Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 15	No. 2	pp. 657-660	2016

Original Research Paper

Some Studies on the Removal of Chromium from Electroplating Industry Waste by the leaf powder of *Hibiscus mutabilis*

Monangi Murali
Aditya Institute of Technology and Management (Autonomous), Tekkali-532 201, A.P., India

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 27-06-2015
Accepted: 20-08-2015

Key Words:
Chromium
Adsorption
Hibiscus mutabilis
Electroplating waste

ABSTRACT

Several methods of treatment have been suggested for removal of chromium from wastewaters which include chemical precipitation, reverse osmosis, ion exchange, foam formation, etc. The main disadvantages of the above processes are that they produce large amounts of sludge and there are no possibilities of metal recovery as they are very costly. The use of plants and other plant materials for the removal of the heavy metals has already been reported in the literature as the non-conventional adsorbents. In the present work, an attempt has been made to study the efficiency of removal of chromium using non-conventional adsorbents. Effluent from an electroplating industry was collected and analysed for pH value, acidity, suspended soils, dissolved solids and chromium. Batch experiments were conducted using the diluted effluent to facilitate the comparison of the results with control sample. *Hibiscus mutabilis* (commonly known as hibiscus plant) leaves were collected locally and were dried, powdered and sieved through standard sieve (I.S. no. 0.075mm). Batch experiments were carried out using this sieved leaf powder. Variation of chromium removal with contact period and dosage of adsorbent is studied using Freundlich plots.

INTRODUCTION

Chromium can exist in different oxidation states like Cr^{3+}, Cr^{5+} and Cr^{6+}. In the water environment, chromium exists primarily in the form of chromates (Cr^{3+}). During the transformation of chromium in water environment, oxidation of Cr^{3+} and reduction of Cr^{6+} takes place depending upon environmental parameters. Furthermore, there is no evidence to indicate that the trivalent (Cr^{3+}) form is detrimental to human health. But, hexavalent chromium (Cr^{6+}) is a powerful oxidant, which can easily penetrate the biological membranes and irritate cells. High concentrations of chromium are toxic to plants, animals as well as to humans. Most of the toxic effects of chromium to man are associated with its occupational exposure rather than its intake with diet and water.

Several methods of treatment have been suggested for removal of chromium which include chemical precipitation, reverse osmosis, ion exchange, foam formation, etc. The main disadvantage of the above process are that they produce large amounts of sludge and there is no possibility of metal recovery. The use of plants and other plant materials for the removal of the heavy metals have already been reported in the literature as the non-conventional adsorbents.

Rais et al. (2003) studied the removal and recovery of Cr(VI) from synthetic and industrial wastewater using bark of *Pinus roxburghii* as an adsorbent. They found that percent recovery of Cr(VI) from industrial wastewater by column operation and batch process are 85.8% and 65%, respectively. They concluded that *Pinus roxburghii* bark can be used as a cost-effective adsorbent for the removal and recovery of Cr(VI) from wastewater. Nouri et al. (2005) studied the chromium bioremoval from tannery industries effluent by *Aspergillus oryzae*. Statistical studies on factors such as pH, temperature, shaking velocity, type and concentration of nutrients on the "biomass growth" and "residual chromium" showed that all of the factors have significant effects (a=0.05, P<0.001). Venkateswarlu et al. (2007) studied the removal of chromium from an aqueous solution using *Azadirachta indica* (neem) leaf powder as an adsorbent. They found that adsorption behaviour followed Freundlich and Langmuir isotherms. Liping Deng et al. (2009) studied the biosorption of Cr(VI) from aqueous solutions by nonliving green algae *Cladophora albida.* They found that the abundant and economic biomass *Cladophora albida* could be used for removal of Cr(VI) from wastewater by the reduction of toxic Cr(III). Rajor et al. (2013) studied the absorption of chromium and nickel from aqueous solution by bacteria isolated from electroplating unit effluent. They concluded that the bioaccumulation is efficient and cost effective eco-friendly process and the isolated bacterial strains, which can tolerate high concentration of heavy metals, can be utilized for metal recovery process.

Amiri et al. (2014) studied the removal of heavy metals Cr(VI), Cd(II) from aqueous solution by bioabsorption of *Elaeagnus angustifolia*. They found that the experimental data were best fit with the Langmuir isotherm model. Their experimental results show natural biosorbent was effective for the removal of pollutants from aqueous solution. Deepa et al. (2014) studied the removal of chromium (VI) in aqueous solution and industrial wastewater using dry pods of *Prosopis spicigera*. They concluded that kinetic models also described and fit good in Pseudo second order. They also analysed the equilibrium data using Langmuir and Freundlich isotherms.

In the present work, a study of the efficiency of removal of chromium using non-conventional adsorbents has been made.

MATERIALS AND METHODS

Effluent from electroplating industry was collected and analysed for pH value, acidity, suspended solids, dissolved solids and chromium. Batch experiments were conducted using this diluted sample to facilitate the comparison of the results with control sample.

Hibiscus mutabilis (commonly known as hibiscus plant) leaves were collected locally and these leaves were dried, powdered and sieved using standard sieve (I.S. No. 0.075 mm). Batch experiments were carried out using this sieved leaf powder.

Experiments were conducted using diluted samples (each 104mL) of electroplating industry waste, taken in 250 mL beakers. Analysis was carried out using leaf powder of *Hibiscus mutabilis.* The experiment includes three phases of analysis for varying contact periods viz. 30 minutes, 60 minutes, 90 minutes.

RESULTS AND DISCUSSION

The collected sample (raw electroplating industry waste) was analyzed to establish its quality. The results of analysis were as follows:

S No.	Parameter	Value
1.	pH	0.28
2.	Acidity	20,000 mg/L
3.	Total Solids	67,480 mg/L
4.	Suspended Solids	51,100 mg/L
5.	Dissolved Solids	16,380 mg/L
6.	Total Chromium	126.29 mg/L

The removal efficiency of chromium by leaf powder of *Hibiscus mutabilis* for different dosages was conducted in different phases by changing the amount of leaf powder and contact period. It was observed that contact period as well as dosage have considerable effect on the removal efficiency.

In the first phase, experiment was conducted for 30 minutes contact period with different doses (i.e., 0.3 g, 0.5g, 0.7g

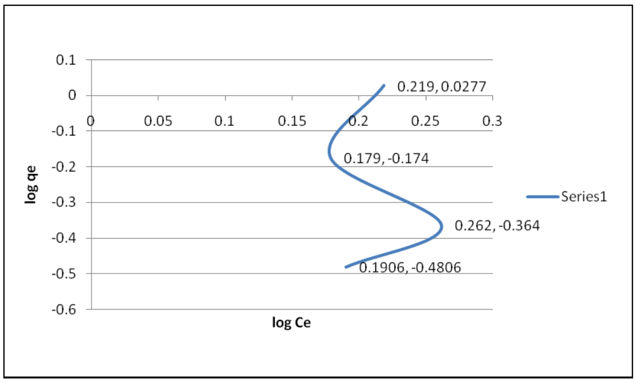

Fig. 1: Freundlich plot for leaf powder for a contact period of 30 minutes.

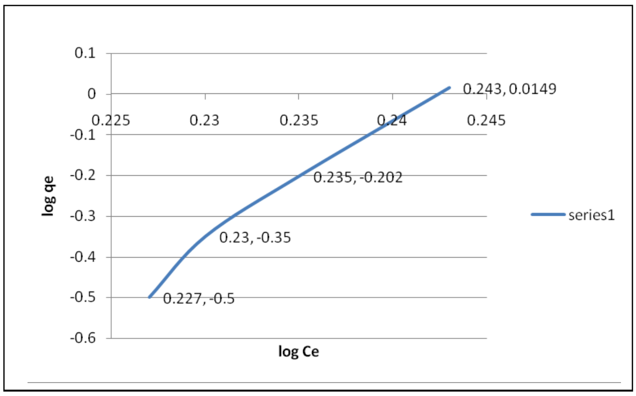

Fig. 2: Freundlich plot for leaf powder for a contact period of 60 minutes.

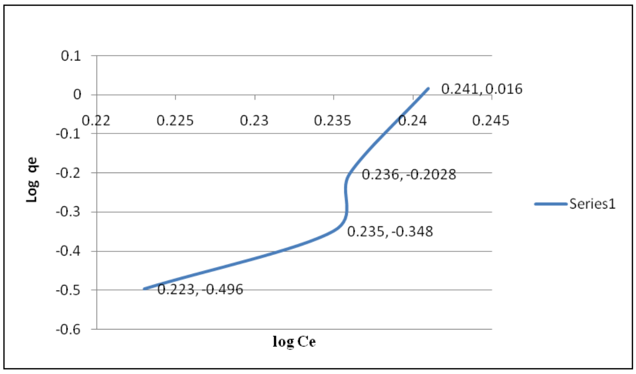

Fig. 3: Freundlich plot for leaf powder for a contact period of 90 minutes.

1.0g) of the leaf powder. The percentage removal of chromium was increased with increased doses. At lower dose (i.e., 0.3g), the percentage removal of chromium was 65.88 % (Table 1) using leaf powder of *Hibiscus mutabilis* for a contact period of 30 minutes and at higher dose (i.e., 1.0g), the percentage removal of was 68.07 % (Table 1, Fig. 1) for

Table 1: Chromium removal efficiency of *Hibiscus* leaf powder for various dosages and 30 minutes contact period.

S.No.	Dosage	Cr conc. before and after adsorpiton		% removal	Ce	Qe	log Ce	log qe
		Initial	Final					
1	0.3 g	4.857	1.657	65.88	1.657	1.066	0.219	-0.0277
2	0.5 g	4.857	1.510	68.91	1.510	0.6694	0.179	-0.174
3	0.7 g	4.857	1.829	62.34	1.829	0.4325	0.262	-0.364
4	1.0 g	4.857	1.551	68.07	1.551	0.3306	0.1906	-0.4806

Table 2: Chromium removal efficiency of *Hibiscus* leaf powder for various dosages and 60 minutes contact period.

S.No.	Dosage	Cr conc. before and after adsorpiton		% removal	Ce	Qe	log Ce	log qe
		Initial	Final					
1	0.3 g	4.857	1.752	63.93	1.752	1.035	0.243	0.0149
2	0.5 g	4.857	1.719	64.61	1.719	0.6276	0.235	-0.202
3	0.7 g	4.857	1.701	64.98	1.701	0.4508	0.230	-0.346
4	1.0 g	4.857	1.686	65.53	1.686	0.3171	0.227	-0.498

Table 3: Chromium removal efficiency of *Hibiscus* leaf powder for various dosages and 90 minutes contact period.

S.No.	Dosage	Cr conc. before and after adsorpiton		% removal	Ce	Qe	log Ce	log qe
		Initial	Final					
1	0.3 gms	4.857	1.742	64.13	1.742	1.038	0.241	0.016
2	0.5 gms	4.857	1.723	64.52	1.723	0.6268	0.236	-0.2028
3	0.7 gms	4.857	1.721	64.56	1.721	0.448	0.235	-0.348
4	1.0 gms	4.857	1.672	65.57	1.672	0.3185	0.223	-0.496

a contact period of 30 minutes.

In the second phase, the experiment was conducted for a contact period of 60 minutes with different doses (i.e., 0.3g, 0.5g, 0.7g and 1.0g) of leaf powder of *Hibiscus mutabilis*. The percentage removal of chromium was increased with increased doses. At lower dose (i.e., 0.3g), the percentage removal was 63.93 % (Table 2, Fig. 2) using leaf powder of *Hibiscus mutabilis* for contact period of 60 minutes.

In the third phase, the experiment was conducted for a contact period of 90 minutes with different doses (i.e., 0.3g, 0.5g, 0.7g, 1.0g) of the leaf powder. At lower dose (i.e. 0.3g) the percentage removal was 64.13% (Table 3, Fig. 3) using leaf powder of *Hibiscus mutabilis* for a contact period of 90 minutes and at higher dose (i.e. 1.0g), the percentage removal was 65.57 % (Table 3) using the leaf powder for a contact period of 90 minutes.

From the above results, it was observed that the percentage removal efficiency increased with increase in dosage of leaf powder of *Hibiscus mutabilis* for a contact period of 60 minutes and 90 minutes. The percentage removal for leaf powder of *Hibiscus mutabilis* increases with increasing contact periods and shows no particular trend for different dosages.

The Freundlich equation seems to fit well defined for all dosages of leaf powder of *Hibiscus mutabilis* for a contact period of 60 minutes, while it seems to fit satisfactory for a contact period of 90 minutes and not satisfactorily for a contact period of 30 minutes. Freundlich curve plotted for the study when the leaf powder was left in contact for a period of 90 minutes exhibits that on unnecessary stirring the chromium that was adsorbed may be desorbed again into the solution.

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