

ADSORPTION STUDIES OF CHROMIUM (VI) ON ACTIVATED CARBON DERIVED FROM CASURINA FRUIT

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ABSTRACT

The removal of Chromium (VI) from synthetic sample by adsorption on activated carbon prepared from Casurina fruit have been carried out at room temperature $32 \pm 1^\circ \text{C}$. The removal of Chromium (VI) from synthetic sample by adsorption on chemical activation (Magnesium chloride) with Impregnation ratio's (I.R) 0.25, 0.50, 0.75 for optimum time, optimum dosages and variation of pH was studied. Increase in adsorption was observed with increase in dosages and with the increase in Impregnation ratio. The maximum removal efficiency is obtained at I.R ratio of 0.75. The optimum contact time, dosage, pH for carbon with I.R-0.75 was found to be 40min, 120mg and 2 respectively with maximum chromium (VI) removal efficiency was found to be of 92.00%.

Keywords: Chromium (VI), Activated Carbon, Adsorption, Impregnation Ratio, Dosage, Kinetics, isotherms, pH, Casurina

I. INTRODUCTION

Chromium is considered a hazardous pollutant worldwide because it is a mutagen and potential carcinogen. This pollutant is generated by various industries which include leather tanning, metallurgical industries and electroplating. Water pollution caused by chromium is an important environmental problem in developing countries. Heavy metal removal from aqueous solutions has been commonly carried out by several processes, which are chemical precipitation, solvent extraction, ion-exchange, reverse osmosis, adsorption. Among these processes, the adsorption by a suitable adsorbent is an effective technique for the removal of heavy metals like chromium from wastewater.^[1] Activated carbon made from easily available agricultural wastes can make the adsorption process economic one. The present endeavor has been contributed to the utilization of the relatively common, cheap and which are not used otherwise but abundantly available material in India –Casurina Fruit for production of activated carbon^[2]

1.1 Objectives of the study

The present study was undertaken with the objective to prepare chemically activated carbon from Casurina Fruit by using magnesium chloride as an activating agent. To determine essential physical as well as chemical

properties of the prepared carbon and to evaluate removal of Chromium (VI) by adsorption as a function of contact time, dosage and pH.

II. MATERIALS AND METHODS

2.1 Material

The material used for preparing carbon was Casurina Fruit. The scientific name of this fruit is Casurina Equisetifolia. Activated carbon made from Casurina Fruit does not impart any colour, taste and odour to water, when it is added to it. So it is a suitable adsorbent for treatment of chromium contaminated water.^[5]

2.2 Characteristics of Casurina Fruit Carbon

Before using the activated carbon prepared from Casurina Fruit as an adsorbent, its characteristics such as moisture content, ash content, pH, decolorizing power, surface area are studied. The results are shown in Table-1.

All the methods of analysis are as per “Standard Methods for the Examination of Water and Wastewater”, 19th edition^[3].

Table-1 Characteristics of Prepared Activated Carbon

| Sl.No. | Characteristics | Chemically activated | | |
|--------|-----------------------------------|----------------------|--------|--------|
| | | MgCl ₂ | | |
| | | 0.25 | 0.50 | 0.75 |
| 1 | Moisture content (%) | 6.0 | 5.0 | 4.0 |
| 2 | Ash content (%) | 16.66 | 16.06 | 14.06 |
| 3 | Decolorizing power, (mg/g) | 30.00 | 34.00 | 40.50 |
| 4 | Surface area, (m ² /g) | 378.50 | 480.50 | 589.25 |
| 5 | pH | 7.80 | 7.78 | 7.50 |

2.3 Methods

Preparation of Activated carbon using MgCl₂ as activating agent:

The known quantity of washed and dried Casurina. fruit powder of size 300 Micron was mixed with the activating agent (MgCl₂), in required quantity, depending upon the impregnation ratio (I.R= 0.25,0.50,0.75).

$$\text{Impregnation ratio (I.R)} = \frac{\text{Weight of the active agent added}}{\text{Weight of carbonizing material}}$$

In that mixture required quantity of distilled water was added and boiled on hot plate till most of the water evaporated and slurry like mixture was retained. After that the mixture was oven dried in a clean tray for 24 hours maintained at 105±5°C, which helps in evaporation of moisture from the mixture. This material was filled in the small container in three layers, by compacting each layer without any air space to avoid its conversion in ash. The small container is then placed into a big container, such that sand surrounded the small container completely, the lid of the big container was tightly fitted. Pin hole has been made on the lids of the containers for the escape of organic vapors. Then the setup is kept in Muffle furnace and heated at steady rate to

attain the temperature of 800°C. Thirty minutes after attaining the 800°C temperature the furnace was allowed to cool for about 10 hours and then the container is taken out. Activated carbon thus prepared was washed with 0.1N HCl to remove the activating agent, followed by hot distilled water for about 8 times to remove the excess HCl present in the activated carbon. The activated carbon was dried at 105 ± 5 °C then packed in polythene bags and kept in desiccators.^[4]

Batch Sorption Experiment

In batch sorption, a pre-determined powder of adsorbent is mixed with the sample, stirred for a given contact time and subsequently separated by filtration. Powder adsorbent is more suitable for the batch type contact process.^[5]

Selection of Optimum Contact Time:

Adsorption is strongly influenced by the contact time. To study the effect of contact time, 100ml of Chromium (VI) solution of concentration 10 mg/L and pH 2.0 ± 0.02 , was mixed with 100 mg of prepared activated carbon, stirred at different contact times (3mins, 5mins, 7mins up to 60mins) and then filtered. These filtrates were analyzed for residual chromium (VI) concentration using spectrophotometer.

Determination of Optimum Dosage of Adsorbent:

To determine the optimum dosage of activated carbon, prepared adsorbent is added to the conical flask in different dosage varying from (20mg, 40mg, 60mg up to 200mg), containing 100ml of 10mg/L concentration of Chromium (VI) solution and pH is adjusted to 2.0 ± 0.02 . The solution in the conical flask is subjected to stirring for pre-determined optimum contact time, filtered and analyzed for residual chromium concentration.

The dosage which gives minimum residual concentration of Chromium (VI) is chosen as optimum dosage.

Selection of Optimum pH on Chromium (VI):

Adsorption is strongly influenced by the pH at which adsorption is carried out. The effect of pH on Chromium (VI) adsorption was studied by performing equilibrium adsorption tests at different pH values from 2.0 to 9.0 at an interval of 1.0. The pH of solution was adjusted by using 0.1N H₂SO₄ or 0.1N NaOH. The maximum concentration of Chromium (VI) removal forms optimum pH.

III. RESULTS AND DISCUSSIONS

The efficiency of removal of chromium (VI) is studied in terms of:

- Effect of contact time
- Effect of dosage
- Effect of pH

3.1 Effect of Contact Time on Chromium (VI) Removal

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 ± 0.02 using chemically activated (MgCl₂) carbon prepared from Casurina Fruit with I.R. 0.25, 0.50 and 0.75 are shown in figure 1. As I.R. increases optimum time decreases due to the increase in surface area. Optimum contact time for all prepared carbons is listed in table-2

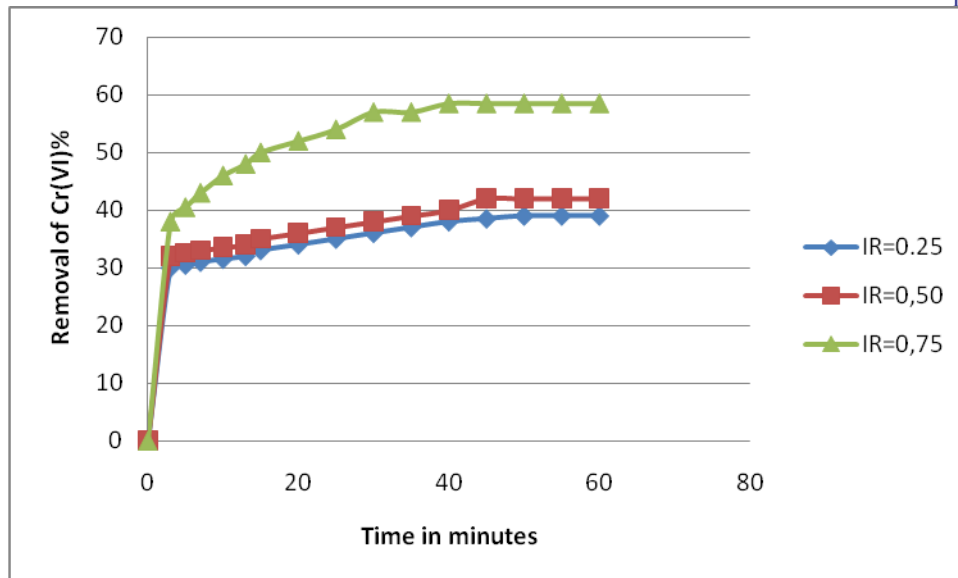


Fig.1: Effect of contact time on Cr (VI) removal by chemically (MgCl₂) activated carbon

3.2 Effect of Adsorbent Dosage on Chromium (VI) Removal

Effect of adsorbent dosage is studied and graph of percentage of residual chromium removal versus dosage is plotted as shown in figure 2. From the graph it is observed that, as the dosage of carbon increases, amount of residual Chromium (VI) decreases sharply and attains equilibrium. The dosage, at which maximum removal is attained, is taken as optimum dosage. After this not much change is observed even after increase in the amount of carbon dosage. The optimum dosage for all prepared carbon are listed in table-2

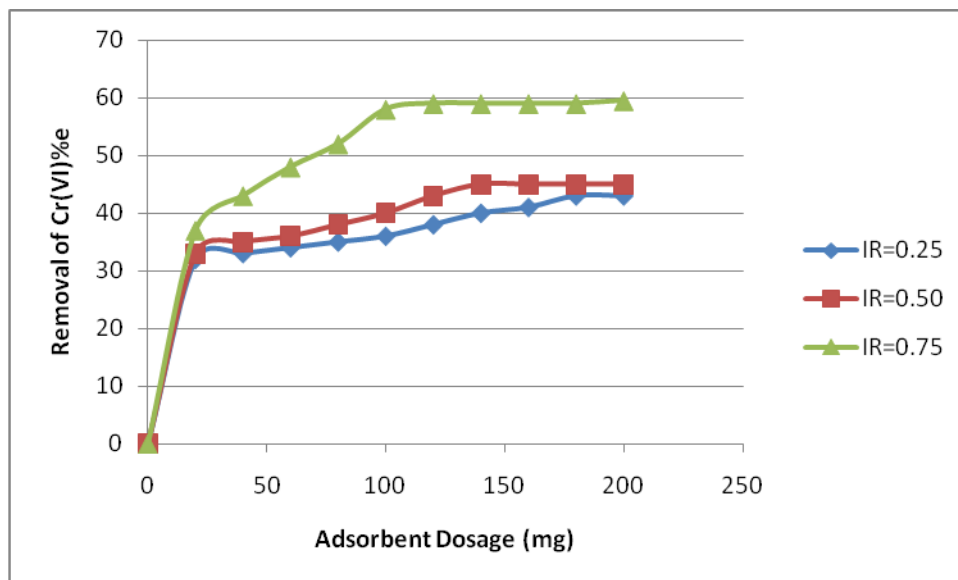


Fig.2: Effect of adsorbent dosage on Cr(VI) removal by chemically(MgCl₂) activated carbon

3.3 Effect of pH on Chromium (VI) 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. From the figures, it is observed that Chromium (VI) is removal efficiency is more in acidic range. As pH increases, the removable efficiency decreases appreciably. The optimum pH for all prepared carbon are listed in table-2

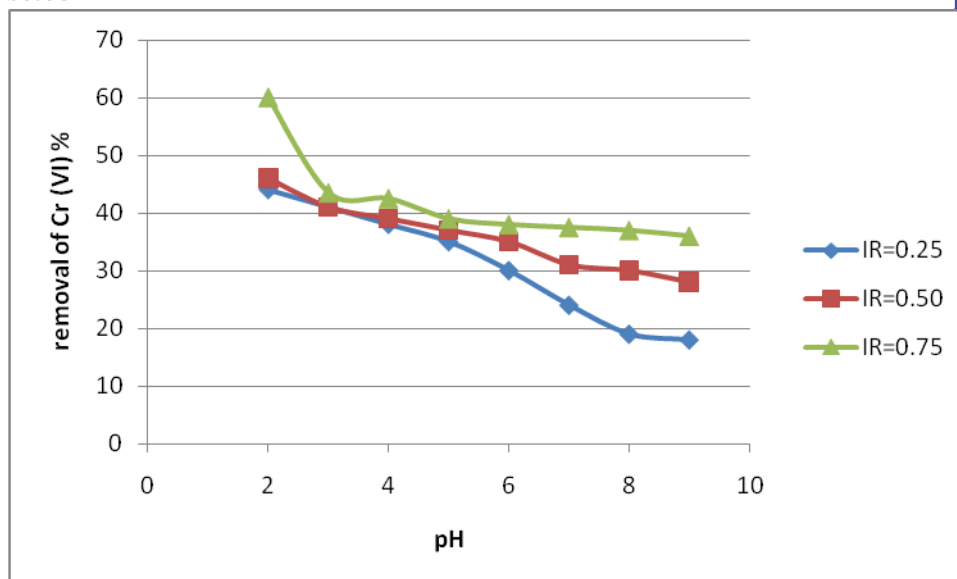


Fig.3: Effect of pH on Cr (VI) removal by chemically (MgCl₂) activated carbon

Table-2 Optimum Contact Time, Optimum Dosage and Optimum pH for Prepared Carbons.

Initial concentration = 10 mg/L

Volume of sample = 100mL

Temperature = 32 ± 1° C

| Type Of Carbon | I.R | Optimum Time (min) | Optimum Dosage (mg) | Optimum pH |
|---|------|--------------------|---------------------|------------|
| Chemically activated (MgCl ₂) | 0.25 | 50 | 160 | 2 |
| | 0.50 | 45 | 140 | 2 |
| | 0.75 | 40 | 120 | 2 |

IV. CONCLUSIONS

Based on the experimental studies carried out the following conclusions were drawn. Chromium (VI) adsorption increases with increase in contact time and then attains equilibrium. The results of experiment on optimization of dosage of adsorbent reveals that increase in amount of adsorbent dosages, shown increase in the removal of Cr (VI) from the solution and almost become constant after saturation dosage for different I.R'S. The removal of Cr (VI) increases mainly due to the enhanced total surface area of the adsorbent. The adsorption of Cr (VI) is pH dependent. The increase in removal efficiencies of the prepared adsorbents were observed with decrease in the pH value. For the initial concentration of 10mg/L, maximum Chromium (VI) removal efficiency was found to be of 92.00%.

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