DUJASE Vol. 2(2) 135-138, 2014 (January)

# Removal of Chromium from Tannery Effluent by Using Low Cost Adsorbent

**Md. Rashed-Ul-Islam, Md. Alaol Azim, Rafiqul Islam, Md. Nurnabi**

*Department of Applied Chemistry and Chemical Engineering University of Dhaka, Dhaka 1000, Bangladesh.*

*E-mail: professorrafiqulislam@yahoo.co.uk, nnabi@du.ac.bd*

Received on 07. 04. 2012. Accepted for publication on 06. 11. 2012

## Abstract

**Current investigation found that tannery effluent contains extremely higher amount of chromium (827.8 ppm). Three naturally occurring adsorbents such as water hyacinth root powder, kitchen waste powder and kitchen waste extracts were evaluated in removing chromium from tannery effluent. It was found that treatment of 100 mL diluted (20 times) effluent with 0.75 g of water hyacinth root powder resulted 100% removal of chromium from tannery effluent, while kitchen waste powder and kitchen waste extracts demonstrated maximum chromium removal capacity of 87% and 26.43% respectively.**

**Keywords**: Chromium, Tanning, Adsorbent, Effluent, Water hyacinth

## 1. Introduction

Today's world is more concern about its environment. Urbanization & Industrialization near the river bank have created new environmental problem. There are around 200 Tanneries in Bangladesh, according to Bangladesh Finished Leather, Leather goods and Footwear Exporters' Association (BFLLFEA). They are mostly situated near the capital city Dhaka and producing huge amount of waste water which is being drained into the river. The waste water from Leather Tanning, Paint, Electroplating and Textile industries contains huge amount of heavy metals such as Chromium, Manganese, Nickel, Zinc etc. Chromium is known as a highly toxic metal because of its high oxidizing capacity [1]. Developing countries like Bangladesh discharges the effluents to surface water with insufficient or no treatment due to technological and economical limitations. A recent survey showed that the aquatic environment of the rivers (e.g. Buriganga) is in the worst situation. The chromium concentration in the effluent of the tannery waste water was found in the range of 100-200 mg/L, where the maximum allowable limit for Bangladesh is 2 mg/L [2]. When a substance or condition degrades the quality of the water body, water pollution occurs and this water then fails to meet the specified standard or cannot be used for specific purposes [3]. The concentration and composition of dissolved constituents in water determine its quality for irrigation [4]. The use of polluted water for drinking, bathing and irrigation is one of the principal pathways for various infectious diseases that kill millions and sickens more than a billion people each year [5]. It is very important to defend the environmental pollution level not only for saving the universe from the upcoming danger but also to offer a congenial atmosphere to the next generations who deserve better and safer environment for living.

During the past years a lot of techniques had been used to mitigate the pollution level of chromium for instance biological method [6], biological and chemical method [7], membrane technique [8], electrolysis [9], ion exchange [10] etc. In recent years, adsorption process was also extensively studied in the treatment of Cr containing waste water using activated carbon treatment [11], modified activated carbon [12], lignin [13], saw dust [14], waste metallic hydroxides [15], soya cake [16], rice bran [17], distillery sludge [18], bituminous coal [19], coconut husk and palm-pressed fibres [20], sugarcane bagasse, sugar-beet pulp and maize cob [21], saltbush biomass [22], tea leaves [23] etc.

In this study we have paid attention on the usefulness of water hyacinth and kitchen waste as low- cost adsorbents for the removal of toxic chromium. Water hyacinth is very cheap and available material in Bangladesh as this grows in plenty in the low lands. However, it has not been investigated with much attention for its potentiality as an adsorbent for the removal of chromium especially from tannery waste water. It seems that the extensive work is still required for removing chromium using water hyacinth as adsorbent for the treatment of waste water. The use of low-cost, natural adsorbents such as water hyacinth and kitchen waste may be beneficial over activated carbon or other procedures because of complicated technology as well as high cost.

## 2. Materials and Methods

**Collection of Effluent**: Bottles were previously washed thoroughly with detergents and deionized water and then soaked in dil. $HNO_3$ for 24 hours. The bottles were then washed thoroughly with tap water and then with deionized water. During collection of samples, bottles were rinsed properly with waste water discharging from the tanning bath. Samples were collected from the tanning bath of Bay Tanneries Ltd. Hazaribagh, Dhaka and were carried to Analytical Lab, Bangladesh College of Leather Technology, Hazaribagh, Dhaka as quickly as possible.

**Adsorbents**: Water hyacinth and kitchen waste were collected from a nearby lagoon and kitchen of one of the investigator. The root of water hyacinth was sun-dried, followed by size reduction (manual) and grinding. Kitchen wastes was first sorted out to discard plastic, glass, metals etc. It was then dried and ground to obtain the adsorbent. Alternatively the raw kitchen waste was made into paste and extracted by diluting 10 gm pest with 100 mL of deionized water followed by shaking for 3 hours and settled down for 3 days and filtered with What man 54 filter paper.

**Sample Preparation**: The waste liquor collected was filtrated with Whatman 54 filter paper. To 5 mL effluent 95 mL distilled water was added to make 100 mL solution. By this way 14 samples were prepared. One sample was measured without any treatment (sample A1) and used as reference sample. The rest of the samples were treated with different amounts (0.1 g – 0.75 g) of water hyacinth root dust (samples A2 – A5) or kitchen waste dust (samples B1 – B4). Treatment with kitchen waste extract was carried out by adding 25-75 mL of the kitchen waste extract to 100 mL diluted (20 times) effluent and the samples were designated as samples C1 – C3. After treatment each sample was filtered with Whatmann 54 filter paper then analysed by Atomic Absorption Spectroscopy.

**Analytical Method**

Chromium was measured using Atomic Absorption Spectrophotometer (Model: AAnalyst 800, PerkinElmer, USA) equipped at the Advance Research Institute, University of Dhaka. Quality control measures for each batch including calibration with reference samples, blanks and replicate analysis were followed throughout the analysis in order to ensure reliable analytical data. One blank sample was run with each set of samples to check the possibility of contamination.

## 3. Result and Discussion

To evaluate the adsorption of chromium in the effluent 5 mL of the raw effluent was diluted with 95 mL deionized water. The dilution factor was fixed so that the concentration of chromium is within the detection limit when measured without any treatment. Thus 14 samples were prepared; one was measured without treatment and the remaining samples were treated with different amount of water hyacinth dust, kitchen waste dust and kitchen waste extract (Table 1). It was observed that treatment of the effluent with 0.1 g and 0.5 g of water hyacinth dust reduced chromium concentration by 94% and 99% respectively, while higher dose of 0.75 g reduced the concentration to almost 100%. Kitchen waste powder also demonstrated little bit poor chromium removing ability as compared with that of water hyacinth powder. Thus when 100 mL of the diluted effluent was treated with 0.5 g of kitchen waste powder 87% of chromium was removed. However, increased dose of and kitchen waste powder did not show better removal of chromium. It was also evident that 100% removal of chromium was possible only with water hyacinth powder and kitchen waste extract failed to show complete removal of chromium.

**Table 1: Treatment of the effluent with water hyacinth powder and kitchen waste powder**

| Sample No. | Adsorbent | Adsorbent/100 mL diluted sample (gm) | Concentration of Cr ( ppm) | Removal of Cr (%) |
|---|---|---|---|---|
| A1 | Water hyacinth | 0 | 41.39 × 20 = 827.8 | - |
| A2 | | 0.10 | 2.10 × 20 = 42 | 94 |
| A3 | | 0.25 | 1.61 × 20 = 32.2 | 96 |
| A4 | | 0.50 | 0.32 × 20 = 6.40 | 99 |
| A5 | | 0.75 | BDL | - |
| B1 | Kitchen waste (powder) | 0.10 | 7.61 × 20 = 152.20 | 80 |
| B2 | | 0.25 | 6.13 × 20 =122.60 | 85 |
| B3 | | 0.50 | 5.18 × 20 =103.60 | 87 |
| B4 | | 0.75 | 5.20 × 20 =104.00 | 87 |

BDL-Below detection limit.

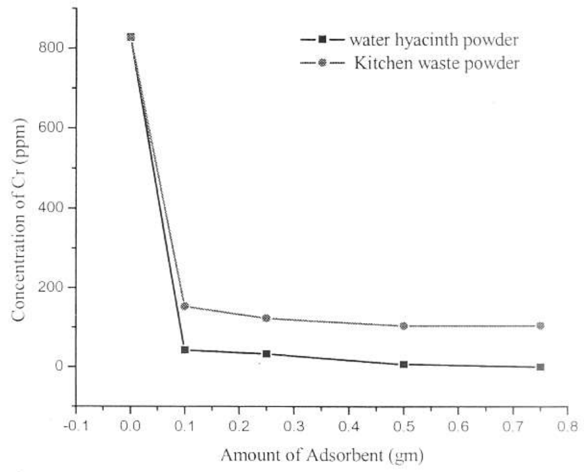


**Fig. 1:** Measured concentration of Cr (ppm) after treatment with different amounts of adsorbents

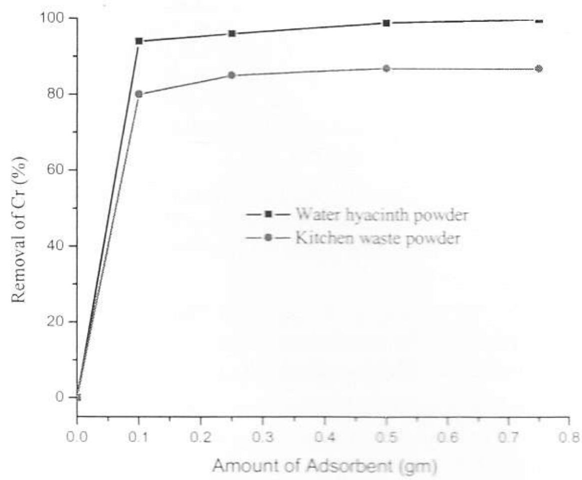


**Fig. 2:** Removal of Cr (%) on treatment with different amounts of adsorbents

**Table 2: Treatment of the effluent with kitchen waste extract**

| Sample No. | Adsorbent | Adsorbent/100 mL diluted sample (mL) | Concentration of Cr ( ppm) | Removal of Cr (%) |
|---|---|---|---|---|
| C1 | Kitchen waste extract | 25 | 30.27 × 25 = 756.75 | 8.58 |
| C2 | | 50 | 20.76 × 30 = 622.8 | 24.76 |
| C3 | | 75 | 17.4 × 35 = 609 | 26.43 |

We also evaluated the chromium removal capacity of kitchen waste extract and our study revealed that this adsorbent is not effective as was evident by the fact that a maximum chromium removal was 26.43% when 75 mL of the kitchen waste extract was employed.

## 4. Conclusion

It has been observed that water hyacinth is very effective for removal of chromium (Cr) from tannery waste water and it may replace existing high cost chemical processes for the removal of chromium from industrial waste water. The adsorbent is available all over Bangladesh and of low cost. It will be environmentally friendly, which is another advantage over chemical processes. Further studies are required to find the industrial scale application.

## Acknowledgement

We thank the Department of Applied Chemistry and Chemical Engineering, Center for Advanced Research for Sciences and Bangladesh College of Leather Technology for support.

## References:

1. Barnhart, J., 1997, "Occurrences, uses and properties of chromium", Regul. Toxicol. Pharmacol., 26, pp S3-S7.
2. Miah, A. B. and A. H. Hoque, 2007, "Kinetics and mechanism of Cr(VI) onto tea-leaves waste", *In Proceding of International Conference and Exhibition on Water and Waste Water treatment* (Eds.: Islam, M. A., E. Drioli, J. Hoinkis, R. R. Huang), Shahjalal University of Science and Technology, Sylhet: Bangladesh, pp 93-100.
3. Ehrlich, P. R. and A. H. Ehrlich, 1970, "Population Resources Environment", W.H. Freeman and Company, Sunfrancisco.
4. Rachel, L. ed. 1984, "Chemistry of Irrigated Soil (Benchmark papers in Soil Science series)", Van Nostrand Reinhold Co. NY.
5. World Bank, 1992, "Development and the Environment", World Development Report, pp 48-49.
6. (a) Aravindhan R., J. R. Rao, K. J. Sreeram and B. U. Nair, 2007, "Biological removal of Cr (VI) using mixed Pseudomonas strains", *J. Gen. Appl. Microbiol.*, 53, pp 71-79.

   (b) Ul Haque R. and A. R. Shakoori, 1998, "Microbiological treatment of industrial wastes containing toxic chromium involviving successive use of bacteria, yeast and algae", *World J. Microbiol. Biotechnol.*, 14, pp 583-585.

   (c) Snehal, M. V., S. John, B. S. Rao, B. U. Nair and R. S. Laxman, 2001, "Chromium removal and reduction in COD of tannery effluent by actinomycetes", *Indian J. Environ. Health*, 43, pp 108-113.

7. Demir, A., and M. Arisoy, 2007, "Biological and chemical removal of Cr (VI) from waste water: cost and benefit analysis" J. Hazard. Mater., 147, pp 275-280.

8. (a) Chaudry, M.A., S. Ahmed and M. T. Malik, 1998, "Supported liquid membrane technique applicability for removal of chromium from tannery wastes", Waste Management, 17, pp 211-218.

(b) For review: Cassano, A., R. Molinari, M. Romana and E. Drioli, 2001, "Treatment of aqueous effluents of the leather industry by membrane process: a review", J. membr. Sci., 181, pp 111-126.

(c) Ho, W. S. and T. K. Podder, 2001, "New Membrane Technology for Removal and Recovery of Chromium from Waste Waters", *Environ. Prog.*, 20, pp 44-52.

(d) Hafez, A.I., M. S. El-Manharawy and M. A. Khedr, 2002, "RO membrane removal of unreacted chromium from spent tanning effluent. A Pilot-Scale Study", 144, pp 237-242.

9. Vlyssides, A. and C. J. Israilides, 1997, "Detoxification of tannery waste liquors with an electrolysis system", *Environ. Pollution,* 97, pp 147-152.

10. Rengaraj, S., K. H. Yeon and S.H. Moon, 2001, "Removal of chromium from water and wastewater by ion exchange resins", *J. Hazard. Mater.,* 87, pp 273- 287.

11. Mohan, D., K. P. Singh and V. K. Singh, 2006, "Trivalent chromium removal from wastewater using low cost activated carbon derived from agricultural waste material and activated carbon fabric cloth", *J. Hazard. Mater.,* 135, pp 280- 295.

12. Lotfi M. and N. Adhoum, 2002, "Modified activated carbon for the removal of copper, zinc, chromium and cyanide from wastewater", *Sep. Puri. Technol.,* 26, pp 137- 146.

13. Lalvani, S. B., A. Hubner, and T. S. Wiltowski, 2000, "Chromium Adsorption by lignin", *Energy Sources,* 22, pp 45-56.

14. Raji, C. and T. S. Anirudhan, 1997, "Chromium (VI) adsorption by sawdust carbon: Kinetics and equilibrium", *Indian J. Chem. Technol.*, 4, pp 228-236.

15. Namasivayam, C. and K. Rangnathan, 1993, "Waste Fe (III)/Cr (III) hydroxide adsorbent for the removal of Cr (VI) from aqueous solution and chromium plating industry waste water", *Environ. Pollution,* 82, pp 255-261.

16. Daneshvar, N., D. Salari, and S. Aber, 2002, "Chromium adsorption and Cr(VI) reduction to trivalent chromium in aqueous solutions by soya cake", *J. Hazard. Mater.*, 94, pp 49-61.

17. Singh, K. K., R. Rastogi and S. H. Hasan, 2005, "Removal of Cr(VI) from wastewater using rice bran", *J. Colloid Interface Sci.*, 290, pp 61-68.

18. Selvaraj, K., S. Manonmani and S. Pattabhi, 2003, "Removal of hexavalent chromium using distillery sludge", *Bioresour. Technol.*, 89, pp 207-211.

19. Rawat N. S. and C. D. Singh, 1992, "Removal of Cr(VI) on bituminous coal", *Asian Environ.*, 14, pp 30- 41.

20. Tan, W. T., S. T. Ooi and C. K. Lee, 1993, "Removal of Cr (VI) from solution by cocoanut husk and palm pressed fibres", *Environ. Technol.*, 14, pp 277-282.

21. Sharma, D. C. and C. F. Forster, 1994, "A preliminary examination into the adsorption of hexavalent chromium using low cost adsorbents", *Bioresour. Technol.*, 47, pp 257-264.

22. (a) Sawalha, M. F., J. L. Gardea-Torresdey, J. G. Parsons, G. Saupe and J. R. Peralta-Videa, 2005, "Determination of adsorption and speciation of chromium species by saltbush (Atriplex canescens) biomass using a combination of XAS and ICP–OES", *Microchem. J.,* 81, pp 122-132.

(b) Sawalha, M. F., J. R. Peralta-Videa, J. Romero-Gonazalez and J. L. Gardea-Torresday, 2006, "Biosorption of Cd(II), Cr(III) and Cr(VI) by saltbush (*Atriplex canescens*) biomass: thermodynamic and isotherm studies", *J. Colloid Interface Sci.*, 300, pp 100- 104.

23. (a) Malkoc, E. and Y. Nuhoglu. 2006, "Fixed bed studies for the sorption of chromium Cr(VI) on to tea factory waste", *Chem. Eng. Sci.*, 61, pp 4363- 4372.

(b) Hossain, M. A., M. Kumita, Y. Michigami, and S. Mori, 2005, "Kinetics of Cr (VI) adsorption on used black tea leaves", *J. Chem. Eng. Jpn.*, 38, pp 402-408.

(c) Mishra, N. K., 2003, "Removal of Chromium (VI) from aqueous solution using low cost adsorbent (tea leaves)", *J. Indian Chem. Soc.*, 80, pp 661-662.