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Adsorption Studies of Hexavalent Chromium Removal on Activated Carbon Derived From Helianthus Annuus (Sunflower Cob)

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Abstracts

The present study deals with removal of hexavalent chromium from aqueous solution using low cost activated carbon prepared from helianthus annuus cob. In adsorption solute present in dilute concentration in liquid or gas phase is removed by contacting with suitable solid adsorbent so that the transfer of component first takes place on the surface of the solid and then into pore of the solid. Batch adsorption study were conducted by varying the contact time, adsorbent dosage & pH.

Keywords: Activated Carbon, Adsorption, Hexavalent Chromium.

Introduction

The scope of interest in this present study is to use Helianthus Annus (sun flower cob) as an alternate low cost adsorbent in removal of chromium (VI). The sun flower cob available locally and abundantly and the cob is thrown away as waste which can be bought at throwaway cost. The interest to choose this cob is that it has not being used as adsorbent in any other studies for the removal of Cr (VI).

Chromium is a common pollutant introduced into newly water due to discharge of variety of industrial wastewater. On the other hand chromium based catalysts are also usually Chromium is considered as one of the top 16th toxic pollutants and because of its carcinogenic and teratogenic characteristics on the public, it has become a serious health concern. According to world health organization (W.H.O) drinking water guidelines, the maximum allowable limit for total chromium is 0.05mg/L.[1]

Cr (III) occurs naturally in the environment and is an essential nutrient. Cr (III) and Cr (VI) are used for chrome plating industries, dyes and pigments, leather tanning, and wood preserving industries. Cr (VI) is mobile in environment and is highly toxic. Cr (VI) can easily penetrate the cell wall and exerts its noxious influence in the cell itself, being also a source of various cancer diseases. At short term exposure levels above maximum contaminant level, Cr (VI) causes skin and stomach irritation or ulceration. Long term exposure at levels above maximum contaminant level causes dermatitis, damage to liver, kidney circulation, nerve tissue damage, and even death in large doses.[2]

Materials and methods

Adsorbent

The material used in this research study is Helianthus Annuus as an adsorbent. For removal of hexavalent chromium from aqueous solution, adsorption technique was employed using activated carbon prepared from helianthus annuus. There are two methods to prepare activated carbon, namely

i. Physically activation (taking three sieve sizes 75,150,300 microns)
ii. Chemical activation, using ammonium chloride (NH_4Cl) as activating agent (taking sieve size 150 microns).

Impregnation Ratio

In chemical activation the degree of I.R. play an important role. It is the ratio of weight of anhydrous activating salt to the dry carbonizing material. The effect of the degree of impregnation ratio on the porosity of the resulting product is apparent from the fact that volume of pores increases with I.R. When degree of impregnation is further raised the number of pores with large diameter increases and the volume of the smallest decreases. In this study 0.25, 0.50 and 0.75 I.R'S. are used.

Batch Sorption Experiment

In batch sorption, a pre-determined amount of adsorbent is mixed with the sample, stirred for a given contact time and subsequently separated by filtration. Powder

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adsorbent is more suitable for the batch type of adsorption.

Selection of Optimum Contact Time

The adsorption is strongly influenced by the contact time. To study the effect of contact time, 100mL of 10mg/L hexavalent chromium solution of pH 2.0 ± 0.02, was mixed with 0.1g of activated carbon, stirred at different contact times varying from (5mins, 10mins, 15mins up to 60mins). Then filtrate was analyzed for residual chromium (VI) concentration using spectrophotometer.

Determination of Optimum Dosage

To determine the optimum dosage of activated carbon, carbon was added to the conical flask in varying amount (25mg, 50mg, and 75mg up to 300mg), containing 100mL concentration of chromium (VI) solution (10mg/L) and adjusted pH 2.0±0.02. The solution in the conical flask was subjected to stirring for optimum contact time, filtered and analyzed for residual chromium concentration. The dosage which gives minimum residual concentration is chosen as optimum dosage.

Selection of Optimum pH on Hexavalent Chromium:

The extent of adsorption is strongly influenced by the pH at which adsorption is carried out. The effect of pH on hexavalent chromium adsorption was studied by performing equilibrium adsorption tests at different initial pH values. i.e. from 1.25 to 3.0. The pH of solution was adjusted by using 0.1N H_2SO_4 or 0.1N NaOH. The pH at which maximum chromium (VI) removal forms optimum pH.

Results and discussions

This chapter deals with the efficiency of prepared carbon for removing hexavalent chromium for:

1. Effect of contact time
2. Effect of dosage
3. Effect of pH

Effect of Contact Time:

Contact time has greater influence in the adsorption process. The effect of contact time on removal of chromium (VI) from synthetic sample at pH 2.0 ±0.02 using physically and chemically activated carbons (Ammonium Chloride (NH_4Cl)) prepared from Helianthus annuus cob powder with I.R. 0.25, 0.50 and 0.75 are shown in figure 3.1.

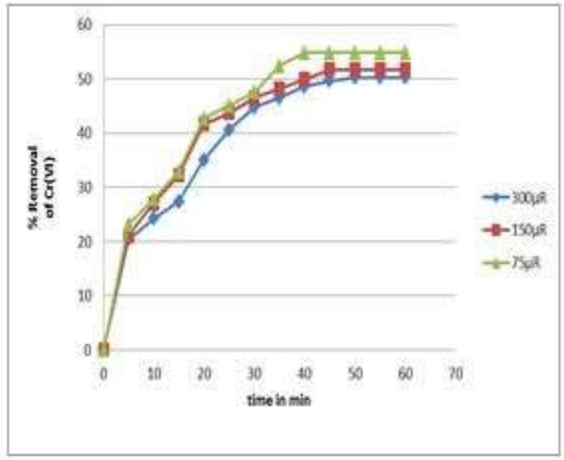

Fig.3.1 Effect of Contact Time on Cr (VI) Removal by Physically Activated Carbon.

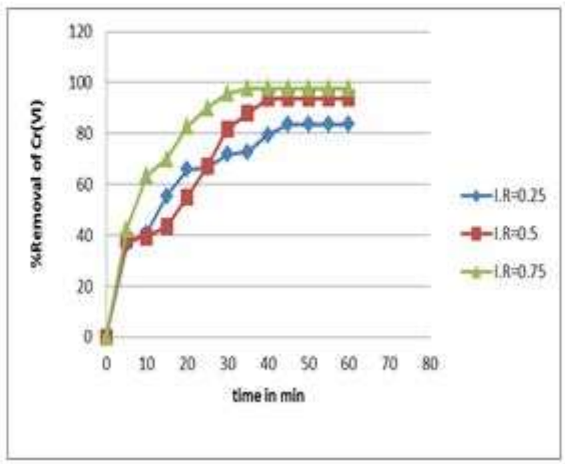

Fig.3.2 Effect of Contact Time on Cr (VI) Removal by Chemically (NH_4Cl) Activated Carbon.

Effect of Adsorbent Dosage:

Adsorption is a process in which continues transfer of solute from solution to adsorption occurs, until residual concentration of solution maintains an equilibrium with what adsorbed by the surface of adsorbent at constant contact time. Effect of adsorbent dosage is studied and graph of percentage of chromium removal versus dosage is plotted as shown in figure 3.3 and 3.4.

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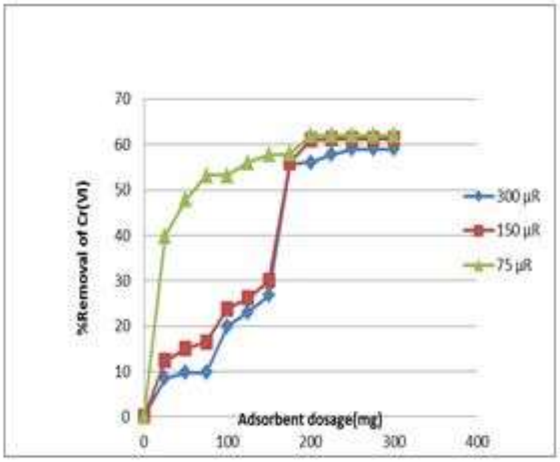

Fig.3.3 Effect of Adsorbent Dosage on Cr (VI) Removal by physically Activated Carbon

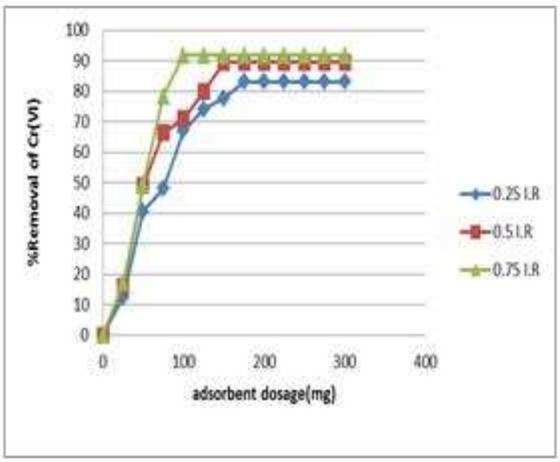

Fig.3.4 Effect of Adsorbent Dosage on Cr (VI) Removal by Chemically (NH_4Cl) Activated Carbon

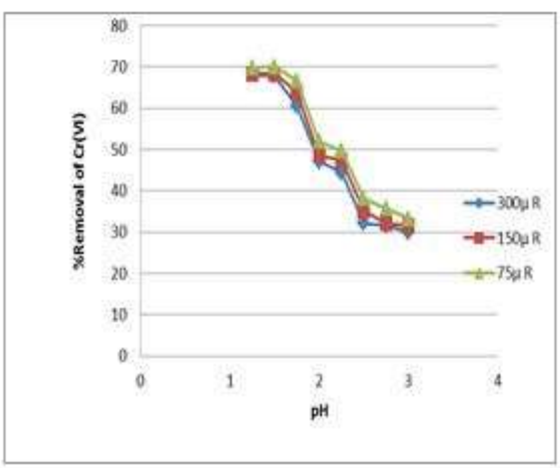

Fig.3.5 Effect of pH on Cr (VI) Removal by Physically Activated carbon

Effect of pH on Hexavalent Chromium removal:
The pH of solution has influence on the extent of adsorption removal efficiencies of chromium (VI) by prepared activated carbon at different pH values are shown in figure 3.5 and 3.6. The amount of Cr (VI) not only depends on the surface area, optimum time and optimum dosage but also depends on pH.

Table-3.1: Optimum Contact time, Optimum Dosage and Optimum pH for Prepared Carbons

Type of Carbon		Optimum Time (Min)	Optimum Dosage (mg)	Optimum pH
1.Physically activated carbon	Sieve size			
	300 µR	50	250	1.25
	150 µR	45	225	1.25
	75 µR	40	200	1.25
2.Chemically activated (NH_4Cl)	I.R			
	0.25	45	175	1.25
	0.50	40	150	1.25
	0.75	35	100	1.25

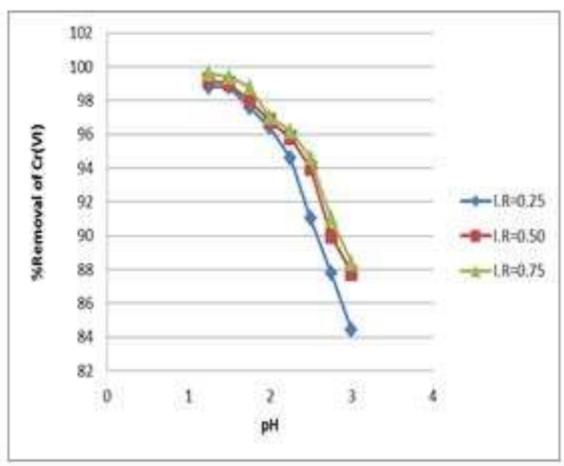

Fig.3.6 Effect of pH on Cr (VI) Removal by Chemically (NH_4Cl) Activated Carbon

Conclusion

1. The Experimental results shows good removal efficiency of Cr (VI) from synthetic solution by

using activated carbon derived from Helianthus annuus cob.

2. The kinetics of adsorption of Cr (VI) with Physically and Chemically activated carbon were studied by estimating the effect of contact time on the percentage removal of Cr (VI). The data and results from the experiment reveal that removal of Cr (VI) increases with increase in contact time and attains equilibrium at particular time. Hence optimum contact time for physically activated carbon at different sizes 300 µ, 150 µ, 75 µ retained are 50min, 45min, 40min with removal efficiency of 50.34%, 51.74%, 54.87%. For NH_4Cl activated carbon at different I.R.-0.25, 0.50, and 0.75 are 45min, 40min, and 35min with removal efficiency of 83.50%, 93.70% and 97.80% respectively..
3. The result of experiment on optimization of dosage of adsorbent reveals that, increase in amount of dosage added, increases the removal of Cr (VI) from the solution. Hence Optimum dosage for physically activated carbon at different sizes 300 µ, 150 µ, 75 µ retained are 250mg, 225mg, &200mg with removal efficiency 59%, 61.2%, 62.0% respectively. Similarly for (NH_4Cl) activated carbon at different I.R.-0.25, 0.50, and 0.75 are 175mg, 150mg, &100mg with removal efficiency of 83.0%, 89.4% and 91.8% respectively.
4. The adsorption of Cr (VI) is mainly pH dependent. The removal efficiency of adsorbent increases with decrease in pH value. It has been observed that maximum adsorption takes place in the acidic medium around pH-1.25. . Hence removal efficiency for physically activated carbon at different sizes 300 µ, 150 µ, 75 µ retained are 68.2%, 68.4%, 69.8% respectively. Similarly Ammonium chloride (NH_4Cl) activated carbon at different I.R.-0.25, 0.50, and 0.75 with removal efficiency of 98.8%, 99.0% and 99.4% respectively.
5. Regeneration and reuse after adsorption can be carried out

Scope for future study

1. Adsorption studies can be further continued on various other heavy metals like arsenic, lead, zinc etc.
2. Experiment can also be conducted with adsorbent of different varying sizes so as to choose the best size of the adsorbent.
3. Experiment can also be conducted by varying temperature.
4. Experiment may also be conducted to know the effect of various Cr (VI) concentrations on removal efficiency of adsorbents.

Acknowledgements

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