



## WATER, ENVIRONMENT AND MANAGEMENT

# Chromium removal from industrial wastewater

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### HEXAVALENT CHROMIUM REMOVAL FROM INDUSTRIAL WASTEWATER USING PONGAMIA PINNATA SHELL AS AN ADSORBENT

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#### Abstract

Heavy metals are continuously released into the aquatic environment in various ways and adversely affect the ecosystem. Thus, the removal of heavy metal is of primary importance. A variety of traditional and advanced techniques are available. Adsorbent is one among the many techniques. In this study, locally available low cost adsorbent (Pongamia Pinnata Shell) is used in place of costly activated charcoal in order to evolve a cheap adsorption technique for removal of Hexavalent Chromium from industrial wastewater. Laboratory studies were conducted to delineate the effect of parameters on uptake of Hexavalent Chromium and the kinetics of adsorption of  $Cr^{+6}$  removal. Parameters evaluated include, pH, size of adsorbent, time of contact and initial adsorbate concentration. Equilibrium studies indicate that the process obeyed Langmuir isotherm. However, Freundlich isotherm was used to predict the ultimate sorption capacity. The results indicate that the Pongamia Pinnata shell can be very effectively, efficiently and economically used to remove  $Cr^{+6}$  from the industrial wastewaters in an acidic range. (pH 2.0)

**[Key Words:** Heavy Metal, Hexavalent Chromium, Adsorption, Pongamia Pinnata Shell, Isotherm]

#### Introduction

During recent years, the words "Pollution", "Environment" and "Ecology" have come into more and more frequent usage and the cleanliness of the world we live in has become the concern of all people. The environmental pollution is caused by a variety of pollutants of major concern in an aqueous environment. The heavy metals reach the water bodies by numerous industrial activities. Among the heavy metals, Chromium is one such heavy metal which occurs in an aqueous system as both Trivalent and Hexavalent ionic forms. Among these Hexavalent is considered as a dangerous toxic pollutant. Much has been reported on the treatment of Hexavalent Chromium from wastewaters. In the present investigation, Pongamia Pinnata Shell is selected as an adsorbent. The study evaluates the effect of parameters such as size of adsorbent, pH, contact time and initial adsorbent concentration and kinetics of hexavalent chromium removal.

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#### Materials and Methodology

The Pongamia Pinnata was procured locally and the seed shell (after removing the seed) was used as an adsorbent. It is dried at 103°C for 24 hours. The shell was pulverised and sieved to a geometric mean size of 0.244 mm. It was then washed in distilled water to remove fines and adhered impurities and dried at 103°C for 24 hours. A local industry which manufactures brass valves and uses Chromic acid for polishing the brass surface was selected to collect the effluent containing heavy metals. Standard Chromium solution was prepared using Potassium Dichromate salt. Hexavalent Chromium was analysed by a colorimetric method (as per Standard methods, 1987) using Beckman DU-50 UV-VIS Spectrophotometer. Batch experiments have been conducted at laboratory temperature.

#### Results and Discussions

The effluent samples were collected from the selected industry and analysed for various parameters. The average flow observed was 82,500 l/d, pH-2.05, Total Solids-3560 mg/l, COD-46,500 mg/l, Sulphate-2920 mg/l and Hexavalent Chromium-200 mg/l.

#### Effect of Particle Size

To arrive at optimum particle size of the adsorbent, experiments were carried out on different particle sizes. The adsorbent capacities are compared by the adsorption isotherm. The adsorption isotherm for different particle sizes are presented in Figure 1. From the figure it is observed that the adsorption isotherm corresponding to the particle size between 0.300 mm and 0.200 mm (GMS of 0.244 mm) is placed above the others. Hence it is evident that the adsorption potential is more in particle size of 0.244 mm GMS than the other particle sizes. Thus for further study, experiments were carried out using effective particle size of 0.244 mm.

#### Effect of pH

The pH of a solution influences the extent of adsorption. From Figure 2 it is predicted that Hexavalent Chromium is removed most effectively in an acidic environment. This may be on the assumption that Pongamia Pinnata Shell particles consist of active sites bearing a negative charge, which are neutralised by  $H^+$  ions and thereby reducing hindrance to adsorption of Hexavalent Chromium ions.

### Effect of Contact Time

Table 1 gives the results of effect of contact time on removal of Hexavalent Chromium. It can be seen that 97% of removal is achieved within a short period of 30 minutes and reaches to 99.91% for a contact time of 120 minutes and attains equilibrium after that.

**TABLE 1 EFFECT OF CONTACT TIME ON Cr<sup>+6</sup> REMOVAL**

Cr+6 Concentration: 200 mg/l, pH: 2.0  
Time of reaction: 2.5 hrs, Adsorbent Dose: 5 gms

Time, min	Final pH	Cr <sup>+6</sup> in soln mg/l	Cr <sup>+6</sup> sorbed, mg/g	%removal of Cr <sup>+6</sup>
5	3.3	36.00	3.280	82.00
15	3.3	20.00	3.600	90.00
30	3.4	6.00	3.880	97.00
45	3.5	3.00	3.940	98.50
60	3.5	0.80	3.984	99.60
90	3.6	0.25	3.995	99.87
120	3.6	0.18	3.996	99.91
150	3.6	0.18	3.996	99.91

### **Effect of metal concentration**

In order to study the influence of initial Hexavalent Chromium concentration on the uptake of Hexavalent Chromium by the adsorbent, various concentrations in the range of 50 to 300 mg/l were analysed. The results are shown in Table 2. It is observed that the Hexavalent Chromium removal percentage decreases with increase in initial concentration of metal ion for an adsorbent dose of 5gms. Using this data a relationship was developed and is expressed by the following non-linear equation.

$1/C = (9.538 \times 10^{-5}) + (0.995) 1/C$ .....(1). It is used to predict the value of  $^{\circ}C$ . The predicted values are found to be deviating at 1.22% from the observed values. Hence this equation can be used to predict the metal removal from industrial wastewaters for any concentration of Hexavalent Chromium up to 300 mg/l.

**TABLE 2 EFFECT OF METAL CONCENTRATION ON Cr<sup>+6</sup> REMOVAL**

pH: 2.0, Time of reaction: 2 hrs, Adsorbent Dose: 5 gms

Cr <sup>+6</sup> mg/l	Final pH	Cr <sup>+6</sup> in solute mg/l	Cr <sup>+6</sup> sorbed, mg/g	%removal of Cr <sup>+6</sup>
50	2.5	0.03	0.999	99.94
100	2.8	0.06	1.999	99.94
150	2.9	0.10	2.998	99.93
200	3.6	0.18	3.997	99.91
250	3.5	0.90	4.982	99.64
300	3.4	11.00	5.780	96.80

The rate of adsorption is found to be 2.51 per hour, which was determined using Lagergren's equations.

### Conclusions

1. Pongamia Pinnata Shell can be effectively and efficiently used to remove Hexavalent Chromium from industrial wastewaters.
2. The removal efficiency of adsorbent increases with decrease in pH and initial metal concentrations and vice versa. Maximum metal removal efficiency was observed at pH 2 and in the concentration range of 50 to 200 mg/l.
3. The rate of adsorption is found to be 2.51 per hour.
4. Hexavalent Chromium removal depends on the time of contact and no significant change in metal removal efficiency after 2 hours of contact.
5. The dependence of amount of Cr+6 adsorbed on contact time can be generalised in the form of empirical model successfully.
6. The sorption equilibrium data fits in to the Langmuir isotherm.

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