Biosorptioanal Analysis of Cr (VI) by Zea mays cob Powder

Nisha¹, Sarika Tejasvi², Vikal Gupta³

¹Research scholar, Department of Chemistry, J.N.V. University, Jodhpur – 342001, Rajasthan, India
²Assistant Professor, Kirorimal college, University of Delhi, India
³Department of Chemistry, J.N.V. University, Jodhpur – 342001, Rajasthan, India

Abstract: The present research work describes biosorption of Cr(VI) ions by Zea mays cob powder. Zea mays, corn or maize, is an annual grass in the family, said as Poaceae is also found in Central America. Here we used batch absorption technique In this study, an attempt has been made for biosorption of Cr (VI) from aqueous solution by Zea mays cob powder using batch adsorption technique. Zea mays are basically found in the sub-humid region and Aravali hills region of the Rajasthan. Effect of contact time, pH and metal ion concentration on bio-sorption has been studied with the help of Langmuir and Freundlich adsorption isotherms. Removal efficiency of Cr (VI) by Zea mays cob powder has been found 85.5% at pH 4.

Keywords: Hexavalent chromium ions, bio-sorption, Zea maize cob powder, removal efficiency, adsorption kinetics.

I. INTRODUCTION

Worldwide water pollution is a major problem. Here we are mainly concerned about heavy metal pollution cause by indiscriminate disposal of waste water. Different water bodies are like rivers, lakes, wetlands and underground aquifers but these sources are polluted by different chemical discharged from industries. [1]-[2]Leather tanning industries use chromium compounds for their product formation and discharge waste chemicals into the environment without proper standard treatment. Chromium is a transition metal which occurs in nine different forms of oxidation states, but the two common valences are trivalent and hexavalent chromium forms. Hexavalent chromium has mutagenic and carcinogenic properties. It is hazardous substances for both human and aquatic life. Current techniques: - Physicochemical approaches i.e. Adjusting pH, Membrane filtration, Ion-exchange, Adsorption, Flocculation. [6]

These techniques are used in large scale and in situ operations. [3]-[5] These are inefficient and expensive. When concentration of ions is low, these techniques are not much effective. Biological approaches:-When naturally occurring processes are used for removal of heavy metals, it is called biological approach Here we are using Zea mays cob powder for the removal of the hexavalent chromium ion. This is a biopolymer which can be applied for biosorption of Cr (VI) from aqueous solution by Zea mays cob powder using batch absorption technique.

II. MATERIALS AND METHODS

A. Preparation of Adsorbent

The maize cob of Zea Mays were collected from CAZARI (Central Arid Zone of Agriculture and Research Institute) Jodhpur. Each of the cobs were rinsed thoroughly with tap water and then with distilled water and dried in sun light and then in oven for 42 hours at 65°C. These were crushed in a mechanical grinder and sieved at different mesh sieves (100-300 µm) to obtain Zea Mays Cob Powder (ZMCP).

B. Preparation of Cr (VI) Solution

A stock solution of Cr (VI) was prepared by dissolving 2.828 g of 99.00% of K₂Cr₂O₇ in 1L double distilled water to obtain 1000 mg L⁻¹ stock solution. Further, 50-300 mg L⁻¹ strength of Cr (VI) was prepared with the help of stock solution. The pH of solutions was adjusted with the help of 0.1 N H₂SO₄ and 0.1N NaOH solutions as per the requirements, pH were measured by pH meter. Three parameters i.e. effect of concentration of Cr(VI), effect of Ph and effect of contact time were studied as shown in Table 1.
Table 1. Experimental conditions

<table>
<thead>
<tr>
<th>Experimental conditions</th>
<th>C₀ (mgL⁻¹)</th>
<th>Ms, gL⁻¹</th>
<th>pH</th>
<th>t, min</th>
<th>S, rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of concentration of Cr(VI), C₀ (mgL⁻¹)</td>
<td>50</td>
<td>3-12</td>
<td>4</td>
<td>85.5</td>
<td>150</td>
</tr>
<tr>
<td>Effect of contact time t, min.</td>
<td>50</td>
<td>9</td>
<td>4</td>
<td>30-110</td>
<td>150</td>
</tr>
<tr>
<td>Effect of pH</td>
<td>50</td>
<td>9</td>
<td>2-4</td>
<td>85.5</td>
<td>150</td>
</tr>
</tbody>
</table>

C. Adsorption Experiment

Adsorption of metal ion by Zea mays was carried out by batch experiment as function of metal concentration (50, 100, 150, 200, 250, 300) mg L⁻¹, contact time (30-110) minutes. After the adsorption of metal ion by Zea mays, metal ion solution was filtered through sintered glass crucible G-3. 10mL of the solution was kept for Cr (VI) analysis. Series of various solutions (50-300) mg L⁻¹ were also kept for analysis. After the completion of experiment, the concentration of Cr (VI) by double beam spectrophotometer.

The following formula was used for the calculation adsorbance of metal ion by Zea mays.

\[ \% \text{ Removal of Cr (VI)} = \frac{C_0 - C_e}{C_0} \times 100 \]  

Where \( C_0 \) is initial metal ion concentration and \( C_e \) is the concentration of metal ion after adsorption.

D. Adsorption Isotherm

According to Langmuir theory, the saturated monolayer isotherm can be represented as:

\[ q_e = \frac{q_{\text{max}} \times b \times C_e}{1 + b \times C_e} \]  

The equation 2 can be rearranged by following linear form:

\[ \frac{C_e}{q_e} = \frac{1}{b q_{\text{max}}} + \frac{1}{q_{\text{max}}} C_e \]  

Where \( C_e \) is the equilibrium concentration, \( q_e \) is the amount of metal ion adsorbed, \( q_{\text{max}} \) is \( q_e \) for a complete monolayer (mgL⁻¹) and \( b \) is sorption equilibrium constant (L mg⁻¹). A graph of \( C_e \) versus \( C_e/q_e \) should indicate a straight line of slope \( 1/q_{\text{max}} \) and an intercept of \( 1/b q_{\text{max}} \). Freundlich found that if the concentration of solute in solvent at equilibrium \( C_e \) (mgL⁻¹) was raised to the power of \( m \), the amount of solute adsorbed being \( q_e \), then \( C_e/m q_e \) was a constant at a given temperature. This fairly satisfactory empirical isotherm can be used for non ideal sorption and is expressed by the following equation in the form of logarithm of both sides.

\[ \log q_e = \log K_f + m \log C_e \]  

An adsorption isotherm is characterized by certain constant, the value of which express the surface properties and affinity of the sorbent and can also be used to compare bio-chemosorptive capacity of biomass for different metal ions. Out of several isotherm equations, two have been applied for this study i.e, the Freundlichian Langmuir isotherms.

III. RESULTS AND DISCUSSION

A. Effect of Concentration of Cr (VI) ion

The experiments were carried out, with the change in the concentration of hexavalent chromium ion from 50-300 mg L⁻¹ and other conditions were maintained constant. As shown in the Fig. 1, with the increase in the concentration of metal ion, the absorption % decreases because the numbers of active sites are fixed. [11]
B. Effect of Contact time
Experiments were carried out with the change in the contact time (30-110) hours and other parameters were kept constant. With the increase in contact time, % absorbance increases as shown in Fig. 2.

C. Effect of pH
The experiment was conducted with the change in the pH 2-4 and adsorption dosage was maintained constant i.e. 9 gL⁻¹; the concentration of the metal ion Cr (VI) was taken 50 mg L⁻¹ at 110 minutes. The removal of metal ion was maximum at 85.5% at pH 4. With the increase of pH, hydrogen ions get decreased. Thus, the interaction between metal and hydrogen ion also gets reduced and the removal of metal ion increases.[12]-[14]
Langmuir and Freundlich model parameters estimated from the fitting of experimental point of Cr (VI) adsorption are shown in Table 2.

Table 2. Langmuir and Freundlich isotherm

<table>
<thead>
<tr>
<th>Langmuir isotherm</th>
<th>Freundlich isotherm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>$q_{max}$ mg g$^{-1}$</td>
</tr>
<tr>
<td>0.98</td>
<td>7.00</td>
</tr>
</tbody>
</table>

IV. CONCLUSION

The present study concludes that the Zea mays is an effective adsorbent for the removal of Cr(VI) from aqueous solution. The adsorption data fits well with Langmuir and Freundlich adsorption isotherm model. Here biosorption exists between solution of metal ion and algal sample. Experimental data indicate that the adsorption efficiency is dependent on operating variable such as hexavalent chromium ion concentration, effect of pH, effect of contact time.

REFERENCES