. Thus the optimal dose is 15g/l.

5.4Results of Adsorption Isotherms:

Langmuir and Freundlich isotherms for Cu (II) by AC-CB were found to be linear showing the applicability of the isotherms. The values of Langmuir and Freundlich constants calculated from the graph are summarized in table: 1 for Cu (II) by AC-CB. Value of n for Cu (II) was 1.5760 by AC-CB at effective dose and contact time, indicates good adsorption potential of the adsorbent.

Values of R2 show the adsorption to be more favorable. A value of R2 was 0.9904 for 60ppm Cu (II) solution by AC-CB.

6 CONCLUSION:

This study indicates that AC-CB has rapid adsorption rate and good adsorption capacity for Cu (II).

Maximum adsorption of copper 74.8 % occurred at pH 6. The adsorption of metal ion on AC-CB reached equilibrium in 105min.and initial concentration 60 ppm. The Freundlich isotherms is followed better than the Langmuir .Since Crotalaria burhia plant are highly abundant and can be easily synthesized at relatively low cost, the adsorbent could be applied for the removal of copper from wastewaters.

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Table: 1

Values of Langmuir and Freundlich isotherm constants for adsorption of Cu (II) by AC-CB

Dose (g/L)	Langmuir constants				Freundlich Constants			
	Q_m (mg/mg)	b (1/mg)	R_L	R^2	K_f	1/n	n	R^2
3	64.51613	0.01085	0.6055	0.9956	1.44843	0.7011	1.37174	0.9952
6	34.12969	0.01142	0.59335	0.9757	1.22348	0.6926	1.44383	0.9933
9	23.69668	0.01252	0.57093	0.9637	1.63794	0.6903	1.44864	0.9988
12	16.31321	0.01688	0.4967	0.9823	1.68189	0.648	1.5432	0.9992
15	12.62051	0.02082	0.44456	0.9967	1.82053	0.6345	1.57604	0.9904
18	10.91701	0.02145	0.43717	0.9899	2.12512	0.6434	1.5542	0.984

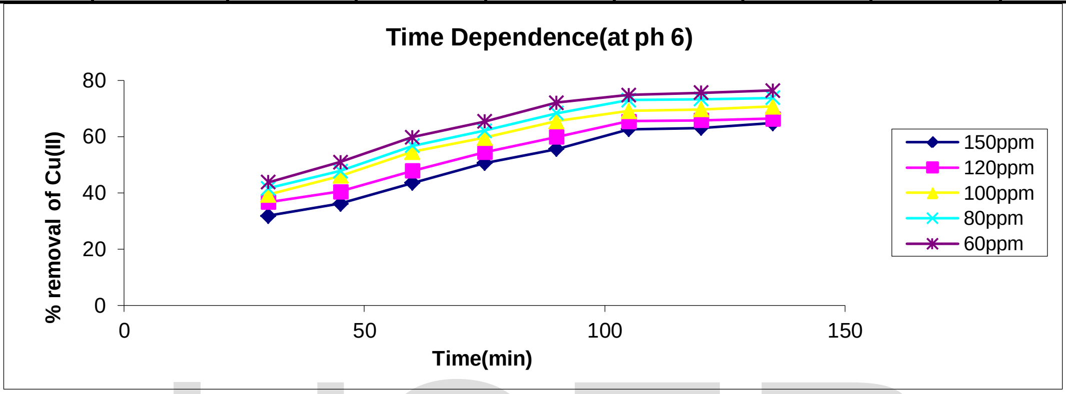

Figure 1: Effect of contact time on removal of Cu (II) at different concentration by AC-CB at pH 6

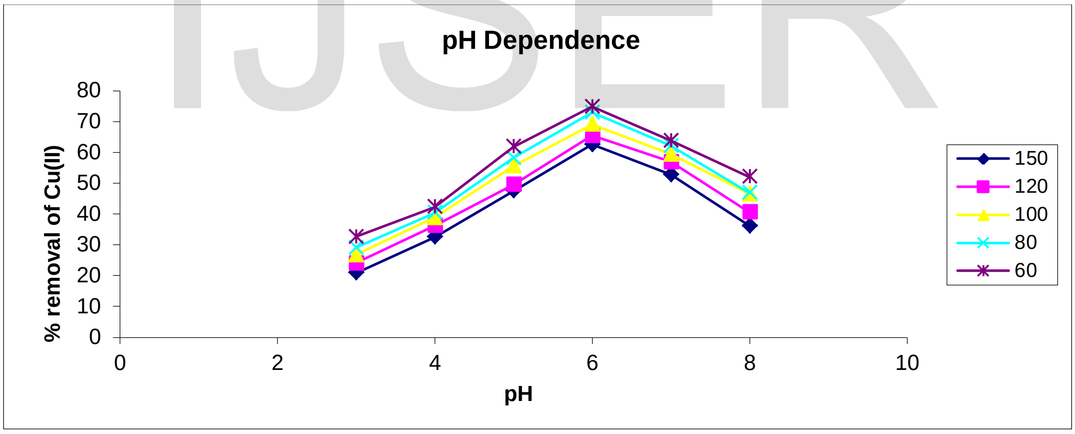

Figure 2: Effect of pH on removal of Cu (II) at different concentrations by AC-CB at constant contact time 105 min.

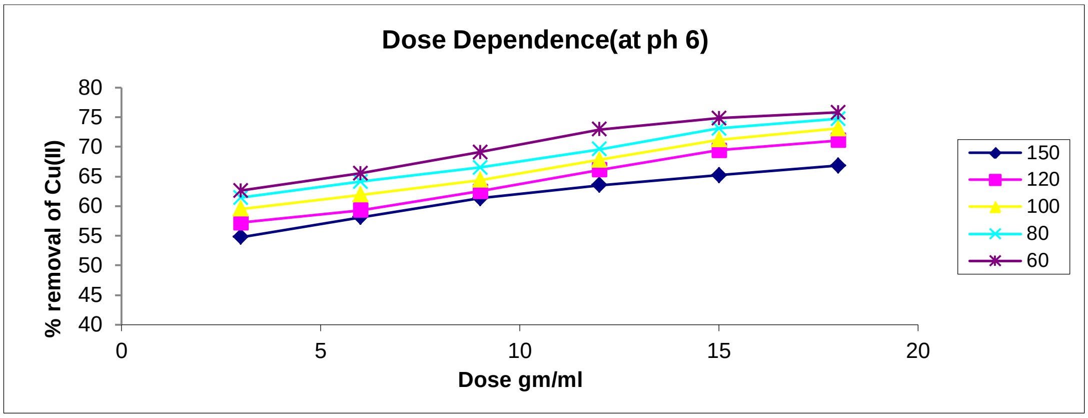

Figure 3: Effect of AC-CB dose on percent removal of Cu (II) at equilibrium contact time 105 min. and effective at pH 6.

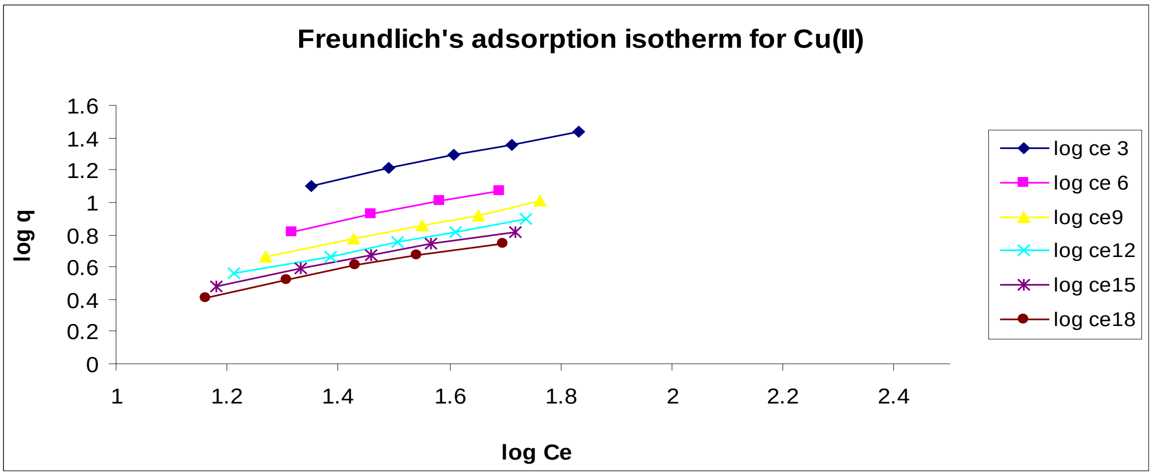

Figure 4: Freundlich Isotherm plot for Cu (II) adsorption by AC-CB at optimum conditions.

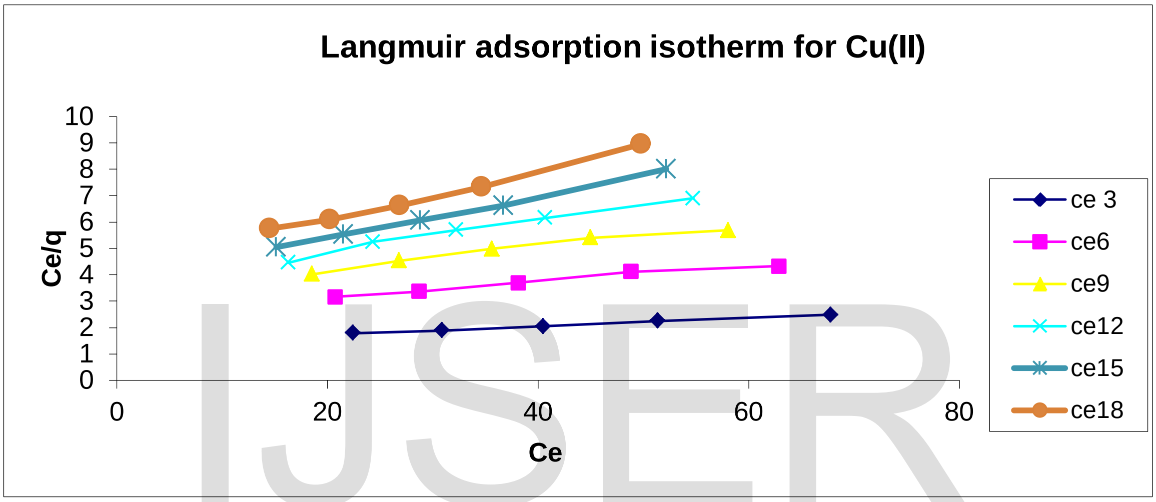

Figure 5: Langmuir Isotherm plot for Cu (II) adsorption by AC-CB at optimum conditions

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