



Kinetics and thermodynamic of adsorption of chromium(VI) from aqueous solution using puresorbe

D. Nityanandi*, C.V. Subbhuraam

Department of Environmental Sciences, Bharathiar University, Coimbatore 641 046, Tamil Nadu, India

ARTICLE INFO

Article history:

Received 8 December 2008

Received in revised form 8 May 2009

Accepted 11 May 2009

Available online 19 May 2009

Keywords:

Adsorption isotherm

Coir-based adsorbent

Adsorption kinetics

Second order kinetics

Thermodynamic studies

ABSTRACT

This paper deals with an investigation on coir-based adsorbent, puresorbe, in the removal of chromium(VI) from the aqueous solutions. The adsorption of chromium(VI) was carried out by varying the parameters such as agitation time, metal concentration, adsorbent dose, temperature and pH. The experimental isotherm data were analyzed using Langmuir, Freundlich and Redlich and Peterson isotherms. Adsorption followed second order rate expression for the particle size 250–500 μm at pH 2. The monolayer adsorption capacity is 76.92 mg chromium(VI) per gram of puresorbe. Thermodynamic parameters show the endothermic nature of chromium(VI) adsorption. Desorption study carried out using distilled water adjusted to pH of 2–10, suggests that chemisorption might be the mode of adsorption.

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1. Introduction

Metals, though natural in origin, have been considered as pollutants in view of their dislocation from the geological sources, uses in various spheres of human activities, consequent higher concentration in many compartments of the total environment, transport through unusual pathways, and effects on the target and non-target organisms based on their role and concentration in them. One such metal is chromium(VI) which has widespread use in leather tanning, textile dyeing, electroplating, cement, mining and photography industries [1]. The permissible limit of chromium(VI) in drinking water is 0.05 mg/L [2]. The toxicological effect of Cr(VI) originates from the action of this form itself as an oxidizing agent, as well as from the formation of free radicals during the reduction of Cr(VI) to Cr(III) occurring inside the cell. Inhalation and retention of chromium(VI) containing material can cause perforation of the nasal septum, asthma, bronchitis, pneumonitis, inflammation of larynx and liver and increased incidence of bronchogenic carcinoma. Skin contact of chromium(VI) compound induces skin allergies, dermatitis, dermal necrosis and dermal corrosion [3,4]. The removal of metal ions from effluents is of importance to many countries of world both environmentally and for water reuse. Processes such as coagulation and chemical precipitation, slow sand filters, membrane technologies and ion exchange resins are rou-

tinely employed to remove toxic metals from aqueous waste. These methods are very costly; hence, sorption is one of the most popular methods for the removal of chromium(VI) from wastewaters. A variety of low-cost material have shown potential for the detoxification of metal bearing effluents over recent year [5] including almond [6], bagasse [7], cactus leaves [5], Saw dust [8] and olive cake [5]. The aim of the present study is to investigate the efficiency commercially available material, puresorbe, an oil adsorbent, in the removal of chromium(VI) from wastewaters. The puresorbe is a coir-based adsorbent, which constitutes about 70% of the coconut husk. India is the third largest producer of coconut in the world [9]. The coir pith is an underutilized waste, available in large quantities. This study showed yet another application of puresorbe as an adsorbent. The present study aims to study the efficiency of puresorbe in the removal of chromium(VI) from aqueous solutions at various agitation times, dosage, temperatures (35–60 °C) and pH.

2. Experimental

2.1. Material

Regent Ecotech private limited, India provided the adsorbent used in the present study. The adsorbent is 100% biodegradable, lightweight and a fire retardant. The adsorbent obtained was sieved to obtain particles of uniform size. The particle size between 250 and 500 μm was used for the present study.

The stock solution of chromium(VI) containing 1000 mg/L was prepared from potassium dichromate in double distilled water. The required standard solutions were obtained by diluting the stock

* Corresponding author at: Department of Biotechnology, Kongunadu Arts and Science College, G.N. Mills, Coimbatore 641 046, India.

E-mail address: nityanandi.cbe@yahoo.co.in (D. Nityanandi).

Nomenclature

a_R	Redlich–Peterson isotherm constant
b	energy of adsorption
b_R	dimensionless lies between 0 to 1
Bt	mathematical function of F
C_0	initial solution concentration (mg/L)
C_e	equilibrium solution concentration (mg/L)
C_t	the concentration at any time (mg/L)
D_i	effective diffusion coefficient (cm^2/s)
F	fraction of solute adsorbed at different times (t)
ΔG	Gibbs free energy (kJ/mol)
ΔH	enthalpy of adsorption (kJ/mol)
k_i	intraparticle diffusion rate constant (mg/g $\text{min}^{1/2}$)
K_{ad}	rate constant of first order adsorption (1/min)
K_2	rate constant of second order adsorption (min/g/mg)
K_o	the temperature independent factor (g/mg min)
K_f	Freundlich constant
K_s	external mass transfer rate (cm/s)
K_R	equilibrium constant (L/g)
m_s	dose of adsorbent
n	indication of favourability
q	amount of Cr(VI) in mg/g of adsorbent at time t
q_e	amount of Cr(VI) in mg/g of adsorbent at equilibrium time
Q_0	Langmuir constants related to adsorption capacity
r	radius of the adsorbent particle (assumed to be spherical)
R	gas constant (J/mol)
R_a	removal of adsorbate
ΔS	change in entropy (J/mol K)
T	temperature (K)
V	volume of solution (L)
W	weight of puresorbent (g)
X/m	amount adsorbed at equilibrium time (mg/g)

solution. The reagents used in the present study were obtained from SD fine chemicals and Loba chemie.

2.2. Methods

2.2.1. Batch adsorption study

Adsorption experiment was carried out by shaking (Model L orbital) 0.1 g of adsorbent with 50 ml of chromium(VI) solution of various concentrations (40–100 mg/L) at 190 rpm for a predetermined equilibrium time. After agitation, the adsorbate and the adsorbent were separated by centrifugation and the uptake of chromium(VI) estimated spectrophotometrically (Hitachi U-3210) using diphenyl carbazide [10]. The amount of adsorption at equilibrium, q_e (mg/g) was computed as follows

$$q_e = \frac{(C_0 - C_e)V}{W} \quad (1)$$

Effect of adsorbent dose on chromium(VI) removal was studied by agitating 50 ml of 40 and 60 mg/L solution of chromium(VI) with different doses of the adsorbent (10–150 mg) for a time period greater than their respective equilibrium times. The influence of pH on the adsorption capacity of puresorbent, was performed by agitating for predetermined equilibrium time 50 ml of 40 and 60 mg/L solution of chromium(VI), with 100 mg of the adsorbent at pH values ranging from 2 to 10. The pH of the solution was adjusted using HCl and NaOH solution.

2.2.2. Desorption studies

After adsorption experiment with 40 mg/L solution of chromium(VI) with 100 mg of the adsorbent, the chromium(VI)-laden adsorbent was separated out by filtration and the filtrate was discarded. The adsorbent was given a gentle wash with double distilled water to remove any unadsorbed chromium(VI) molecules entrapped between the adsorbent particles. Desorption studies were carried out by agitating the adsorbent with 50 ml of distilled water adjusted to pH 2–10, for a time greater than the equilibrium time and then the desorbed chromium(VI) was estimated as given above.

2.2.3. Thermodynamic studies

Effect of temperature on chromium(VI) removal was studied by agitating 50 ml of 100 mg/L solution of chromium(VI) at different temperatures (30–60 °C) for different agitation times till equilibrium is attained, and then the filtrate was analyzed for the residual chromium(VI) concentration as described above.

3. Results and discussion

3.1. Effect of pH

Fig. 1 shows the effect of pH on the adsorption of chromium(VI) from aqueous solution using puresorbent. The percent removal of Cr(VI) ions was at its maximum at pH 2 (99.85%) and then recorded a decrease with further increase in pH until it reached a plateau at the initial pH of 4. It is well known that the dominant form of Cr(VI) at pH 2 is HCrO_4^- . Increasing the pH will shift the concentration of HCrO_4^- to the other forms, CrO_4^{2-} and $\text{Cr}_2\text{O}_7^{2-}$. Maximum removal at pH 2 indicates that Cr(VI) ions in the HCrO_4^- form adsorbed profoundly on the protonated active sites of puresorbent and the nature of adsorption could be electrostatic. As the pH increased the net surface change has become negative thus the percent removal decreased. The pH_{ZPC} of puresorbent was found to be 5.5 [11], this indicates that at pH lower than 5.5, the surface of puresorbent is positively charged and chromium is mainly present as HCrO_4^- at pH 2, at which maximum removal was observed at equilibrium condition for puresorbent. Similar observation was recorded by Elliot and Weng for Cr(VI) onto fly ashes [12]. Optimum biosorptive removal of chromium(VI) at low pH 2 has been reported for *Rhizopus nigricans* [13], *Bacillus* sp. [14] and *Dunaliella*

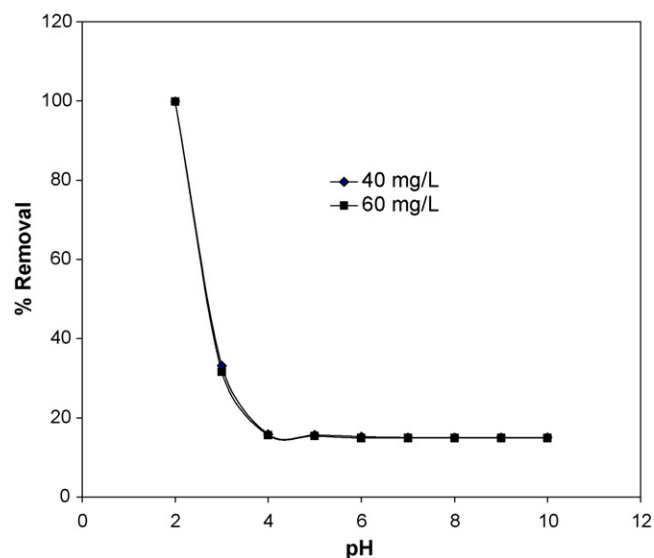
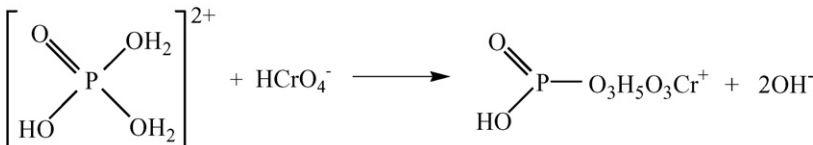
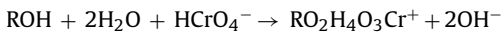
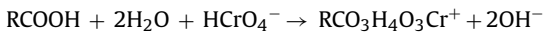


Fig. 1. Effect of pH on removal of chromium(VI) by puresorbent. Conditions: particle size, 150–250 μm ; temperature, 303 K; dose, 100 mg/50 ml.

Table 1
Comparison of the first order and second order adsorption rate constants and calculated and experimental q_e values for different initial chromium(VI) concentrations and temperature adsorbed by puresorbe.

Initial Cr(VI) concentration (mg/L)	Temperature (°C)	First order kinetic model				Second order kinetic model			
		q_e , experimental (mg/g)	K_{ad} (1/min)	q_e , calculated (mg/g)	R^2	K_2 (g/mg/min)	q_e , calculated (mg/g)	R^2	
40	30	19.97	0.0896	14.32	0.9907	0.0107	21.28	0.9976	
60	30	29.95	0.0503	19.98	0.959	0.0044	31.95	0.9996	
80	30	39.89	0.0414	29.34	0.9004	0.003	42.02	0.9992	
100	30	49.5	0.0226	25.33	0.9926	0.0018	51.83	0.9992	
Effect of temperature on adsorption									
100	30	49.5	0.0214	24.26	0.9804	0.002	52.35	0.9998	
100	40	50	0.03201	26.5	0.9728	0.002	52.63	0.9999	
100	50	50	0.04974	41.99	0.8901	0.003	52.63	0.9999	
100	60	50	0.09626	61.32	0.8963	0.003	54.63	0.9991	

sp. [15]. Electrostatic interactions have also been demonstrated to be responsible for Cr biosorption by Fungi *Gonaderma lucidum* and *Aspergillus niger* [16,17]. The major components of the lignocellulosic material contain functional groups such as carboxylates, phenolic and aliphatic hydroxyls and carbonyl groups with the ability to adsorb metals [18]. The adsorbent was prepared by treating the raw coir pith with superphosphate containing Ca^{2+} , and Na^+ and K^+ as natural components of the coir pith. The reaction with various functional groups could be predicted as below



3.2. Effect of agitation time and initial chromium(VI) concentration on chromium(VI) adsorption

The adsorption capacity of puresorbe increased with an increase in the agitation time and attained equilibrium at 80, 120, 160, 200 min for the initial chromium(VI) concentration of 40, 60, 80 and 100 mg/L, respectively (Fig. 2). On the basis of the results obtained, the contact times for further study were as 230 min. The adsorption equilibria (mg/g) increased with an increase in chromium(VI) concentration whereas the percentage of chromium(VI) removal decreased from 99.85% to 98% as the chromium(VI) concentration increased from 40 to 100 mg/L. The curves were smooth, simple and continuous suggesting the monolayer coverage of chromium(VI) on the surface of the adsorbent.

3.3. Adsorption kinetics

To analyze the mechanism of adsorption the data was fitted to various kinetic models such as, first order reaction and second order reaction. Intraparticle diffusion model and Boyds kinetic expressions were employed to find out the rate controlling step in the process of adsorption of chromium(VI) onto puresorbe. The rate constant of adsorption is determined from the first order rate expression given as [19]

$$\log_{10}(q_e - q) = \log_{10}q_e - \frac{K_{ad}t}{2.303} \quad (2)$$

The linear plot of $\log_{10}(q_e - q)$ vs. t for the metal studied at different concentrations indicate the applicability of the above

equation. Though a linear plot was obtained the experimental q_e was not equal to calculated q_e . This shows that the adsorption of chromium(VI) onto the adsorbent is not a first order reaction. Comparisons of the results with the correlation coefficient are given in Table 1.

The second order kinetic model was expressed as [20]:

$$\frac{t}{q} = \frac{1}{K_2q_e^2} + \frac{1}{q_e} \quad (3)$$

The constant K_2 was used to calculate the initial sorption rate h , at $t \rightarrow 0$ as follows

$$h = K_2q_e^2 \quad (4)$$

If second order kinetics is applicable, the plot of t/q vs. t should show a linear relationship. The second order rate constant, K_2 and q_e were calculated from the intercept and slope of the plots. The linear plot of t/q vs. t obeys very well with the second order kinetic

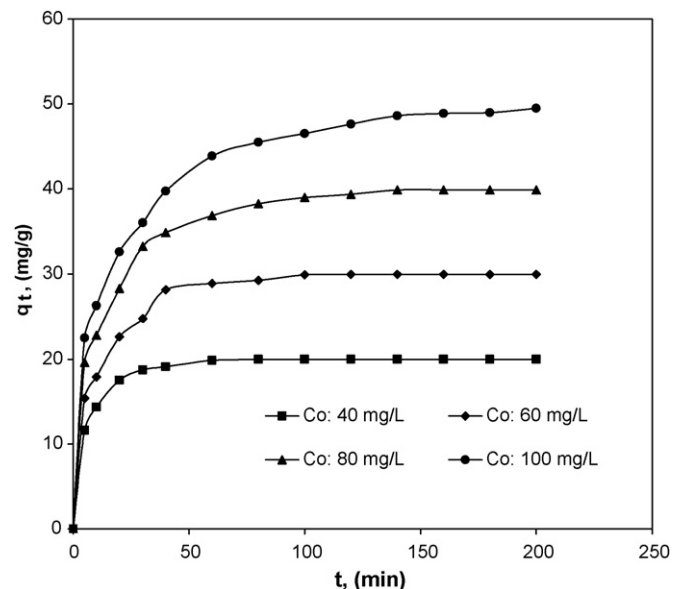


Fig. 2. Effect of agitation time on the removal of chromium(VI) by puresorbe. Conditions: particle size, 150–250 μ m; temperature, 303 K; dose, 100 mg/50 ml.

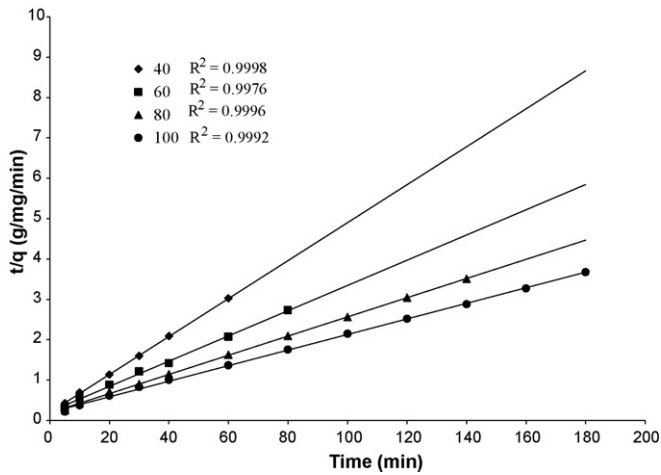


Fig. 3. Plot of pseudo second order adsorption kinetics of chromium(VI) on pure sorbe at different initial concentrations.

model showing a good agreement of the experimental q_e value (Fig. 3). The correlation coefficient for the second order kinetics are greater than 0.994 for all the concentrations (Table 1). The corresponding linear plots of the values of q_e , K_2 and h against C_0 for chromium(VI) was regressed to obtain expressions for these values in term of the initial metal concentration as suggested by Ho and McKay [21].

$$q_e = \frac{C_0}{6.982 \times 10^{-4} C_0 + 1.848} \quad (5)$$

$$h = \frac{C_0}{0.19806 C_0 + 0.5055} \quad (6)$$

$$K_2 = \frac{C_0}{741.66 C_0 - 27386.16} \quad (7)$$

Substituting the values of q_e and h from Eqs. (5) and (6) into Eq. (3), the rate law for a pseudo second order reaction and the relationship of q_t , C_0 and t can be represented as:

$$q_e = \frac{C_0 t}{(0.19806 C_0 + 0.5055) + (6.982 \times 10^{-4} C_0 + 1.848) t} \quad (8)$$

Eq. (8) represents the generalized prediction model for chromium(VI) to calculate the amount adsorbed (mg/g) at any contact time and initial concentration within the specified concentration range.

3.3.1. Rate controlling steps in the process of adsorption

As a result of optimization of agitation rate and time which influence the bulk transfer of metal ions, the other steps involved in the process of metal adsorption were evaluated by plotting q_e against $t^{1/2}$ in accordance with the intraparticle diffusion model of Weber and Morris [22]

$$q_t = k_t t^{1/2} \quad (9)$$

The plots between $t^{1/2}$ and q_e presenting a multilinearity, depict that two or more steps take place. The first sharper portion is the external surface adsorption or instantaneous adsorption stage. The second portion is the gradual adsorption stage, where intraparticle diffusion is rate controlled. The third portion is the final equilibrium stage where intraparticle diffusion starts to slow down due to extremely low adsorbate concentrations in the solution. As in Fig. 4 the stage 1 is completed within 5 min which could not be identified well and stage 2 continues from 5 to 30 min and third stage continues after 300 min. The intraparticle diffusion rates constant were calculated from the slope of the plots. The intraparticle

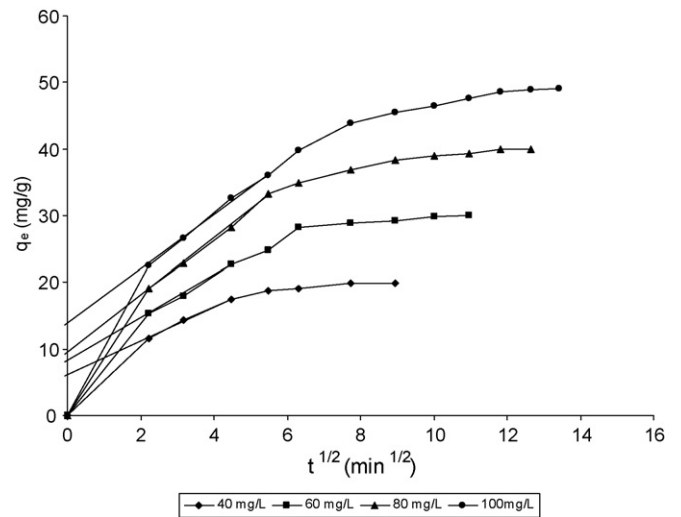


Fig. 4. Plot of intraparticle diffusion model for adsorption of chromium(VI) on pure sorbe at different initial concentrations.

rate constant for 40, 60, 80 and 100 mg/L was 2.612, 2.992, 4.209 and 4.255 $\text{mg/g min}^{1/2}$, respectively. The straight line of the plots do not pass through origin, suggesting that adsorption proceeds from boundary layer mass transfer across the interface to the intraparticle diffusion within the pores of adsorbent [23].

The rate constants for the external mass transfer for the initial time period of sorption process were calculated from the plots of $\ln C_t/C_0$ vs. time t [24]. The slopes of the plots were calculated based on the assumption that the relationship between $\ln C_t/C_0$ and t was linear for the first rapid phase. Assuming that the external mass transfer occurs in 5 min for chromium(VI) as understood from the kinetic plots, the values of rate constant K_s (cm/s) were calculated from the slopes of the plots. The external mass transfer rate constant for 40, 60, 80 and 100 mg/L was 2.171, 1.792, 1.680 and 1.491 cm/s, respectively. The relationship between K_s and C_0 (Fig. 5) for various chromium(VI) is expressed as follows:

$$\text{Chromium(VI)} : K_s = \frac{C_0}{(800.19 C_0 - 14363)} \quad R^2 = 0.9948 \quad (10)$$

Since both external mass transfer and intraparticle diffusion constants varied with initial metal concentration indicating the occurrence of both surface adsorption and intraparticle diffusion, the sorption data were further analyzed by the kinetic expression

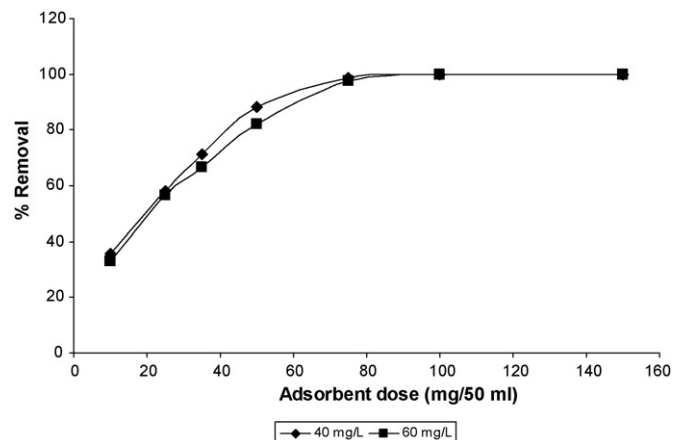


Fig. 5. Effect of adsorbent dose on removal of chromium(VI) by pure sorbe.

given by Boyd et al. [25]

$$F = 1 - \frac{6}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} \exp\left[-\frac{D_i t \pi^2 n^2}{r^2}\right] \quad (11)$$

$$F = 1 - \frac{6}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} \exp[-n^2 Bt] \quad (12)$$

to find out which one is the actual rate controlling step in the metal sorption process.

$$F = \frac{q_t}{q_e} \quad (13)$$

Substituting Eq. (13) into Eq. (9), the kinetic expression becomes

$$Bt = -0.4977 - \ln\left(1 - \frac{q_t}{q_e}\right) \quad (14)$$

The value of Bt was calculated for each value of F using Eq. (14). The calculated Bt values were plotted against time and it was observed that the plots were linear but did not pass through the origin, indicating that, for the studied concentration range of metal, the external mass transfer mainly governs the rate limiting process. The calculated B values were used to calculate the effective diffusion coefficient D_i (cm^2/s) using the relation

$$B = \frac{\pi^2 D_i}{r^2} \quad (15)$$

The D_i values for 40, 60, 80 and 100 mg/L were 0.4552, 0.3084, 0.2008 and 0.1729 cm^2/s , respectively.

3.4. Effect of mass of the adsorbent on chromium(VI) adsorption

The effect of mass of the adsorbent on the uptake of chromium(VI) is depicted in Fig. 5. There was a substantial increase in adsorption when the dosage of the adsorbent increased upto 75 mg and attained a stable removal above that dosage, which may be attributed to the increase in the adsorbent surface area with a higher number of functional group on the adsorbent. The mathematical relationships to predict the percentage of chromium(VI) removal by adsorption for any adsorbent dose within the tests limit at pH 2 and initial chromium concentrations of 40 and 60 mg/L are

$$40 \text{ mg/L} : \%R_a = m_s/0.2023 + 8.08 \times 10^{-3} m_s \quad R^2 = 0.9952$$

$$60 \text{ mg/L} : \%R_a = m_s/0.2250 + 8.032 \times 10^{-3} m_s \quad R^2 = 0.9973$$

3.5. Adsorption isotherms

The purpose of the adsorption isotherm is to relate the adsorbate concentration in the bulk solution and the adsorbed amount at the interface. The analysis of the isotherm data is important to develop an equation which accurately represents the results and which could be used for the design purpose. Several isotherm equations are available. Five of them have been selected for this work: Langmuir, Freundlich, and Redlich–Peterson.

3.5.1. Langmuir isotherm

The linear form of Langmuir equation can be given as follows [26]:

$$\frac{C_e}{q_e} = \frac{1}{Q_0 b} + \frac{C_e}{Q_0} \quad (16)$$

According to the equation, a plot of C_e/q_e vs. C_e should be a straight line with a slope $1/Q_0$ and intercept $1/Q_0 b$ when adsorption follows the Langmuir equation. The values of Q_0 and b for the

Table 2

Sorption capacities of low-cost adsorbents for chromium(VI).

S. No.	Adsorbent	Q (mg/g)	Reference
1	Leaf mould	43.1	[27]
2	Sphagnum moss peat	65.8	[28]
3	Palm pressed fibre	14	[29]
4	Sawdust	3.3	[30]
5	Fly ash	0.0005	[31]
6	Raw bagasse	0.001	[31]
7	Used tyres	55.25	[32]
8	Coal	6.78	[33]
9	Cactus	7.08	[33]
10	Almond	10.62	[33]
11	Pine needles	21.50	[33]
12	Saw dust	15.82	[33]
13	Olive cake	33.44	[33]
14	Wool	41.15	[33]
15	Clinoptilolite	2.40	[34]
16	Chabazite	3.60	[34]
17	Cork biomass	3.4	[35]
18	Sawdust	20.02	[36]
19	Raw algae	31	[37]
20	Acid treated algae	35.2	[37]
21	Sunflower stem	4.9	[38]

adsorption of chromium(VI) with pure sorbent are 76.92 mg/g and 0.4851 L/mg. The correlation coefficient (r) was 0.9913 indicating a very good mathematical fit. The fact that the Langmuir isotherm fits the experimental data very well assumes that intermolecular forces decrease rapidly with distance and consequently predicts the existence of monolayer coverage of the adsorbate at the outer surface of the adsorbent. It assumes that adsorption takes place at specific homogenous sites within the adsorbent and once a metal ion occupies a site, no further adsorption occurs at that site. It also assumes that all sorption sites are identical and energetically equivalent. A comparison of the adsorption capacities for Cr(VI) ions of other low-cost adsorbents is given in Table 2.

3.5.2. Freundlich isotherm

It is another form of Langmuir approach for adsorption on amorphous surface. It assumes the heterogeneity of surface and the exponential distribution of active sites and their energies. Freundlich equation form could be written as follows [39]:

$$\log_{10} \frac{X}{m} = \log K_f + \frac{1}{n} \log_{10} C_e \quad (17)$$

Linear plots of $\log_{10} C_e$ vs. $\log_{10} X/m$ showed that the adsorption of chromium(VI) onto pure sorbent has a low regression coefficient of 0.8809, suggesting that the adsorbent does not form heterogeneous coverage.

3.5.3. Redlich and Peterson isotherm

Jossens and co-workers modified the three-parameter isotherm first proposed by Redlich and Peterson [40] to incorporate features of both the Langmuir and Freundlich equations [41]. It can be described as follows:

$$q_e = \frac{K_R C_e}{1 + a_R C_e^{b_R}} \quad (18)$$

The linearized form is

$$\ln\left(\frac{K_R C_e}{q_e} - 1\right) = b_R \ln(C_e) + \ln(a_R) \quad (19)$$

It has three isotherm constants K_R , a_R and b_R ($0 < b_R < 1$).

(a) where if $b_R = 1$

$$q_e = \frac{K_R C_e}{1 + a_R C_e} \quad (20)$$

i.e. Langmuir form results

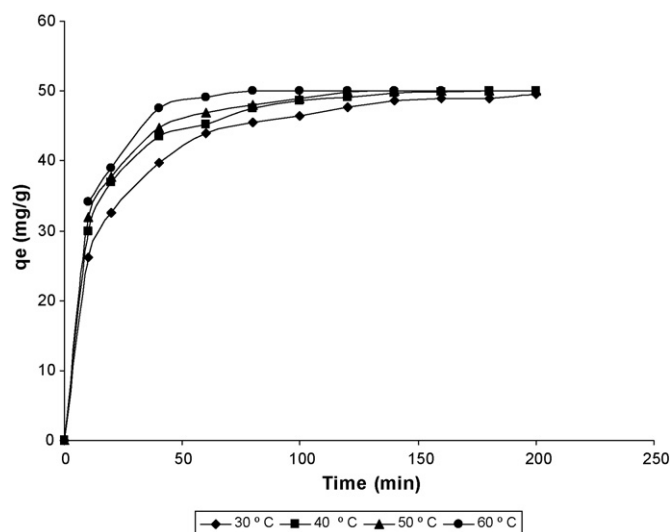


Fig. 6. Effect of temperature on adsorption of chromium(VI) by puresorbe. Conditions: particle size, 150–250 μm ; temperature, 303 K; dose, 100 mg/50 ml.

(b) where if $b_R = 0$

$$q_e = \frac{K_R C_e}{1 + a_R} \quad (21)$$

i.e. Henry's law equation results.

The plots of $\ln C_e$ vs. $\ln(K_R C_e / q_e - 1)$ for chromium(VI) was linear with a regression coefficients of 0.9987. The constants K_R , b_R and a_R were evaluated from the linear plots represented by Eq. (19) using trial and error optimization methods. The values of K_R , a_R and b_R are 620, 0.06 and 0.949, respectively. Examination of the R^2 values obtained for various isotherm equations shows that the three-parameter Redlich–Peterson model exhibited better fit to the sorption data than the two-parameter Freundlich and Langmuir isotherm for Cr(VI) indicating that the surface of the adsorbent is not homogenous and contain more than one type of active sites. The values of $b_R < 1$ for chromium(VI) suggest that the Langmuir isotherm is not convenient for the equilibrium modelling of the above metals and puresorbe system.

3.6. Desorption studies

The disposal method of chromium(VI)-laden adsorbent involves the incineration and land disposal, which may be harmful to the environment. Hence regeneration of the adsorbent and the metal ion was attempted. The amount of chromium(VI) desorbed was only 3%, at pH 10, this shows that the mechanism of chromium(VI) adsorption on puresorbe is predominantly chemisorption.

3.7. Thermodynamic studies

The effects of agitation time and temperature on chromium(VI) are given in Fig. 6. There was an increase in the %removal as the temperature increased which may be attributed to the change in the size of the pores, and enhanced rate of intraparticle diffusion of adsorbate species [42]. According to van't Hoff equation

$$\log_{10} k_c = \frac{\Delta S}{2.303R} - \frac{\Delta H}{2.303RT} \quad (22)$$

$$\Delta G = -RT \ln k_c \quad (23)$$

The plot of $1/T$ vs. $\log_{10} k_c$ is given in Fig. 7. ΔS and ΔH were calculated from the slope and intercept of the plot (Table 3). The negative value of ΔG suggests that adsorption is spontaneous. The

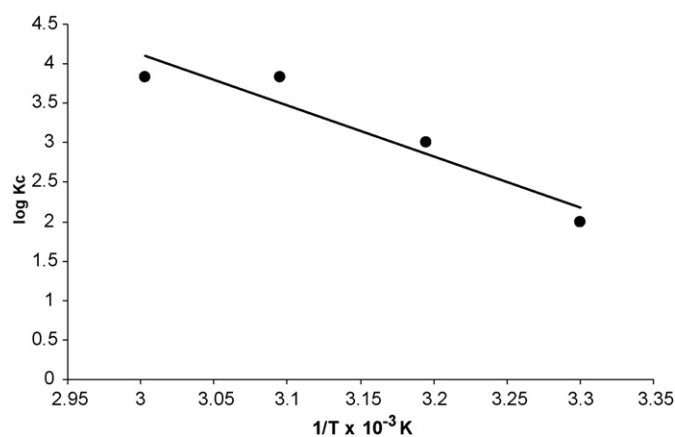


Fig. 7. van't Hoff plot for chromium(VI) adsorption by puresorbe.

Table 3

Thermodynamic parameters for the adsorption of chromium(VI) by puresorbe.

Temperature (K)	ΔG (kJ/mol)	ΔS (J/mol K)	ΔH (kJ/mol)
303	-11.578	123.84	39.25
313	-15.862		
323	-17.588		
333	-22.966		

positive value of ΔH may suggest endothermic process of adsorption. The positive value of ΔS shows the feasibility of adsorption and the increased randomness at the sorbent/solution interface during the adsorption of metal ions onto puresorbe.

4. Conclusion

In the present study puresorbe has been shown to be an effective adsorbent for chromium(VI) removal from aqueous solutions. The adsorption increased with increase in contact time and reached equilibrium after 200 min. Adsorption of chromium(VI) followed second order rate kinetics. The adsorption capacity of puresorbe was found to be 76.92 mg chromium(VI) per gram of puresorbe. Adsorption data was analyzed using Langmuir, Freundlich and Redlich–Peterson isotherms to find out the process of adsorption. The regeneration of the adsorbent is not effective in any pH range 2–10. The use of coir pith modified adsorbent for metal removal makes the process environmental friendly and economic. Chemical treatment of coir pith using nutrients such as superphosphate provides a cheaper method of adsorbent preparation than the traditional preparation of activated carbon (physical and chemical activation), where expensive chemicals as well as thermal energy are employed.

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