# Treatment of Industrial Wastewater by using easily available Natural Plant Material as Adsorbent

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**ABSTRACT:**

The intensification of industrial activity and environmental stress greatly contributes to the significant rise of heavy metal pollution in water resources making threats on terrestrial and aquatic life. The toxicity of metal pollution is slow and interminable, as these metal ions are non bio-degradable. The most appropriate solution for controlling the biogeochemistry of metal contaminants is sorption technique, to produce high quality treated effluents from polluted wastewater. Prosopis spicegera, a readily available tree leaves was used as sorbent for the removal of Cr (VI) from aqueous media. Adsorption studies were performed by batch experiments as a function of process parameters such as sorption time, pH, and concentrations of sorbate and sorbent. Freundlich model fitted best with the experimental equilibrium data among the two tested adsorption isotherm models. The kinetic data correlated well with the Lagergren first order kinetic model for the sorption studies of Cr (VI) using P. spicegera. It was concluded that adsorbent prepared from P. spicegera to be a favorable adsorbent to remove the heavy metal Cr (VI) and can be used for the treatment of heavy metals in wastewater.

**Keywords:** Heavy metal adsorption, isotherms, kinetics, Prosopis spicegera

## INTRODUCTION

Globally, innumerable research on heavy metal pollution to land, aquatic biota and its ecosystem are streamlined towards biomonitoring, accumulation, toxicity and the origin of anthropogenic sources. Likewise, measures to pollution are emphasized towards the physical and chemical treatment processes, bioremediation through phyto and microorganisms and soil reclamation process. An increase in population initiating rapid industrialization was found to consequently increase the effluents and domestic wastewater into the aquatic ecosystem. Thus, the treatment of wastewater containing heavy metals has become a major concern. Among the various metals, Chromium (Cr) was found significant in Indian waters and suspected to cause deleterious effect to aquatic ecosystem. Chromium exists in nature in two oxidation states Cr (III) and Cr (VI). Chromium (VI) is introduced into the environment through industrial discharges from electro plating, leather tanning, glass, ceramic paints and canning industries [1-2]. Cr (VI) is very toxic in nature. Exposure to Cr (VI) affects human beings, plants, animals and as well as ecosystem. Hence removal of Cr (VI) is essential and important [3].

Several techniques used for the removal of toxic metals include ion exchange, precipitation, reverse osmosis, evaporation, chemical reduction and electro-dialysis [4]. Owing to the operational difficulties and treatment expenditure of removing Cr in developing countries, the above methods were found unaffordable for large scale treatment of wastewater rich in Cr (VI). Adsorption using low-cost adsorbents is one of the effective and economic methods [5]. Various low-cost adsorbents have been used for the removal of heavy metals. Abiotic adsorbents include brick kiln ash; fly ash [6] and Wallastonite [7]. Biotic adsorbent includes peanut hull [8], bidi leaves [9], teak leaves [1], Chinese reed [10], amla dust [11] and neem leaves [12]. The adsorption process is superior to many other methods in the removal of heavy metals by virtue of its low cost and simplicity of design. Leaves of trees are very versatile natured chemical species as these contain a variety of organic and inorganic compounds. Cellulose, hemicellulose, pectins and lignin present in the cell wall and chlorophyll, carotene, anthocyanin and tannin in leaves are the most important sorption sites [13]. The important feature of these compounds is that they contain hydroxyl, carboxylic, carbonyl, amino and nitro groups which are important sites for metal sorption [13]. The objective of this investigation is to study the synergistic effect of initial concentration of Cr (VI) solution, pH, adsorbent dosage and agitation time on removal of Cr (VI) by adsorption and to fit the adsorption data to Langmuir and Freundlich adsorption isotherms and Lagergren first order kinetics.

## MATERIALS AND METHODS:

Preparation of adsorbent Prosopis spicigera was collected and sun dried. Dry biomass was cut into small pieces of size 3 mm. The biomass was washed with distilled water, filtered and finally dried overnight at 60oC. They were homogenized to 63 Km size in a mortar, activated by 0.1M H2SO4 for 24h, carbonized and subsequently used for adsorption experiment following the earlier methodology [14]. Preparation of hexavalent chromium solution The stock Chromium (VI) solution was prepared by dissolving 500 mg of Analar grade K2Cr2O7 in 250 ml of distilled water and the volume made to 700 ppm concentration. Different standards of 35, 70,140,175 and 210 ppm were prepared by diluting the stock solution. Batch equilibrium tests Batch equilibrium experiments were conducted by adding the biomass (1g) to 50ml of different test solutions at different pH (1-6) in an Erlenmeyer flask (100ml capacity). The initial solution pH was adjusted using 0.1 M HCI. The flasks were agitated at 150rpm in a rotary shaker for 3h contact time. The biomass was separated from the test solution by filtration using a vacuum filter. The Cr content in the supernatant liquid was determined using photoelectric calorimeter measured below 870 cm-1. Before analysis, the equipment was initially calibrated using standard Cr solution. Concentrated samples were diluted with distilled water before analysis. The amount of Cr adsorbed by biomass was calculated from the difference between the concentration of Cr in test solution and the concentration of Chromium in the supernatant liquid.

## RESULTS AND DISCUSSION:

The experimental data obtained from the different batch type experiments in the present investigation was analyzed and interpreted based on the adsorption of the adsorbent material, P. spicigera. The present study showed P. spicigera to successfully remove Cr (VI) and supported evidences to the earlier studies [7-8, 15].

### Effect on equilibrium time

The time of contact versus % removal of Cr was plotted. Results indicated that maximum adsorption has taken place at the 3rd h, thereafter a marked increase was not observed.

Hence, the equilibrium time was calibrated for 3h. This was found to be effective than the earlier findings at 6h equilibrium time on the extent of hexavalent chromium removal using iron bearing industrial sludge [16].

**Effect of initial concentrations to metal removal**

Percentage of Cr (VI) uptake was found to increase with initial sorbate concentrations. This may be probably as a result of the fact that for a fixed adsorbent dose, the total available adsorption sites remain invariable for all the concentrations checked. Hence the percentage removal of Chromium has shown significant decrease with the increase in the initial sorbate concentrations **(Fig. 1).** Earlier studies [15] showed similar results with Soya bean hull.

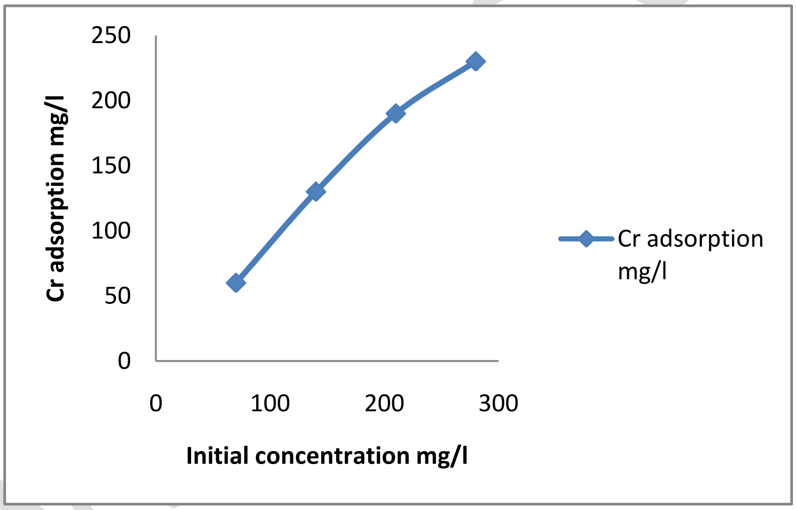


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**Fig. 1: Effect of initial concentration on the removal of Cr (VI)**

**Effect of pH**

The results showed that adsorption is maximum at pH 2 **(Fig. 2)** .This shows that almost acidic pH is preferred for Chromium removal using adsorption technique using the adsorbent P. spicegera and supported evidences to the investigation [15-16].

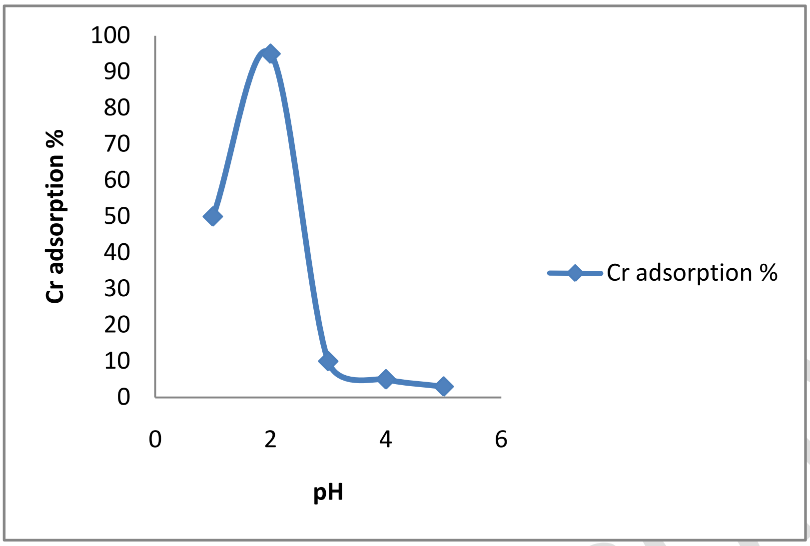


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**Fig. 2: Effect of pH on the removal of Cr (VI)**

**Effect of contact time:**

In these experiments the weight of the adsorbent was 1g **(Fig. 3).** Time taken for the completion of adsorption was 60 minutes (within 3 hours). These findings were similar to that of the observations [17] in the removal of Cr (VI) by fly ash and bagasse.

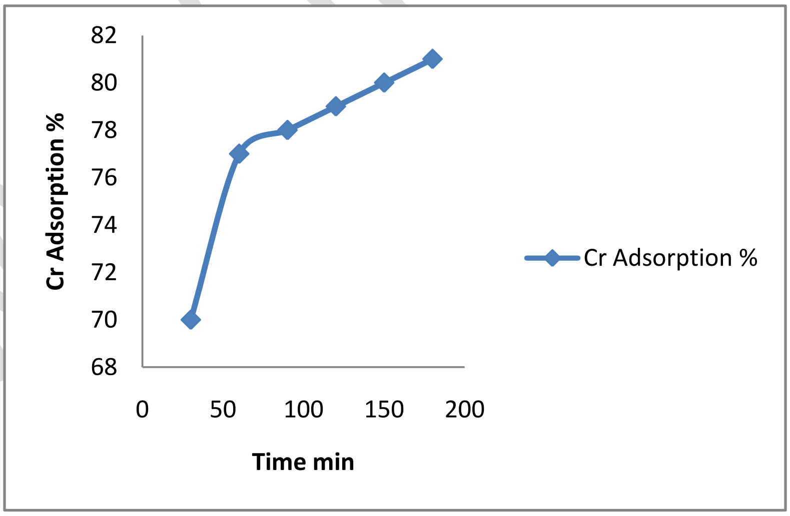


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**Fig. 3: Effect of contact time on the removal of Cr (VI)**

**Effect of Dosage of Adsorbent**

Various amounts of adsorbent P. spicigera ranging from 1-6g were used **(Fig. 4).** The percentage removal of Chromium ions varied linearly with the amount of the adsorbent P. spicigera and amount of adsorbate, Cr solution.

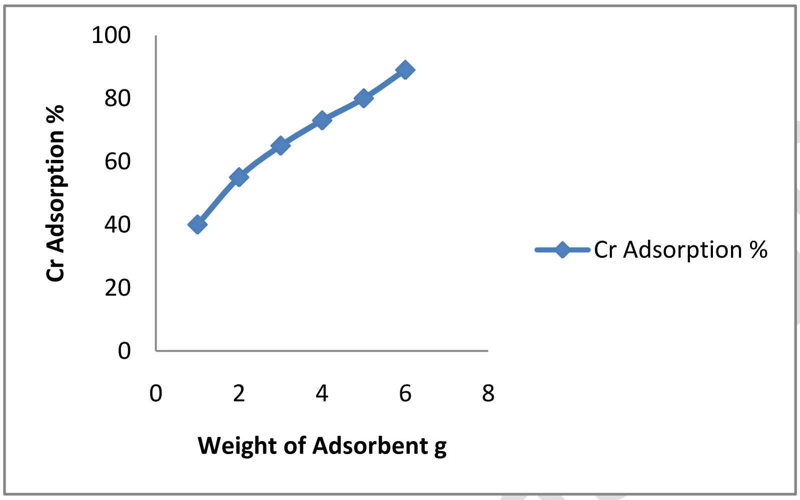


**Fig. 4: Effect of adsorbent dosage on the removal of Cr (VI)**

**Study on the adsorption kinetics**

Observation revealed a linear trace on Lagergren plot, log (qe-q) against time following the first order of adsorption kinetics and supported the earlier views [15] **(Fig. 5).**

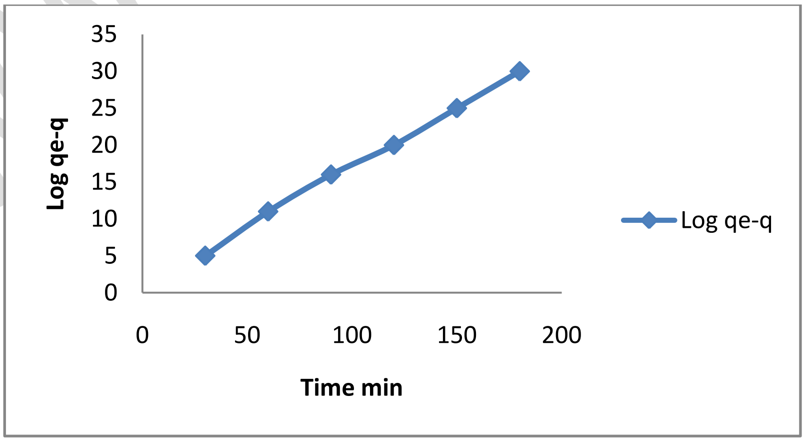


**Fig. 5: Lagergren plot (initial concentration 70 mg/l)**

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**Studies on the adsorption isotherm**

From the Langmuir adsorption isotherm **(Fig. 6),** formation of unimolecular layer of adsorbate on adsorbent was verified [17]. Freundlich isotherm **(Fig. 7)** also validated the linearity that confirmed the unimolecular adsorption [15]. Freundlich plot confirmed the processes of adsorption. Further, the present study showed Cr (VI) uptake at 97.69 % for initial sorbate concentration of 70 ppm with adsorbent dosages of 500 mg.

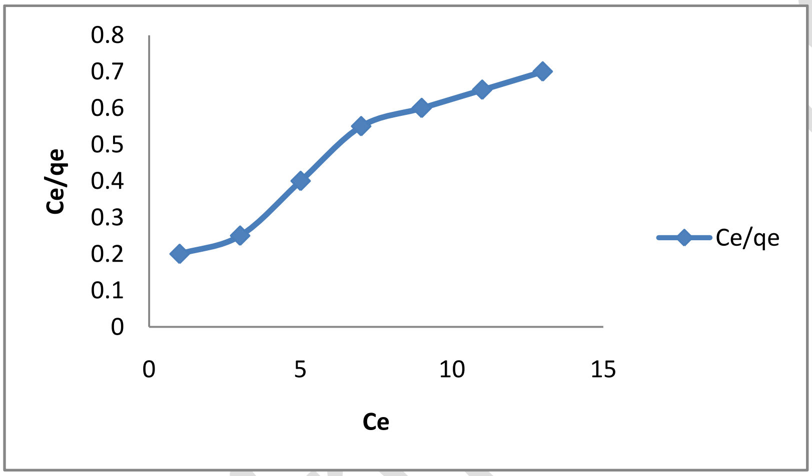


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**Fig. 6: Langmuir plot (time 30 minutes)**

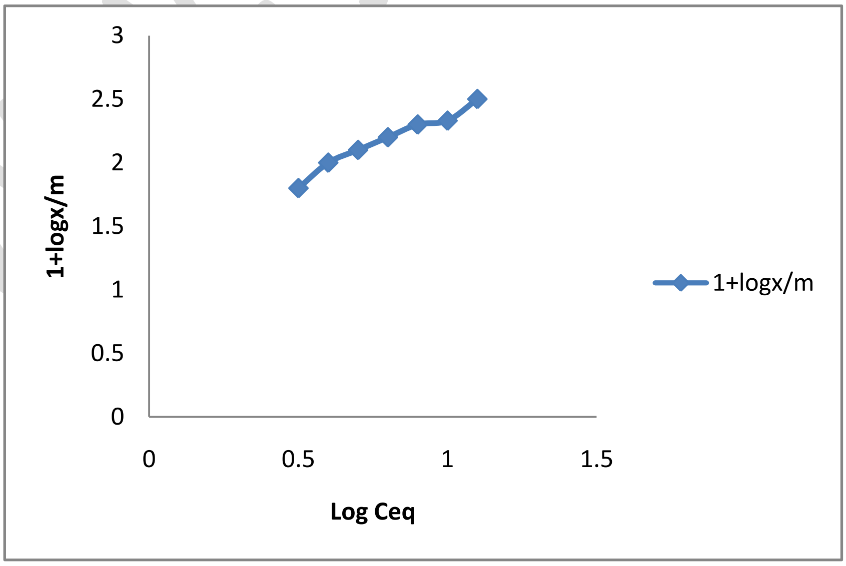


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**Fig. 7: Freundlich plot (Time in minutes)**

**CONCLUSION:**

The present study adsorption on Cr (VI) characterized Prosopis spicegera as an efficient low-cost adsorbent for the removal of toxic Cr (VI) from aqueous solution. The adsorption of Cr (VI) was found dependent on initial concentration of metal ion, pH, adsorbent dosage and agitation time. The maximum removal of Cr (VI) was observed at pH 2. The equilibrium adsorption data showed significant correlation to Langmuir and Freundlich adsorption isotherms and supported the adsorption of Lagergren first order kinetics.

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**REFERENCES:**

i. Ajamal, H., Mohammad, A. and Anwar, S. 2001. Sorption studies of heavy metals on teak leaves using thin layer and column chromatographic technique. Pollut. Res. 20 (3): 425 – 428.

ii. Shiny, K.J., Remani, K.N., Jalaja, T.K. and Sasidharan, V.K. 2004. Removal of chromium by two aquatic Pteridophytes. Indian J. Environ. Health 46: 249–251.

iii. Wittbrodt, P.R.and Palmer C.D. 1995. Reduction of Cr (VI) in the presence of excess soil fulvic acid. Environ. Sci. and Technol. 29: 255 – 265.

iv. Hossain, M.A., Kumita, M., Michigami, Y. and Mori, S. 2005. Optimization of parameters for Cr (VI) adsorption on used black tea leaves. Adsorption 11(5-6): 561-568.

v. Nikhel, K. 2005. Ecological management of polluted waters due to mining and allied industries. J. Indust. Pollut. Contamin. 12 (2):225-271.

vi. Rai, A.K and Surendra K. 1999. Removal of Cr (VI) by using brick kiln and flyash. Indian J. Environ. Health, 41(1): 65-73.

vii. Sharma, Y.C. 2001. Adsorption of Cr (VI) onto wallastonite: Effect of pH. Indian J. Chem. Technol. 8: 191 – 194.

viii. Brown, P., Jefcoat, I., Parrish, A., Dana, G., Sarah, S. and Graham, E. 2000. Evaluation of the adsorptive capacity of peanut hull pellets for heavy metals in solution. Adv. Environ. Res., 4(1):19-29.

ix. Shrivastava, R.K., Ayachi, A.K. and Mora, M. 2001. Removal of Cr (VI) by utilization of Bidi leaves. Pollut. Res. 20(4): 639 – 643).

x. Namasivayam, C. and Holl, W.H. 2004. Chromium (III) removal in tannery wastewaters using Chinese reed (Miscanthus Sinensis), a fast growing plant. Holz. Roh. Werkst. 62: 74 – 80.

xi. Anbalagan, K. and Juliet, J.C. 2004. Adsorption of Cr (VI) ion onto activated amla dust: Adsorption isotherms and kinetics. Indian J. Chem. Technol. 43 A: 45:50.

xii. Sharma, A. and Bhattacharya, D. 2005. Utilisation of biosorbent based on Azadirachta indica (Neem) leaves for removal of water soluble dyes. Indian J Environ. Chem. 12: 285-295.

xiii. Volesky, B. (2003).Sorption and Bi-sorption. Montreal-St. Lambert, Quebec, Canada, BV Sorbex Inc., 316p.

xiv. Mohanty, K., Jha, M., Biswas, M.N. and Meikap, B.C. 2005. Removal of chromium (VI) from dilute aqueous solutions by activated carbon developed from Terminalia arjuna nuts activated with zinc chloride. Chem. Engg. Sc. 60(11): 3049-3059.

xv. Jambulingam, M., Rehugadevi, N., Karthikeyan, S., Kiruthika, J., Patabhi. S. 2005. Adsorption of Cr(VI) from aqueous solution using a low cost activated carbon. Indian J Environ. Protect. 25(5): 458-63.

xvi. Singh, I.B. and Singh, D.R. 2001. Hexavalent chromium removal using iron bearing industrial sludges: Indian J. Chem. Technol. 8: 487-495.

xvii. Rao, M. and Bhole, A.G. 2001. Chromium removal by adsorption using flyash and bagasse . J. Indian Water Works Assoc. 97: 997 – 1000.