REMOVAL OF HEXAVALENT CHROMIUM FROM AQUEOUS SOLUTION BY ADSORPTION ON COMMIPHORA MYRRHA BARK

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ABSTRACT

Adsorption technique using Granular Commiphora Myrrha Bark has been applied for the removal of Chromium (VI) from aqueous samples. Batch experiment has been carried out for adsorption of Chromium (VI) onto Commiphora Myrrha Bark. The effect of various parameters influencing the Cr(VI) adsorptions such as effect of pH, Contact time, Adsorbent concentrations and initial metal ion concentrations have been studied. The data obtained from the batch processes have used to fit in Freundlich and Langmuir isotherm equations. This method is quite feasible, economic and time saving. The optimum contact time found is equal 360 min. The optimum dosage is equal to 0.5 mgs. The percentage removal is ranging between 75% - 80%.

Keywords: Adsorption, Commiphora Myrrha Bark, Chromium (VI), Batch adsorption process, Adsorption kinetics, Thermodynamics adsorption isotherm.

INTRODUCTION

The contamination of ground and surface water by Cr (VI) ions has become an increasingly serious environmental problem in the world. An increased use of metals and chemicals in the process industries has resulted in the generation of large quantities of aqueous effluents that contain high levels of heavy metals, thereby creating serious environmental disposal problems. Also exponential growth of the world’s population over the past 20 years has resulted in environmental build up of waste products, of which heavy metals are of particular concern. Enhanced industrial activity during recent decades has led to the discharge of large volumes of wastewater, which is a serious cause of environmental degradation. Heavy metals, due to their high toxicity, pose a serious threat to biota and the environment. The pollution from industrial and urban waste effluents and from agro chemicals in some water bodies and rivers has reached alarming level. There are numerous ill effects of pollution, each type of pollutant having different effects, on human and animal health and ecology. Chromium has been 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. The toxicity of Chromium compounds depends on the type of metal, dose and the ionic form. In industrial waste water mostly the Chromium is found in two forms, one is hexavalent and other is trivalent. The hexavalent form is more toxic than trivalent form. It is toxic to micro-organisms, plants, animals and humans. India possesses 4% of total average run-off in the rivers of the world. The water availability of natural run off is only 2,500 m³/year compared to the other countries. The adsorption process is being widely used by various researchers for the removal of heavy metals from waste streams and Activated Carbon has been frequently used as an adsorbent. The consumption and demand for water is increasing. The quality of water is deteriorating day by day due to the industrial pollution and human intervention. In order to improvise the quality of water, the study is carried out by using Commiphora Myrrha bark.
EXPERIMENTAL

Preparation of Adsorbent

*Commiphora Myrrha* Bark (CMB) was collected from a local farm. It was cut into small segment and dried in sunlight until almost all the moisture evaporated. Then it was ground to get desired particle size of 100 to 200 micron. It was then soaked 2 hours in 0.1M NaOH solution to remove the lignin content. Excess alkalinity was then removed by neutralizing with 0.1 N HCl. The CMB was then washed several times with distilled water till the washings are free from color and turbidity. The washed CMB was oven dried at 200°C for 24 hrs and stored in desicator for the further study.

Preparation of solutions

All the reagents used were of AR grade.

**Cr (VI) solution**

Stock Chromium ions solution (1000 mg/L) was prepared by dissolving 29.4 gm of A.R. grade K$_2$Cr$_2$O$_7$ in 1000 ml distilled water. The solutions of lower concentrations were prepared by dilution of appropriate volume of stock solution. 3 Molar aqueous solution of H$_2$SO$_4$ was prepared by dissolving 42ml H$_2$SO$_4$ in 250 ml volumetric flask.

**Diphenyl Carbazide**

0.25% solution was prepared by dissolving Diphenyl Carbazide in 50% Acetone.

Adsorption Isotherms

Equilibrium adsorption isotherm equations are used to describe the experimental adsorption data. The parameters obtained from the different models provide important information on the sorption mechanisms and the surface properties and affinities of the adsorbent. The most widely accepted surface adsorption models for single-solute systems are the Langmuir and Freundlich models. The correlation with the amount of adsorption and the liquid-phase concentration was tested with the Langmuir and Freundlich isotherm equations. Linear regression is frequently used to determine the best-fitting isotherm, and the applicability of isotherm equations is compared by judging the Correlation coefficients.

**Freundlich Adsorption Isotherm**

The sorption data of Chromium ions onto CMB was also fitted to Freundlich isotherm, in the following linear form -

\[
\log q_e = \log K_f + \frac{1}{n} \log C_e
\]

Where, $q_e$ is the amount of metal ion adsorbed per gram of adsorbent (mg/g). $C_e$ is the equilibrium concentration of metal ion in solution (mg/L). $K_f$ and $1/n$ are Freundlich constants, indicating the Adsorption Capacity and Adsorption Intensity respectively. Straight lines were obtained by plotting log $q_e$ against log $C_e$, which show that sorption of Chromium ions obeys Freundlich isotherm well. The $K_f$ and $1/n$ values were calculated from intercept and slop of the plot respectively and presented in Table 1. The Correlation coefficient $R^2 > 0.983$ and the values of $n$ were higher than 1.0, indicating that adsorption of Cr (VI) ions on CMB follows the Freundlich isotherm.

**Langmuir Adsorption Isotherm**

The Langmuir isotherm is valid for sorption of a solute from a liquid solution as monolayer adsorption on a surface containing a finite number of identical sites. Langmuir isotherm model assumes uniform energies of adsorption onto the surface without transmigration of adsorbate in the plane of the surface. The Linear form of Langmuir equation is-

\[
\frac{1}{q_e} = \frac{1}{b Q_0} X \frac{1}{C_e} + \frac{1}{Q_0}
\]

$Q_0$ and $b$ is Langmuir constants related to the capacity and energy of sorption respectively. A plot of $q_e$ versus $C_e$ should indicate a straight line of slope $1/b Q_0$ and an intercept of $1/Q_0$. The values of $Q_0$ and $b$
and Correlation coefficient obtained from the Langmuir model are shown in Table 1. The Correlation coefficient $R^2 > 0.993$ suggests that adsorption of Cr(VI) ions onto CMB follows the Langmuir isotherm. The maximum monolayer capacity $Q_0$ obtained from the Langmuir is 111.11 mg/g.

### Table-1: Isotherm Constants

<table>
<thead>
<tr>
<th>Cr(VI) Concentration</th>
<th>Freundlich Constants</th>
<th>Langmuir Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conc.</td>
<td>K</td>
<td>I/n</td>
</tr>
<tr>
<td>20mg/L</td>
<td>2.506</td>
<td>0.887</td>
</tr>
</tbody>
</table>

**Effect of pH**

The solution of pH is an important parameter in the adsorption process of metal ions from aqueous solutions, which affect both the dissociation degree of functional groups from adsorbent surface and the speciation and solubility of metal ions. The effect of pH on the removal of Chromium ion using CMB as an adsorbent was studied with initial pH range from 2 to 6. The pH affects the solubility of chromium ion to a great extent. The pH of the aqueous solution is the controlling factor in the adsorption process hence it become necessary to determine at what pH, maximum adsorption will takes place. The maximum removal efficiency was 80 % at 2.0 pH value.

![Fig.-1: Effect of pH on removal of Cr(VI) system: CMB](image1)

![Fig.-2: Effect of contact time on removal of Cr(VI) system: CMB](image2)

**Effect of contact time**

The effect of Contact time on the amount of Cr (VI) ions adsorbed was investigated by using various initial concentration of Cr(VI) ions with 0.5 gram (CMB) at pH 2.1. The effect of Contact time and metal ions concentrations on the percent removal of Cr (VI) by CMB is shown in Fig.-II. The result indicates that removal of Cr (VI) ions increases with increase in Contact time and equilibrium was attained in about
360 min. The extent of removal of Cr(VI) by CMB was found to increase, reach a maximum value with increase in contact time.

**Effect of adsorbent dose**

The effect of the amount of adsorbent dose on the rate of uptake of Chromium ions is shown in Fig.-III. It can be seen that, the rate of the removal of Chromium ions increases with an increase in the amount of adsorbent dose. The amount of adsorbent dose varies from 200mg/200ml to 1000mg/200ml. The retrieval efficiency is maximum at dose of 700mg/200ml which is up to 75%.

![Fig.-3: Effect of adsorbent dose on removal of Cr(VI) system: CMB](image)

**CONCLUSIONS**

1. The present work is attempt for the systematic studies of removal of Chromium from waste-water using low cost adsorbent prepared from Commiphora Myrrha Bark.
2. From the Experimental Findings, It has been observed that the adsorbent material can be used successfully for removal of Chromium from aqueous solution.
3. The maximum removal efficiency was observed up to 75% for Biosorbent prepared from Commiphora Myrrha bark at the optimum values of parameters.
4. Due to high efficiency for removal of Cr(VI), the treated Commiphora Myrrha Bark is an ideal adsorbent for removal of Cr(VI) from aqueous solutions.
5. The result reveals that at pH 2.0, percentage removal of Chromium is maximum

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**REFERENCES**


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