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Chromium Removal from Aqueous Medium Using Modified Sawdust

B.SARITHA Dr.M.P.CHOCKALINGAM HIRAJ JHA
Department of Civil Engineering, Bharath Institute of Higher Education and Research, Bharath University, Selaiyur, Chennai-73, INDIA

Abstract
One of the serious environmental issues is the presence of toxic heavy metals contaminants in water bodies because of discharge of untreated heavy metals due to urbanization, combustion byproducts, automobile emissions, mining activities.Chromium is widely used in many industries and usually present in high concentration in the aqueous medium. This study involved the investigation of the adsorption of hexavalent form of the heavy metal (Cr) by modified teakwood sawdust. The study demonstrated that the teak wood sawdust has a moderate potential to remove hexavalent chromium.The equilibrium data of adsorption very well fitted into the models and the maximum loading capacity was obtained from adsorption isotherms by applying the Langmuir model.
Keywords: Hexavalent chromium, sawdust, adsorbent,aqueous solution,batch adsorption experiments.

1 Introduction

Disposal of heavy metals in ground by human activity is nowadays increased due to urbanization, combustion byproducts, automobile emissions, mining activities. Disposed heavy metals are not biodegradable substances and they tend to accumulate in living organism causing various disease and disorder (Bailey et al.,1999)[1]. Among the toxic heavy metals, hexavalent form of chromium is known to cause wide range of human health effect including mutagenic and carcinogenic risks (Park and Jung) [2,3].

Heavy metal like chromium is used in various industries and are usually present in high concentration in the aqueous medium which are usually released directly into the environment without any pretreatment. The commonly used treatment methods includes chemical precipitation, reverse osmosis, evaporation, ion exchange etc. Among these methods, adsorption has been proved to be very effective technique.

The adsorption batch study has been conducted to examine the use of sawdust in the adsorptive removal of chromium ions.

2 Materials and Methods

2.1 Adsorbent Preparation

The sawdust (teak wood) was cleaned with water to remove dust and insoluble substances and dried. Then sawdust passing through 600 microns sieve were taken and washed again until pH 7. Then sawdust chemically treated with hydrochloric acid (HCl) and was termed as activated sawdust . A suspension containing 30 gm sawdust, 500 ml of distilled water and 10 ml of 0.5 N HCl was prepared in a beaker. The contents in the beaker was stirred for 1 hr magnetic stirrer. After filtering, the sawdust was cleaned many times using distilled water until the filtrate pH became neutral. The sawdust was kept in the oven at 100^0C for 60 minutes and again dried in air at room temperature.

The concentration of chromium in adsorbent was determined by placing 2g of adsorbent in 20ml distilled water for 1 hour with continuous agitation, after which it was centrifuged with laboratory centrifuge. The supernatant was carefully decanted and analysed using AAS (Atomic Absorption Spectrophotometer).

2.2 Adsorbate solution

Hexavalent chromium solution was made by taking 1.41g of $K_2Cr_2O_7$ and dissolved in 100 ml distilled water. The prepared solution can be used by diluting as required to obtain standard solutions.

2.3 Experimental study

The study has been conducted by agitating standard solution for 30 minutes in orbital shaker. Experimental study was conducted by varying the dosage of adsorbent from 0.2gm/100ml to 1.6gm/100ml solution with concentration of hexavalent chromium of 50mg/l. Adsorption isotherm study was performed by changing Cr (VI) concentration from 10-80mg/l while the dosage of sawdust is maintained at 0.4gm/100ml and with pH between 2-12.

The quantity of metal ions adsorbed per gram of adsorbent and the adsorption efficiency (%) were found using the following expressions:

$$Q = \frac{Co - Ce}{M} \text{ X V} \qquad (1)$$

$$\text{Sorption efficiency (\%)} = \frac{Co - Ce}{Co} \text{ X 100} \qquad (2)$$

Q_e = concentration of adsorbent after equilibrium
C_o = adsorbate initial concentration
C_e = adsorbate final equilibrium concentration after adsorption has occurred
M = mass of sawdust
V = volume

2.4 Adsorption isotherms

The Freundlich and Langmiur adsorption isotherm models were used. The Freundlich isotherm (Fruendlich, 1906)[5] is given as

$\text{Log}(Q_e) = \text{Log}(K_f) + (1/n)[\text{Log } C_e]$ (3)

(K_f) = Constant called Freundlich constant
(n)= Freundlich constant indicates the intensity of sorption.
Langmiur isotherm (Langmiur, 1918)[6] is expressed as

$[C_e/Q_e] = [1/Q_m b] + [C_e/Q_m]$ (4)

Q_m and b are constants .

3 Discussions

3.1 Study of sawdust dosage

The removal of Cr(VI) increased with increase of adsorbent dosage and it has been clearly depicted in **Fig 1**. However, the adsorption capacity showed a decreasing trend with increasing dosage.Adsorption capacity was maximum at 0.4g/l.

3.2 Study of contact time

The adsorption of hexavalent chromium with respect to time is shown in From **Fig. 2**. In this the percentage removal increases with more contact time and the equilibrium was obtained after 50 minutes. Therefore, the adsorption for 50 minutes could be considered for whole batch experiments. The agitation speed was 150 r.p.m.

3.3 Study of pH

The adsorption of Cr(VI) slows down with increase in pH (**Fig 3).** At pH range 3-4, the maximum adsorption takes place.

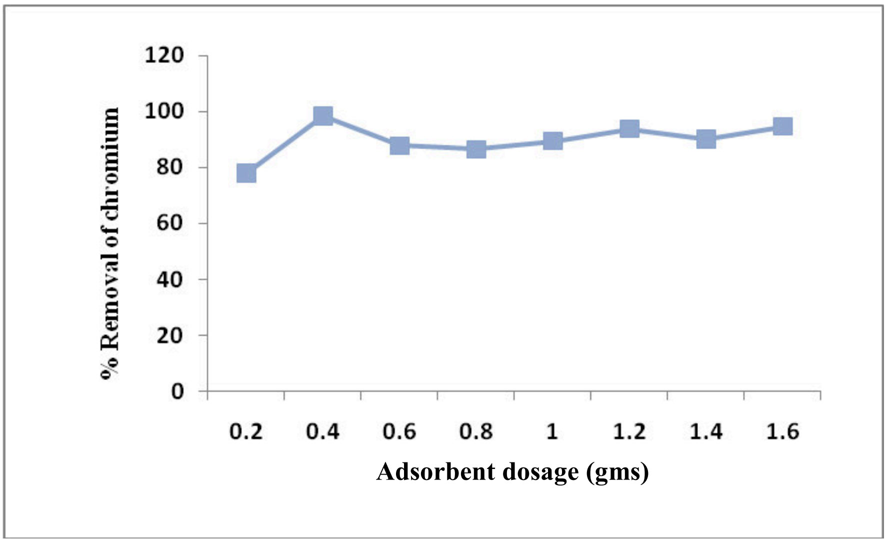

Fig. 1 Study of varying dosage of sawdust on adsorptive removal of Cr(VI)

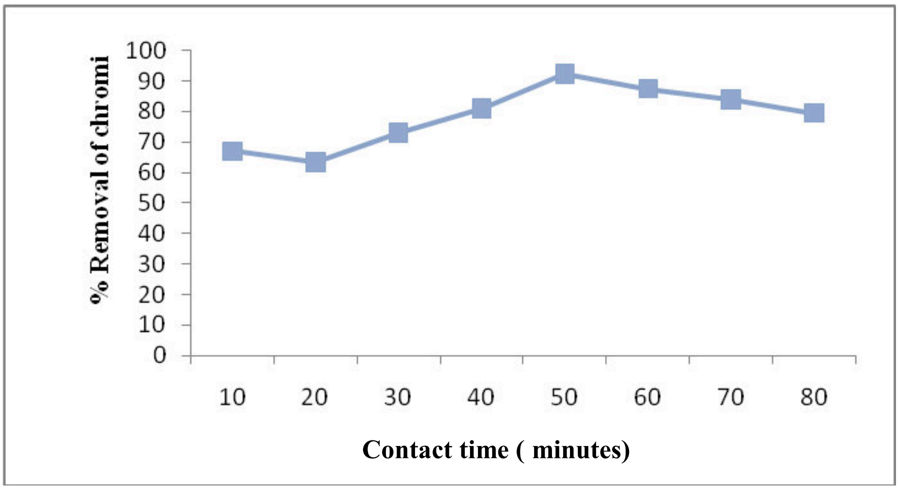

Fig. 2 Study of varying time of contact on adsorptive removal of Cr(VI)

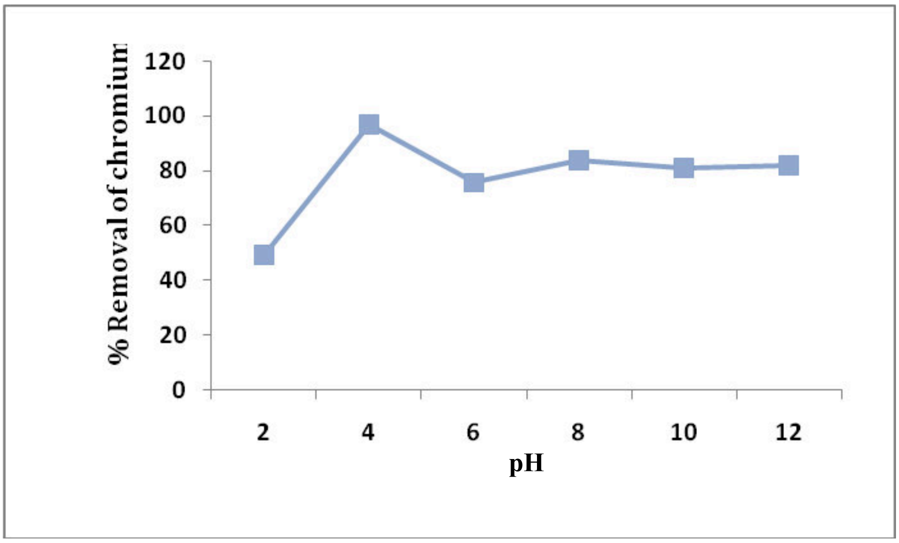

Fig. 3 Study of varying pH on adsorptive removal of Cr(VI)

3.4 Adsorption Isotherm Models

3.4.1 Langmuir Plot

The plots of the Langmuir graph shows us that the removal process obeys Langmuir adsorption isotherm as shown in **Fig. 4**. Q_m and b obtained were presented in **Table 1**. R_L, defined by (Hall et al.)[7].

$$R_L = \frac{1}{1+bCo} \qquad (5)$$

Where Co is metal ions (mg/l) and b is the constant (1/mg).

Table 1 The values of R_L for adsorption of hexavalent chromium on modified sawdust

Q_m (mg/g)	b (l/mg)	Hexavalent chromium concentration [Co (mg/l)]	R_L
14.79	0.716	10	0.1225
		20	0.0652
		30	0.044
		40	0.033
		50	0.027
		60	0.022
		70	0.019
		80	0.017

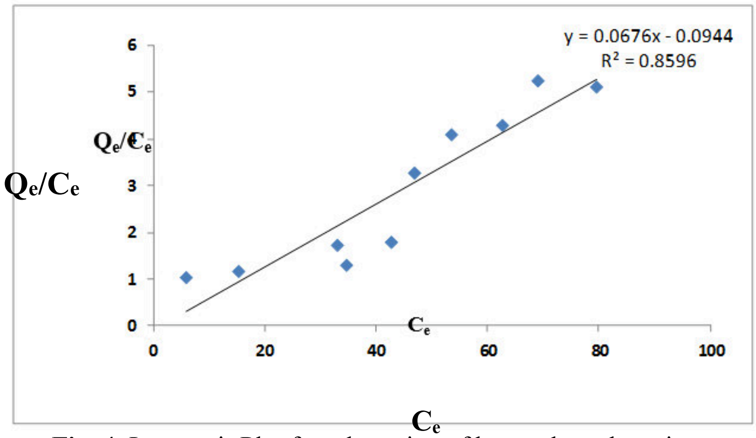

Fig. 4 Langmuir Plot for adsorption of hexavalent chromium

3.4.2 Freundlich adsorption isotherm

The adsorption of hexavalent chromium follows Freundlich isotherm model obtained from graph of Log Q_e vs Log C_e in **Fig. 5** (K_f = 5.02 and n = 1.4345). The modified sawdust shows value of 'n' as 1.4345 which proves effective removal of hexavalent chromium from aqueous medium because according to Treyball [8], n = 1- 10 is considered as a good adsorbent.

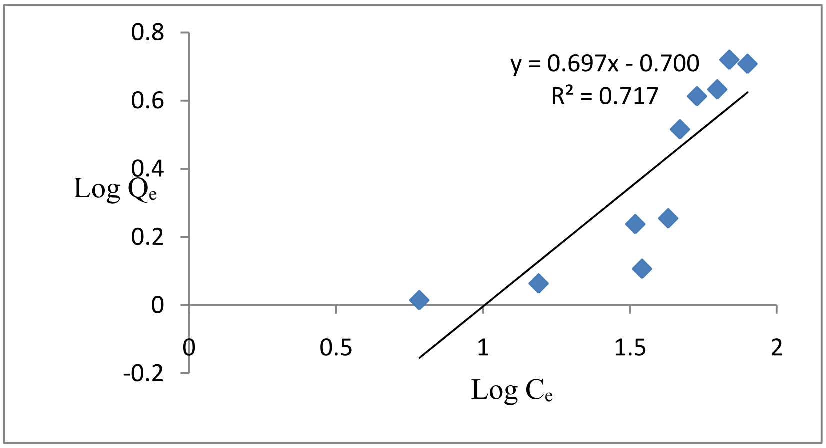

Fig. 5 Freundlich Plot

4 Conclusion

The modified teak wood sawdust has a moderate potential to remove hexavalent chromium. The adsorptive removal percentage of hexavalent chromium depends on dosage of adsorbent, pH, time of contact, and initial concentration of hexavalent chromium. The results demonstrated that the modified teak wood sawdust can be more efficient natural adsorbent for maximum removal of hexavalent chromium.

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