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Advances in Applied Science Research, 2010, 1 (3): 147-152

ISSN: 0976-8610
CODEN (USA): AASRFC

Adsorption studies of Fe (II) on low cost biomaterial

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ABSTRACT

Jute & Sunnhemp has been used as adsorbate for the adsorption of metal ions. The forces operating between the molecules of an adsorbate and the adsorbent are mostly short range forces as suggested by Langmuir. These forces may be non specific like dispersion forces, orientation forces and induction forces or may be chemical bonds. Adsorption depends on the surface area of the adsorbate, pH, contact time etc. The surface charge of the adsorbate is an important criterion in adsorption. The adsorbing powers of many substances can be increased by temperature treatment. In the present study, the effect of contact time, temperature, pH, etc is reported. The paper also discusses the applicability of Freundlich and Langmuir adsorption isotherms.

Key words: Adsorption, Iron, Jute, Sunnhemp, etc.

INTRODUCTION

Pollution is the burning topic of the modern world. The most dangerous type of pollution is water pollution. Various toxic metal ions presents in the industrial effluent are a major source of the pollution. Different methods are suggested for the removal of such toxic metal ions from aqueous solution such as ion-exchange, solvent extraction etc. The most useful and economic process is adsorption method. Researchers used different kind of adsorbate material for the removal of metal ions. Some of them are tea leaves, cotton capsule shell, bajra hull, moong shell, bidi leaves, saw dust, paddy husk, etc.

Various researchers used plant materials as adsorbate. Plant materials are used as a cheap and low cost material for adsorption e.g. modified corn starch[1], phosphate treated saw dust[4], water lettuce[5] , Algal material[6], and adsorption of different metal ions[7-8] etc. Adsorption of different metal ions and organic compounds onto solid surfaces has immersed as a promising field of great value and has been extensively studies in the recent past.

Jute having Botanical name *corchorus sp.* with family Tiliaceae is the most important bast fiber and among natural fibers it is only second to cotton. The fiber is obtained from the steam. Jute was used to India since very ancient time but it became important as sackcloth in the late sixteenth century and first shipment of Jute fiber from India to England was made in 1791.

The surface of the fibers is smooth and the fibers appears Polygonal in outline in transections the fibers are stiff, brittle and coarse with low stretchability and elasticity jute fibers contain on an average 63% cellulose, 22 to 26% hemicelluloses, 10 to 12% lignin and small quantities of fats, waxes gums and minerals.

Sunnhemp having family tabiaceae is an important Asiatic plant found through out the India, *Sunnhemp* is a bast fiber obtained from the stem. The ribbon like strands of fibers are very light in colour, lustrous fairly resistant to micro-organisms and moisture with tensile strength. The individual cells of the fiber are cylindrical with surface striation and cross markings. The ends of the cells are irregularly thickened and blanted chemically. The fiber is chiefly composed of cellulose around 80% with relatively thick layer of lignin.

Sunnhemp is essentially a cordage fiber and is thus widely used for ropes, twines, cords, canvas, matting etc.

In the present paper, the results of adsorption of Fe (II) ion on *Jute & Sunnhemp* from its aqueous solution are reported.

MATERIALS AND METHODS

Ferrous ammonium sulphate used as adsorbent was supplied by S.D. Fine Chemicals Ltd. and used without any purification. The aqueous solution of FE (II) was prepared by weighing appropriate quantity of F.A.S.

The plant material of *Jute & Sunnhemp* was collected from local field. It was dried and grinded to fine powder. Batch experiments were carried out, in which solution of Fe (II) ions treated with 1 gram of plant powder and kept for shaking at room temperature for a contact period of one hour. Finally, the solutions were filtered through Whatman filter paper No.42.

The amount of Fe (II) was determined spectrophotometrically using 1, 10-phenanthrolein as a reagent[9]. Effect of contact time, temperature, pH and initial concentration was also determined.

RESULTS AND DISCUSSION

Effect of contact time: It was observed that *Jute & Sunnhemp* can be used as a low cost adsorbate effectively. The maximum time required for adsorption is 40 minutes for 60% adsorption, after which the amount adsorbed remains virtually constant. The removal curve was found to be smooth and continuous indicating the formation of monolayer coverage of adsorbent on the surface of adsorbate.

Effect of pH: The plant *Jute & Sunnhemp* powder proved to be effective adsorbate for the removal of Fe (II) from aqueous solution at pH2. With increase in pH, adsorption decreases. This may be due to decrease in negative charge on the adsorbate as the pH of the solution increases.

Adsorption isotherm: To Study the validity of Freundlich adsorption isotherm, the following equation was used

$$x/m = Kc^{I/n}$$

The linear plot of log x/m vs. log C indicates the applicability of Freundlich adsorption isotherm.

This show a system, which exists with monolayer coverage of the adsorbent on the surface of adsorbate.

To verify Langmuir adsorption isotherm I/C_e is plotted against 1/q. The value of 'b' is calculated graphically, which is used to calculate the equilibrium parameter R_L.

$$R_L = \frac{1}{1 = bco}$$

The range $O<R_L<1$ reflects favorable adsorption.

In the present study, the value of R_L was found to be less 1 (one). The Langmuir adsorption parameters are very useful in predicting adsorption capacities and also for incorporating a mass transfer relationship. The isotherm can be written as

$$\frac{C_e}{Q_e} = \frac{1}{k_L} + \frac{Q_L}{k_L} C_e$$

C_e is the concentration of the adsorbate at equilibrium, Q_e is the amount of metal ions adsorbed per unit weight of the adsorbent, q_L and k_L are Langmuir constants. q_L indicates the intensity of adsorption and $K_L = q_L\ b_L$ where B_L is the adsorption capacity. For present study, we obtained q_L= 0.1732 L/mg and b_L=17.66 mg/g

Thermodynamic Study: The experiments were carried out different temperatures to study the effect of temperature on adsorption. Thermodynamic parameters such as ΔG, ΔH, and ΔS were determined using following equations:

$$Kc = \frac{C_{ad}}{C_e}$$

$$\Delta G = -RT\ 1n\ K_c$$

$$\log K_c = \frac{\Delta S}{2.303R} - \frac{\Delta G}{2.303RT}$$

K_c = Equilibrium constant
C_{ad} = Amount of metal ion adsorbed per liter of the solution at the equilibrium

C_e = Equilibrium concentration (mg/L) of the metal in the solution.
Various effects are given in Figures. 1-5.

Kinetic study of the adsorption process of metal ion adsorption on the surface of *Jute & Sunnhemp* plant has also studied. It was observed that it obeys Lagergen equation.

$$\log (Q_e - Q) = \log Q_e - (Kd/2.303)t$$

Where Q_e and Q are the metal ion adsorbed (mg/g) at equilibrium and at time t.

The plot of log Q_e - Q vs t is a straight line. The value of K_d was calculated from the graph. It was found that K_d decreases with increase in initial concentration of the metal ion. Intraparticle diffusion was also studies by plotting mass of solute adsorbed vs square root of contact time and the plot was linear. From the slope, intraparticle diffusion constant was determined. It is observed that with increase in concentration of metal ion, intraparticle diffusion rate constant also increases. The adsorption rate constant was found to be 7.25 x $10-^{2}$ min. The adsorption capacity of *Jute* is more than *Sunnhemp* this might be because of more percentage of cellulose and fibers in it than *Sunnhemp.*

Table No.1: Adsorption Capacities of *Jute*
(Initial Concentration Co = 4.5 gm/ Ltr.)

Mass of Adsorbent	Equilibrium Concentration Ce gm/Ltr.	Log Ce	X=Co-Ce	$y = \frac{(Co-C)V}{M}$	$fr = \frac{Co-C}{Co}$	X/ M	Log X/M	Ce/X/M
250 mg	4.1	0.2570	0.4	80	0.088	1.6	0.1445	2.81
300 mg	3.9	0.2455	0.6	100	0.1333	2.0	0.1585	2.25
400 mg	3.7	0.2344	0.8	100	0.1333	2.0	0.1585	2.25
500 mg	3.2	0.2089	1.3	130	0.288	2.6	0.1820	1.7306
600 mg	2.8	0.1905	1.7	141	0.3777	2.8	0.1905	1.6071

Table No. 2: Effect of Contact Time

Time (min.)	$\sqrt{t}$	Ce	q=Co-Ce	qe-q	Log qe-q
5	2.2	4.1	0.4	3.7	0.2344
10	3.1	3.9	0.6	3.3	0.2138
15	3.8	3.7	0.6	2.9	0.1950
20	4.4	3.2	1.3	3.2	0.2089
25	5.0	2.8	1.7	1.1	0.1288

Table No. 3: Thermodynamic Parameters

Temp. (K)	1/T x 10^{-3}	Kc	Log Kc	□ G (J/ Mole)
303	3.30	0.9111	-0.9595	-5566.61
308	3.24	0.8666	-0.9370	-5525.78
313	3.19	0.8222	-0.9149	-5483.04
318	3.14	0.7111	-0.8519	-5187.04
323	3.09	0.6222	0.7938	-4833.28

Table 4. Variation of pH

pH	Equilibrium concentration (Ce g/ltr)	Amount adsorbed (Q)
1	**3.9**	0.6
2	**3.7**	0.6
3	**3.2**	1.3
4	**2.8**	1.7

Sunnhemp :

Table No.1: Adsorption Capacities Of *Sunnhelp*

(Initial Concentration Co = 4.3 gm/ Ltr.)

Mass of Adsorbent	Equilibrium Concentration Ce gm/Ltr.	Log Ce	X=Co-Ce	$y=\frac{(Co-C)V}{M}$	$fr=\frac{Co-C}{Co}$	X/M	Log X/M	Ce/X/M
250 mg	**3.9**	**0.2455**	**0.4**	**80**	**0.0930**	**1.6**	**0.2041**	**2.437**
300 mg	**3.6**	**0.2291**	**0.7**	**116**	**0.1629**	**2.33**	**0.1710**	**1.5450**
400 mg	**3..1**	**0.2042**	**1.2**	**150**	**0.2790**	**3.0**	**0.1995**	**1.0333**
500 mg	**2.8**	**0.1905**	**1.5**	**150**	**0.3480**	**3.0**	**0.1995**	**0.033**
600 mg	**2.2**	**0.1660**	**2.1**	**175**	**0.4883**	**3.5**	**0.2239**	**0.628**

Table No. 2: Effect of Contact Time

Time (min.)	$\sqrt{t}$	Ce	q=Co-Ce	qe-q	Log qe-q
5	2.2	3.9	0.4	3.5	0.2239
10	3.1	3.6	0.7	2.9	0.1950
15	3.8	3.1	1.2	1.9	0.1549
20	4.4	2.8	1.5	1.3	0.1349
25	5.0	2.2	2.1	0.1	0.1023

Table No. 3: Thermodynamic Parameters

Temp. (K)	1/T x 10^{-3}	Kc	Log Kc	□ G (J/ Mole)
303	3.30	0.9069	-0.9571	-5552.69
308	3.24	0.8372	-0.9229	-5434.36
313	3.19	0.7209	-0.8573	-5137.84
318	3.14	0.6511	-0.8136	-4953.84
323	3.09	0.5116	-0.7084	-4313.29

Table 4. Variation of pH

pH	Equilibrium concentration (Ce g/ltr)	Amount adsorbed (Q)
1	3.6	0.7
2	3.1	1.2
3	2.8	1.5
4	2.2	2.1

Fig. 1
Langmiur adsorption isotherm

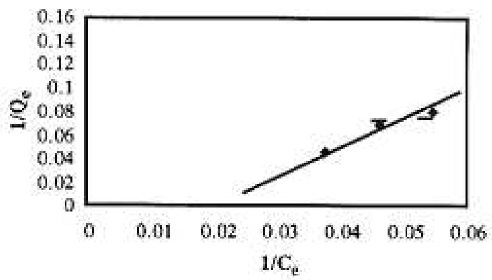


Fig. 2
Effect of temperature

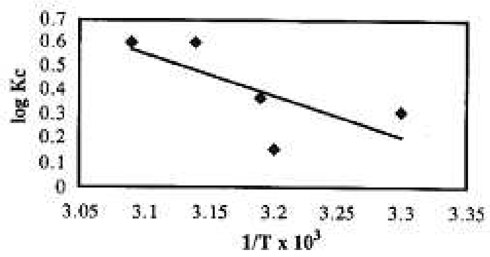


Fig. 3

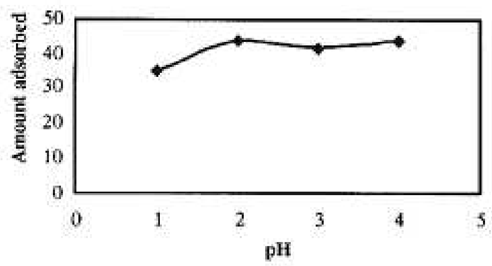


Fig. 4
Lagergen plot

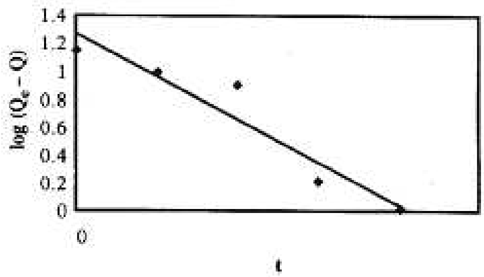
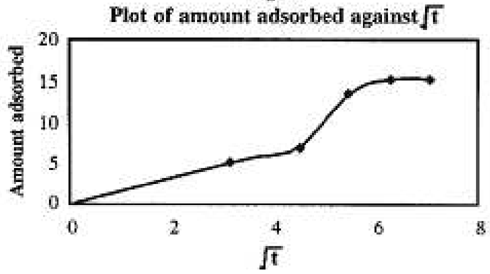


Fig. 5
Plot of amount adsorbed against $\sqrt{t}$



REFERENCES

[1] S.P. Dam, S.S. Dara, *Journal of IPHE* , 4, 47-54, **1983**.
[2] D.B. Bankar, S.S. Dara, of *Chemi Era* XVIII, 10, 251-254, **1982**
[3] D.S. Day, J.K. Basu, *Ind. J. Env prot* 19, 6, 416-421, **1999**
[4] Bilquees Ara Siddiqui, P.P. Sharma, Mohd. Sultan, Ind. J. Env. Prot. 9,11, 846-852, 1999
[5] Selvapati, J. Juliet Jesline and S.Prabha. *J. Env prot*. 18, 16. 1-6. **1998**
[6] Sayyed Hussain at, el *Asian J Chem*,. 22, (7), 5261-5264. **2010**
[7] Mortaheb H.R., Kosuge H. Mokhtarani B. Amiini M.H. and Banihashemi H.R., *J Hazard Mat*, 165 (1-3) , 630- 636, **2009**
[8] Qiu W. and Zheng Y. , *Chem Eng J*, 145 (3), 483-485, **2009**.
[9] Day & Underwood, Quantitative Analysis VI Ed$^{n.}$, Prentice Hall India, **1993**