Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2010, 1 (2): 102-105

ISSN: 0976-8610
CODEN (USA): AASRFC

Kinetics of the Removal of Hexavalent Chromium Using a Low-Cost Activated Carbon Adsorbent

Renugadevi N, Anitha. G and Lalitha P

Avinashilingam Deemed University for Women
Coimbatore - 641 043

ABSTRACT

Carbonized *Areca catechu* shell waste has been used as an adsorbent for the removal of hexavalent chromium from aqueous solution. The optimum contact time for effective adsorption of Cr (VI) from aqueous solution has been determined. The kinetics of the process of adsorption of chromium onto activated carbon prepared from *Areca catechu* has been carried out using Lagergren's first order kinetic equation. The adsorption of Cr (VI) was found to be concentration dependent. Conformation of data to the Lagergren's rate equation indicates first order kinetics for Cr (VI) removal by adsorption .

Keywords: areca catechu, adsorption, Lagergren's first order equation.

INTRODUCTION

The effluents from electroplating, tannery, coal combustion, metallurgical industries, paints, pigments, printing and graphics, mine production ,waste disposal, agricultural waste and sewage are the main sources of chromium pollution. The toxic effects of chromium on human beings [Grover and Narayanswamy, 1982; Ajay Kumar, 2002], aquatic system [Dhanapal et al., 1990] , plants and animals[Vajpayee et al., 2001], ecosystem [Kotas and Stasicka, 2000]are well documented. Hence there is a need to remove chromium from aqueous solution.

In the present study carbonized *Areca catechu* shell waste was used as an adsorbent for the removal of hexavalent chromium from aqueous solution. The optimum contact time for effective adsorption of Cr (VI) from aqueous solution has been determined. The kinetics of the process of adsorption of chromium onto activated carbon prepared from *Areca catechu* has been carried out using Lagergren's first order kinetic equation.

MATERIALS AND METHODS

Preparation of activated carbon

Shells of Areca catechu were collected from the Thondamuthur village in Coimbatore district. The shells were cut into small pieces, dried in sunlight for 5 days and further dried in a hot air oven at 60^0C for 24 hours. The completely dried material was powdered well and chemically activated by treating with concentrated sulphuric acid with constant stirring and kept for 24 hours. The carbonized material obtained washed well with plenty of water several times to remove excess acid and dried at 105-110^{o}C in a hot air oven for 24 hours. The adsorbent thus obtained was ground well and sieved through a 250 mesh and kept in an airtight container for further use.

Preparation of Cr (VI) metal ion solution

All chemicals used were of analytical grade. In order to assess the performance of the low-cost adsorbent prepared and to avoid interference by other contaminants in waste water, the experiments were conducted with aqueous solution of Cr (VI) prepared by dissolving 283mg of potassium dichromate in one liter of double distilled water.

Preparation of complexing reagent

The complexing reagent was prepared by dissolving 250mg of diphenyl carbazide in 50ml of acetone.

Equipments

Elico pH meter was used to measure pH. Elico CL157 colorimeter was used for spectrophotometric work. Genuine Equipment Manufacturers mechanical shaker was used for the shaking of solution containing adsorbent and adsorbate.

Effect of variation of initial concentration of Cr (VI) solution and contact time on the adsorption of Cr (VI)

100ml of Cr (VI) standard solutions containing 0.06, 0.08, 0.1 and 0.12 µg of chromium (VI) was added with 100mg of the adsorbent taken in Pyrex bottles and shaken in an electrical horizontal bench shaker for various time intervals (10 to 180 minutes) at room temperature and at constant pH4$\pm$0.02. The solutions were filtered and Cr (VI) concentrations in the filtrate were estimated colorimetrically by diphenyl carbazide method.

RESULTS AND DISCUSSION

Effect of variation of initial concentration of Cr (VI) solution on adsorption of Cr (VI) from aqueous solution

The adsorbate concentrations were varied form 0.06 to 0.12 mg/l and batch studies were performed to optimize the initial concentration of the adsorbate. The percentage removal of Cr (VI) with variation in initial concentration of Cr (VI) solution is given in table 1. The results show an increasing percentage removal of Cr (VI) when the adsorbate concentration was varied from 0.12 to 0.06 mg/l. This may be probably due to the fact that for a fixed adsorbent dose, the total available adsorption sites are limited thereby adsorbing almost the same amount of Cr (VI) causing a decrease in percentage removal of Cr (VI) corresponding to an increased initial adsorbate concentration.

Table – 1: Adsorption potential of Cr (VI) with variation of initial concentration of Cr (VI) solution

Conditions

Adsorbent dosage : 100mg ; pH : 4.00 ± 0.02 ;Temperature : 32°C; Contact time : 10-180 minutes

Time in minutes	Removal of Cr (VI) in percentage			
	0.06 mg/l	**0.08mg/l**	**0.1mg/l**	**0.12mg/l**
10	17. 16	13.12	10.6	10.5
20	20	15.25	12.3	12
30	23	17.5	14.1	13.5
40	25.83	21.75	17.6	15
50	28.66	26.12	21.1	17.91
60	31.5	28.37	24.6	20.91
90	34.33	30.5	26.4	23.91
120	37.16	32.62	29.9	26.91
150	43	37	34.4	29.91
180	45	39.25	36.9	32.91

Effect of contact time on adsorption of Cr (VI) from aqueous solution

Effect of agitation time (contact time) on adsorption is one of the factors affecting the adsorption potentials. The percentage adsorption of Cr (VI) increased with increase in contact time. This may be attributed to the increased surface area available for adsorption at the initial stages. Once the optimum time is reached it may be anticipated that almost all the sites would have been filled and then adsorption would decrease.

Lagergren's Kinetic Modeling for Cr(VI) adsorption

The rate constant of adsorption was calculated (table - 2) using the Lagergren's first order kinetic equation.

$$\log(q_e - q) = \log q_e - K_a/2.303\ t$$

where, q and q_e are the amount of Cr (VI) adsorbed at time'ť' and at equilibrium time.

K_a is the rate constant for Cr (VI) adsorption.

The linear plot obtained by plotting log $(q_e - q)$ Vs time't' shows the validity of Lagergren first order kinetic equation for the adsorption of Cr (VI). The rate constant K_a evaluated from the slope of Lagergren plots is given blow.

Concentration of Cr(VI) in mg /l	K_a in minutes^{-1}
0.06	1.462×10^{-2}
0.08	1.600×10^{-2}
0.1	1.552×10^{-2}
0.12	1.388×10^{-2}

Table 2: kinetic modeling for Cr (VI) adsorption using Lagergren equation (variation of initial concentration of Cr (VI) solution)

Time in minutes	**log (q_e-q)**			
	0.06 mg/l	**0.08mg/l**	**0.1mg/l**	**0.12mg/l**
10	-1.7644	-1.6798	-1.5800	-1.5702
20	-1.8096	-1.7166	-1.6090	-1.6003
30	-1.8632	-1.7594	-1.6420	-1.6326
40	-1.9208	-1.8538	-1.7144	-1.7235
50	-1.9871	-1.9788	-1.8013	-1.7447
60	-2.0655	-2.0604	-1.9100	-1.8416
90	-2.1611	-2.1549	-1.9788	-1.9665
120	-2.2839	-2.2747	-2.1549	-2.1426
150	-2.7695	-2.7447	-2.6020	-2.4436
K_a in minutes	1.462×10^{-2}	1.6×10^{-2}	1.552×10^{-2}	1.388×10^{-2}

CONCLUSION

The carbon derived from the Areca catechu shell can be used as an adsorbent for the removal of toxic Cr (VI) from aqueous solution.The adsorption of Cr (VI) was found to be concentration dependent. Conformation of data to the Lagergren's rate equation indicates first order kinetics for Cr (VI) removal by adsorption . The activated carbon prepared from the Areca catechu shell is inexpensive and use of the same provides an effective solution for treatment of effluents containing hexavalent chromium. Hence the use of low cost carbon prepared and used as an adsorbent for Cr (VI) removal in this study is of practical importance and is expected to be economical.

Acknowledgement
The authors thank the concerned authorities of the Avinashilingam Deemed University for women for providing facilities to carry out this research work.

REFERENCES

[1] K.Bhagi, G.R.Chatwal, Environment Chemistry, Himalaya Publishing House,6, **2001**.
[2] S.Dhanpal, A.Sivakumar, K.Logankumar , M.Aruchamy, *Ind..J.Enviro.Hlth*,**2001**, 32(2),142-145.
[3] M.Grover , M.S. Narayanaswamy, *J. Institution of Engineers*(India) *Environmental Engineering Division*,**1982**,(63),36-39.
[4] J.Kotas , Z.Stasicka,*Environment Pollution*, **2000**, 107,263-283.
[5] P.Vajpayee, U.N.Rai,M.B.Ali, R.D. TripatiR.D, *Environ. ion. term. toxicol*,**2001,** 67,246-256.