

## Adsorption Studies of Chromium by Using Low Cost Adsorbents

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### Abstract

The presence of toxic heavy metals such as chromium (VI) contaminants in aqueous streams, arising from the discharge of untreated metal containing effluents into water bodies, is one of the most important environmental problems. Adsorption is one of the effective techniques for chromium (VI) removal from wastewater. In the present study, adsorbent was prepared from low cost adsorbents and studies were carried out for chromium (VI) removal. Batch adsorption studies demonstrated that the adsorbents had significant capacity to adsorb the chromium from aqueous solution. It was found that the adsorption increased with increase in contact time and adsorbent dosage. An attempt was made to study mixed algae as an adsorbent for removal of chromium (VI).

**Key words:** Chromium, Adsorption, Multhani mitti, Batch adsorption, Mixed algae

### Introduction

Water is the most vital element among the natural resources, and is crucial for the survival of all living organisms. The increasing urbanization and industrialization of Hyderabad have negative implications for water quality. The pollution from industrial and urban waste effluents and from agrochemicals in some water bodies and rivers has reached alarming levels. There are numerous ill effects of pollution, each type of pollutants having different effect, on human and animal health and ecology. Chromium is one of the water pollutants which is actually a micro nutrient required by our body in minute quantity. This form of chromium is the safe trivalent or 'Chromium-3'. Chromium also exists in

another very rare form known as 'Hexavalent chromium' or 'Chromium-6'. Hexavalent chromium-6 is usually introduced into ground water when chemical industries using chromium, discharge their water without proper treatment. Hexavalent chromium-6 is poisonous and should be guarded against people using well water. It causes cancer, anuria, nephritis, gastrointestinal ulceration, perforation in partition of nose. It penetrates cell membrane and badly affects central nervous system, causes respiratory trouble, and lung tumors when inhaled. Trace amount of Cr III is essential for normal glucose, protein and fat metabolism and hence it is an essential trace element in diet.

The accumulation of metals by algae has been extensively studied in the last two decades (APHA, 1992).

Chromium metal ions are usually removed by precipitation although ion exchange and adsorption are also used for its removal. The hydroxides of heavy metals are usually insoluble, so lime is commonly used for precipitating them. There are various methods to remove Cr (VI) including chemical precipitation, membrane process, ion exchange, liquid extraction and electro dialysis (Argun *et al.*, 2007). These methods are non-economical and have many disadvantages such as incomplete metal removal, high reagent and energy requirements, generation of toxic sludge or other waste products that require disposal or treatment. In contrast, the adsorption technique is one of the preferred methods for removal of heavy metals because of its efficiency and low cost (Hasan *et al.*, 2003). Utilizing the waste material from agriculture and industries can make treatment process economical and solve the solid waste disposal problem. The present study was aimed at selection of a low cost adsorbent, which can adsorb chromium from the wastewater.

#### Materials and methods

The adsorbents primarily screened were *mangifera indica* dust, horse gram powder, ragi powder, multhani mitti, brick powder, concrete, custard apple leaf and peel powder, chalk powder (Tab.1). Initially, all the adsorbents were screened by adding 1g of each adsorbent to 100 ml of solution of chromium.

Adsorption methods were adopted for removal of heavy metals and these methods are suitable when chromium is present in

low concentrations. For this purpose, an aqueous solution of 100 ml of chromium of various concentrations was taken in 100 ml Stoppard bottles and 1g of adsorbent was added to the solutions. Batch adsorption experiments were carried out at room temperature, a contact time of 24 h was maintained. The initial and final concentrations of aqueous solution of chromium were determined by colorimeter and percentage removal of chromium was determined (Gupta *et al.*, 2003).

**Table 1.** Adsorbents and sampling sites.

Adsorbent	Sampling site
Manjifera indica bark dust	Timber depots
Horse gram powder	Fields
Raghi powder	Fields
Multhani matti	Super market
Chalk powder	Class room
Brick powder	Construction site in Hyderabad city
Concrete	Construction site in Hyderabad city
Papaya peel powder	Fields
Papaya seed powder	Field
Mixed algae	Over head tank/ Water storage tank

#### Preparation of Cr (VI) solution

A stock solution of Cr (VI) (0.35g/100ml) was prepared by dissolving appropriate quantity of AR grade  $K_2Cr_2O_7$  in 100 ml of distilled water from Millipore purification unit. The stock solution was further diluted with distilled water to desired concentration for obtaining the test solutions. The initial metal ion concentrations ranged from 10  $\mu$ g to 85 mg/ml.

Final residual metal Cr (III) and Cr (VI) concentration after adsorption was directly measured with spectrophotometer. To estimate the percentage removal of chromium from aqueous solution the following equation was used:

$$\text{Removal of chromium} \\ = \frac{C_{\text{initial}} - C_{\text{final}}}{C_{\text{initial}}} \times 100$$

### Results and discussion

The order of adsorption by different low cost material was Multhani matti > papaya seed powder > mango bark dust > mixed algae > chalk powder > papaya peel powder > horse gram seed powder > brick powder > ragi seed powder > concrete (Fig. 1). The adsorption capacity was more at lower concentrations than at higher concentrations.

Multhani mitti is known as montmorillonite and it contains grains of fine sand particle (Antunes *et al.*, 2003; Hameed, 2009). Brick powder is the waste material from construction sites and it is used as the adsorbent. It has a high porosity and it is made from the local red mud from Hyderabad which has iron oxide, which forms chromium oxide. Chalk powder is the classrooms waste material. Chalk powder due to certain porosity adsorbs chromium from aqueous solution of chromium. Concrete material is a mixture of silica, stones and cement in the ratio of 1: 2:4. Mango bark dust was collected from a timber industry. It is most effective for the removal of chromium. Horse gram is a bio adsorbent for removal of chromium. Papaya peel is also a bio adsorbent responsible for chromium adsorption from aqueous solution. Ragi seeds are also responsible for chromium adsorption from aqueous solution. Mixed algae acts as a bio adsorbent for the removal of chromium. Papaya seeds acts as a bio adsorbent and effectively removes chromium from aqueous solution.

In most of adsorption processes commercially available, activated charcoals

are used to study the adsorption. In the present study the adsorption found was very less because of less porosity and hardness of coal. Green algae, especially *Cladophora* species, are generally considered as the best bio indicator of aquatic bodies' contamination by nutrients as well as by heavy metals (Chmielewská-Horváthová, 1996). The role of algae in waste water treatment and their affinity for heavy metal cations, based on high negative surface charge, has been recognized for several decades. Taking all these factors into consideration mixed algae was selected as bio adsorbent. The batch adsorption studies were carried out with respect to contact time initial concentration of chromium and adsorbent dosage.

#### *Effect of contact time*

The initial and final concentrations were determined at regular intervals of time. The results are given in figure 2.

Volume of chromium solution: 1000 ml

Amount of mixed algae biomass: 1.0 g

Concentration of Cr: 85 mg/lit

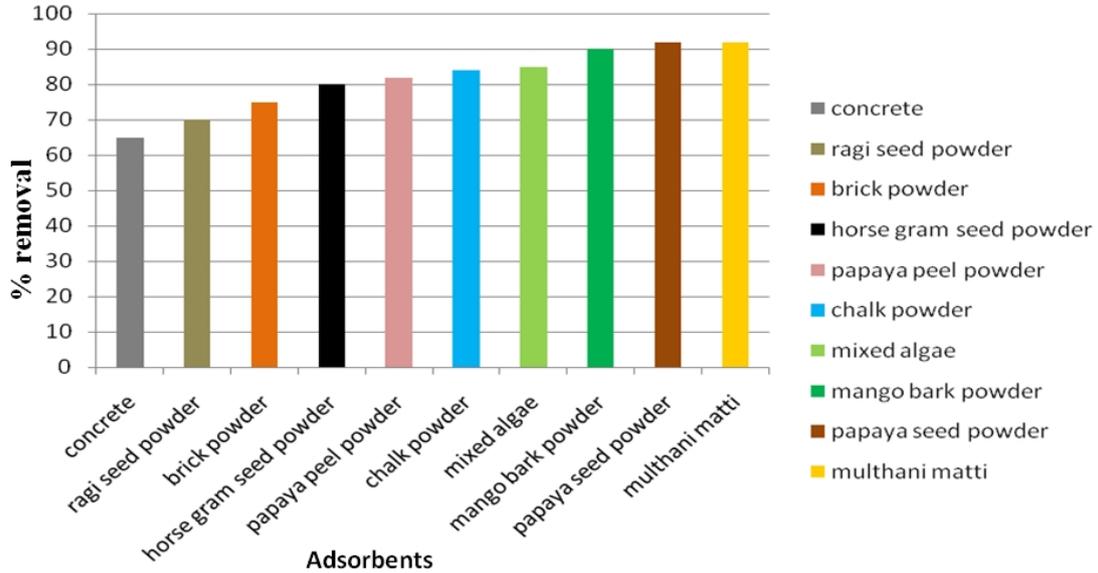
The study revealed that as contact time increases the percentage removal increases. It indicates that initially the adsorption process is directly proportional to contact time and it attains equilibrium in 5 min (Appel and Ma, 2002; Bose *et al.*, 2002).

#### *Effect of concentration of chromium on algae*

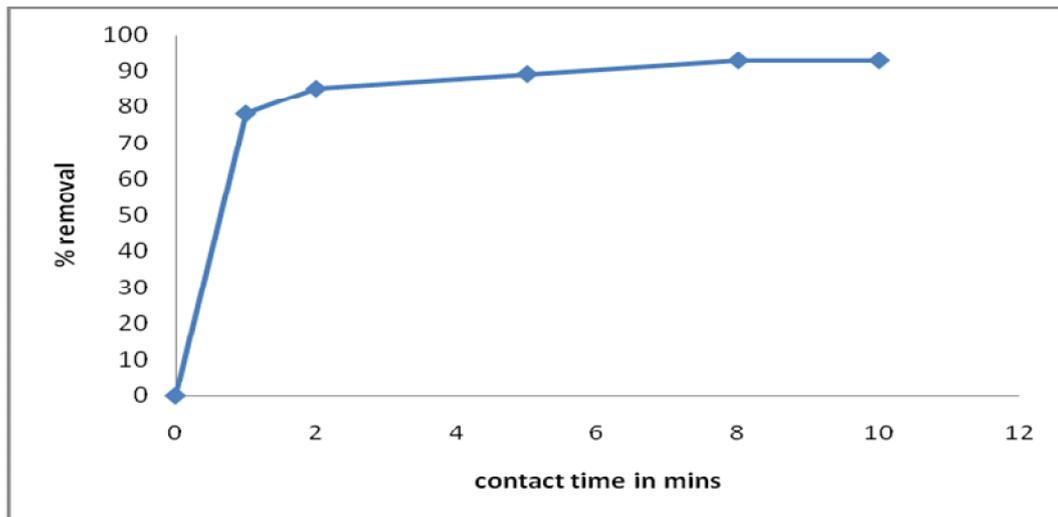
Different concentrations of chromium were studied, which consisted of a fixed amount of adsorbent. The experiments were carried out with constant contact time and the contact time was fixed depending upon contact time experiments.

Volume of chromium solution: 100 ml

Mixed algae biomass: 1.0 g



**Figure 1.** Order of effectiveness of adsorbents (Multhani matti > papaya seed powder > mango bark dust > mixed algae > chalk powder > papaya peel powder > horse gram seed powder > brick powder > ragi seed powder > concrete).



**Figure 2.** Variation of contact time between chromium and mixed algae.

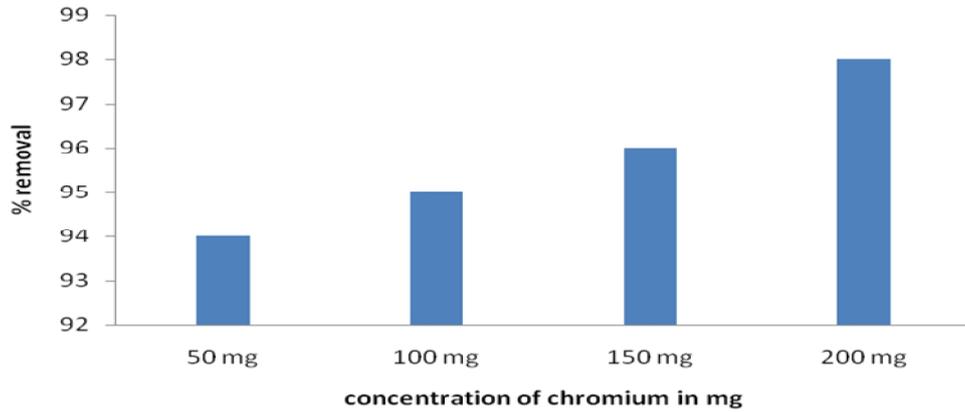


Figure 3. Variation of initial concentration of chromium.

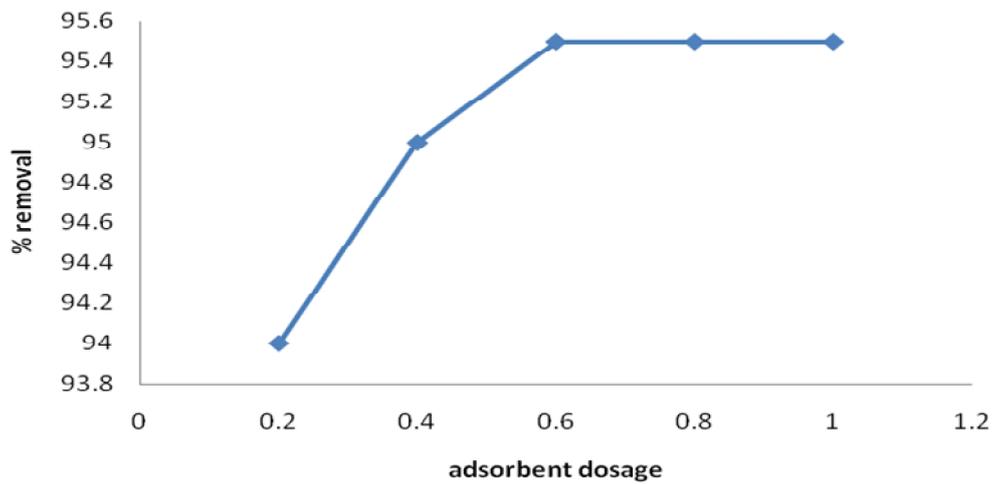


Figure 4. Variation of mixed algae dosages

The chromium removal efficiency is found to be increased with increase in chromium concentration (Fig. 3). The percentage removal of Cr is more and it is ranging between 93-98% for all concentrations (Orhan and Buyukgangor, 1993).

#### ***Effect of algae dosages***

To study the effect of adsorbent dose (g) on the uptake of Cr (VI), experiments were

done with 100 ml of 85 mg solutions, while the amount of adsorbent added was varied from (0.2-0.8 g). Results in figure 4 showed that the percentage removal of Cr (VI) from aqueous solution increased with the adsorbent dose and reached an optimum at 0.8 g of sorbent. The increase in ion removal was due to the increase in the available sorption surface area (Rafatullah *et al.*, 2010)

### Conclusions

Among ten different adsorbents studied, Multhani mitti and Mango bark dust proved to be the most effective adsorbent of chromium from aqueous solution of chromium. Thus, our study proves that the effect of harmful metals like chromium can be reduced by using naturally available wastes and low cost materials like brick powder, Mango bark dust, mixed algae, Chalk powder, Ragi seed powder, horse gram seed powder, papaya seed powder, papaya peel powder, multhani mitti and Concrete. Among all the bio adsorbents mixed algae is widely available. Hence, this study provides an economic solution for cleaning up environmental water pollutant chromium and it is recommended to use these adsorbents in industries.

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