Bagasse as a Potential Adsorbent of Cadmium Removal from Aqueous Solutions

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Abstract - The main parameters influencing cadmium metal adsorption on bagasse were: initial metal ion concentration, amount of adsorbent, temperature and pH of solution was studied. The maximum percent metal removal was after about 3 hrs. Batch experiments results showed that the adsorptive capacity of bagasse 17.73 mg/g was observed at pH 4. The Langmuir Isotherm and Freundlich Isotherm model were used to then adsorption equilibrium of cadmium on bagasse. The both isotherms constants for adsorption of Cadmium on bagasse were determined and the goodness of fitness was obtained with Langmuir and Freundlich adsorption isotherms from the equilibrium adsorption data. The adsorbent can be effectively regenerated using 0.1N strong acid and reused.

Keywords: Heavy metals, Cadmium Removal, Bagasse, Adsorption Isotherms.

I. INTRODUCTION

Heavy metal pollution occurs in many industrial wastewaters such as those produced by metal plating facilities, mining operations, battery manufacturing processes, the production of paints and pigments, and the glass production industry. This wastewater commonly includes Cu, Ni, Cr, Cd, and Pb. These heavy metals are not biodegradable and their presence in streams and lakes leads to bioaccumulation in living organisms, causing health problems in animals, plants, and human beings. Excessive human intake of Cu leads to severe mucosal irritation and corrosion, widespread capillary damage, hepatic and renal damage, and central nervous system irritation followed by depression [1]. Heavy metals at elevated concentrations, determinial to human health and ecosystem stability, and threshold values have been set for these metals for waste water discharged into environment. In order to reduce pollution, contaminated water need to be cleaned [2]. Therefore, these wastewaters are to be treated using low cost methods. Many conventional methods like Ion Exchange, electrolysis, membrane filtration, Chemical precipitation etc, for removing of metal ions from industrial effluents suffer with high capital and regeneration costs of the materials. Therefore, these are not suitable for the small scale industries [4]. Compared with conventional methods for the removal of toxic metals from waste water by using low cost adsorbents more advantages such as low operating cost, minimization of chemical sludge, high efficiency of heavy metal removal from diluted solutions, regeneration of adsorbents, possibility of metal recovery and environmental friendly[5].

II. MATERIALS AND METHODS

All the chemicals used in this study were of analytical grade and were proceed from Sd. Fine Chem. Ltd.

The adsorbent was selected for removal of Cadmium by bagasse. The adsorbent were grounded and wasted with deionised water. The adsorbents were dried at room temperature (32 ±10C) till a constant weight of the adsorbents was achieved. Adsorption is an effective and versatile method for removing metals(Cadmium).

A. Adsorbent Preparation:

The adsorbent is washed and dried at room temperature to avoid the release of color by adsorbent into the aqueous solution. The activation of adsorbents is carried out by treating it with concentrated sulphuric acid (0.1N) and is kept in an oven maintained at a temperature range of 1500C for 24hr. Again it is washed with distilled water to remove the free acid.

B. Cadmium Solution Preparation:

Aqueous solutions of cadmium s were prepared by dissolving a weighed quantity of cadmium chloride monohydrate in deionzed distilled water. Before the adsorption study, the pH of the Cadmium solution was adjusted to required value with 0.1N $H_2S0_4$and 0.1 N NaOH Solutions using pH meter (ELICO, LI 613).

C. Batch adsorption Studies:

The batch experiments are carried out in 250ml borosil conical flasks by shaking a pre-weighed amount of the saw dust with 100ml of the aqueous cadmium solutions of known concentration and pH value. The metal solutions were agitated in a rotary shaker at 120 rpm for a desired time. The samples were withdrawn from the shaken at the predetermined time intervals and adsorbent was separated by filtration. Cadmium concentration in the filtrate was estimated using AAS. The experiments were carried out by varying the cadmium concentration in the solution (50mg/L-500mg/L), at pH 6. The adsorbent dosage 0.2-1gr/100ml for contact time is 6hrs, with initial metal concentration of 100mg/L at room temperature 30 ±2^{0}C and solution pH 6.

The samples were collected at different time intervals 15 min to 150 min and the adsorbent was separated by filtered using filter paper.

$$\% \text{ removal of copper} = (C_{int} - C_{fin}) \times 100 / C_{int} \qquad (1)$$

Where C_{int} and C_{fin} are the initial and final cadmium concentrations, respectively.

III. RESULT AND DISCUSTIONS

A. Effect of contact time:

The contact time was evaluated as one of the important parameter for the adsorption of cadmium on adsorbent. Fig 1 shows the percentage removal of cadmium for different initial concentration ranging from 50 mg/l to 500 mg/l at pH 6. It was observed that, while increasing the cadmium concentration from 50 mg/l to 500 mg/l. The percentage removal increases with rise in contact time up to 90 min after then it is almost constant**.**

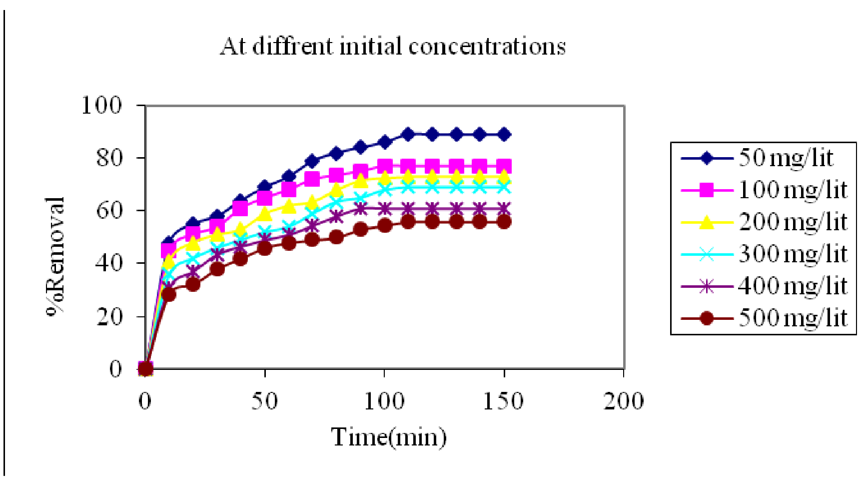

Figure 1: Effect of contact time on cadmium removal by using bagasse at different initial concentrations

B. Effect of Initial concentration:

The Initial metal concentration in the aqueous solution has a bearing on the removal efficiency. Hence, same aqueous solutions with different initial metal concentrations (50 -500 mg/l) were agitated with a fixed dosage of bagasse (2 g/lit) at every 10 min interval the residual cadmium concentration was measured by using atomic adsorption spectrophotometer and tabulated. The Percentage removal of cadmium decreases from 89 to 56% after completion of 2 hrs contact time and adsorption capacity increases from 2.175 to 14 mg/g.

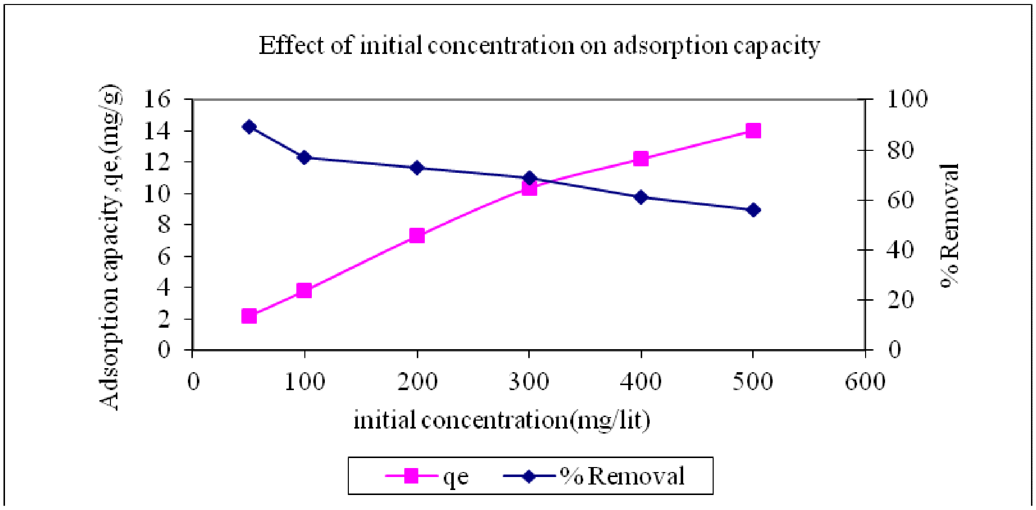

Figure 2: Effect of initial concentration on cadmium removal by using bagasse at different initial concentrations

C. Effect of pH: Adsorption of heavy metal ions depend on the pH of solution. As the pH of the cadmium solution observed from 2 to 10, the removal percentage of cadmium increased up to pH 4 and then decline rather rapidly with further increase in pH [Fig.3]. According to Namasivayam and Ranganathan[6] , precipitation of cadmium starts at pH 8.2. Therefore, in this study the effect of pH on cadmium adsorption was performed at pH range 2-10. At low pH, cadmium ions had to compete with H^+ ions for adsorption sites on the adsorbent surface. As the pH increased, this competition weakens and more cadmium ions were able to replace H^+ bound to the adsorbent surface. Similar findings were reported by Taty-Costodes *et al.[7]*. Therefore, all further studies were carried out at pH 4.

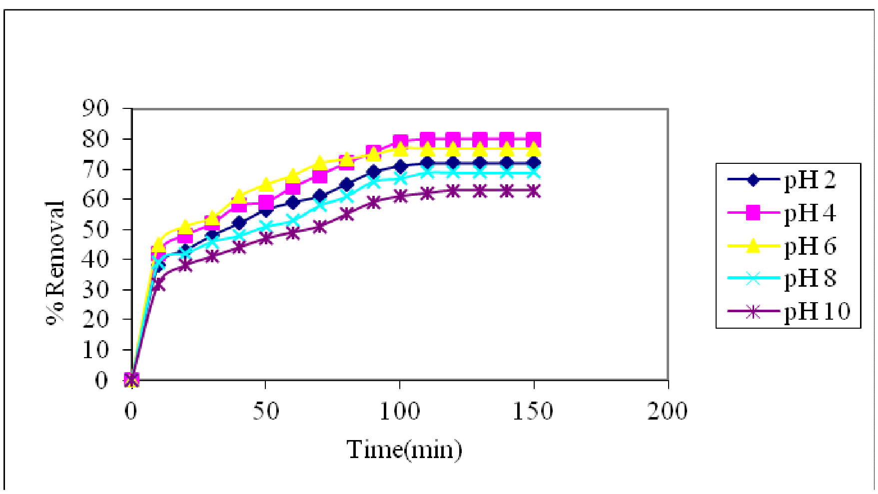

Figure 3: Effect of pH on cadmium removal by using bagasse

D. Effect of Adsorbent dose:

Removal of Cadmium increases with increase of adsorbent dosage. The percentage removal increases from 77% to 98% by increasing the adsorbent dosage from 2 – 10 gm/l. (Fig.4), for a constant initial concentration of 200 mg/L in the solution. The increase in cadmium removal percentage with increasing adsorbent amount is due to the increasing surface area and available sites for adsorption. However, the adsorption capacity decreases from by increasing the adsorbent amount from 2 to 10 grams /lit (Fig.5).

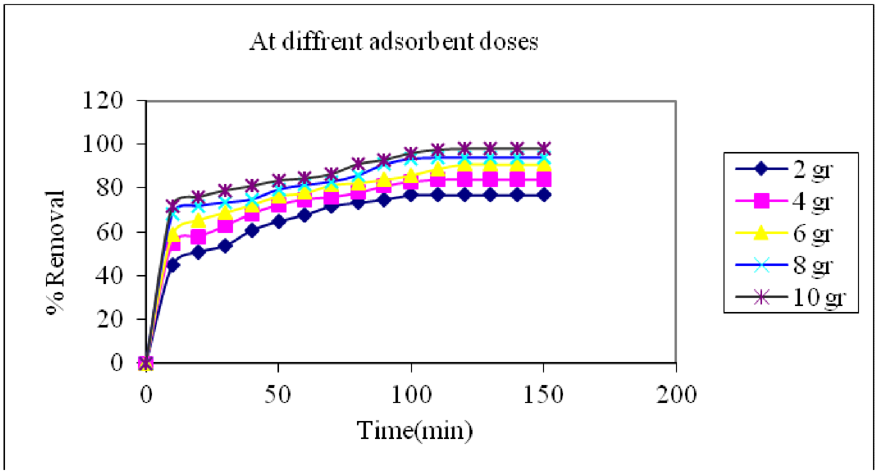

Figure.4.Effect Adsorbent dose on cadmium removal by using bagasse at different adsorbent doses

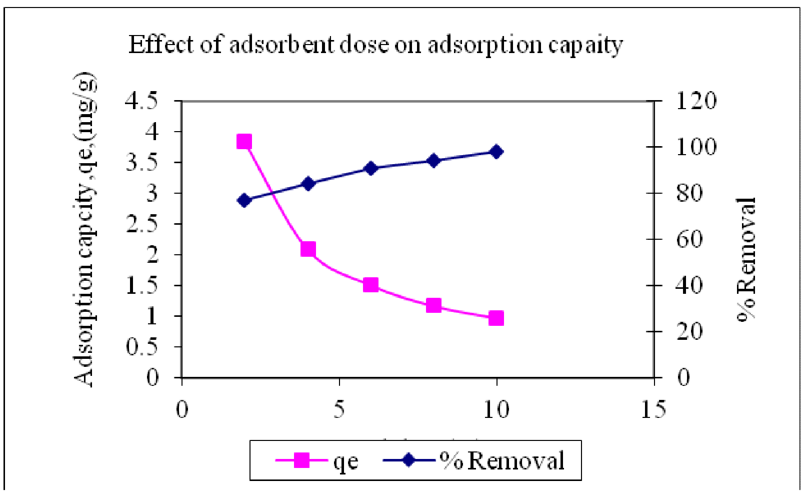

Figure 5. Effect of Adsorbent dose on cadmium removal by using bagasse

E.Effect of Temperature: The effects of temperature variation on the adsorption of cadmium from aqueous solution were shown in Fig.6. Adsorption studies were conducted at 30, 40, and 50^{0}C to determine the influence of temperature on the adsorption of cadmium on to bagasse. The extent of percentage removal for cadmium increases along with an increase of temperature from 77 to 91 %. In fact, when the temperature increased from 30 to 50^{0}C, an increase of adsorption was indicating the adsorption process to be endothermic nature[4].

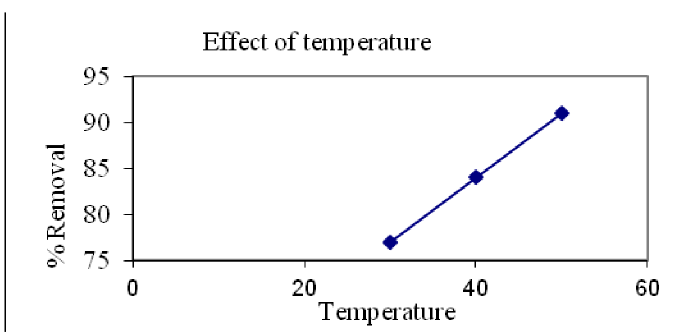

Figure 6: Effect of Temperature on cadmium removal by using bagasse

F. Scanning electron microscopy (SEM):

SEM micrographs of the material showed a surface porosity, as can be verified by the images of Fig.7 These micrographs irregular and porous surfaces could be observed. Based on this fact, it was concluded that the material presented an adequate morphology for metal adsorption. The SEM images were obtained and found that the treated bagasse was showing that the surface of the adsorbent is more clear with openings of the pores.

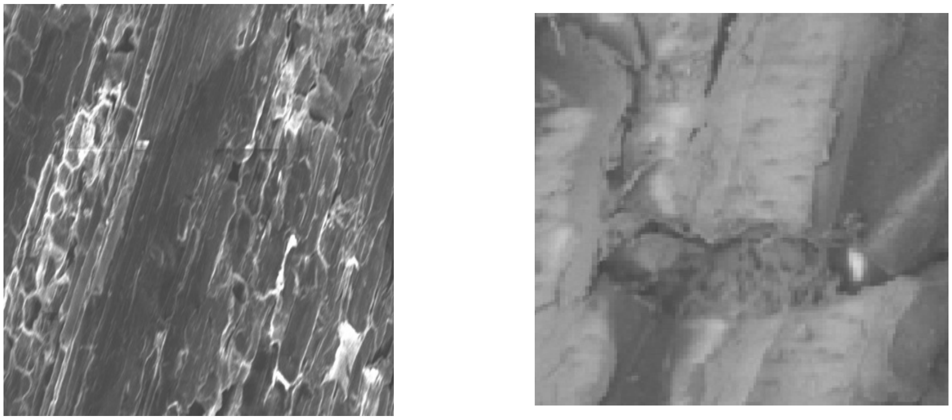

Figure 7: SEM images of Bagasse before and after treatment

G.Adsorption Isotherm Models:

Figures 8 and 9 show the Freundlich and Langmuir isotherms at equilibrium data of bagasse prepared from sugar cane in removing cadmium from aqueous solutions. The isotherm data given in table 1.The isotherms are in conformity with Freundlich isotherm.

H. Langmuir Adsorption Isotherm Model:

The Langmuir adsorption isotherm plot between Ce/q_e verses Ce, From Fig.8 shows the Langmuir constant $q_{m,}$ which is a measure of the monolayer adsorption capacity of bagasse is obtained 17.73 mg/gr. The Langmuir constant b, is found to be 0.0158.. The dimensionless parameter R_L, which is a measure of adsorption favorability is found to be 0.288($0< R_L<1$) which confirms the favorable adsorption process for removal of cadmium by saw dust. R_L, also known as the separation factor[8], given by

$$R_L = 1/(1+bC_0) \qquad (2)$$

Langmuir equation is

$$Ce/q_e = 1/(bq_m) + (1/q_m)\, Ce \qquad (3)$$

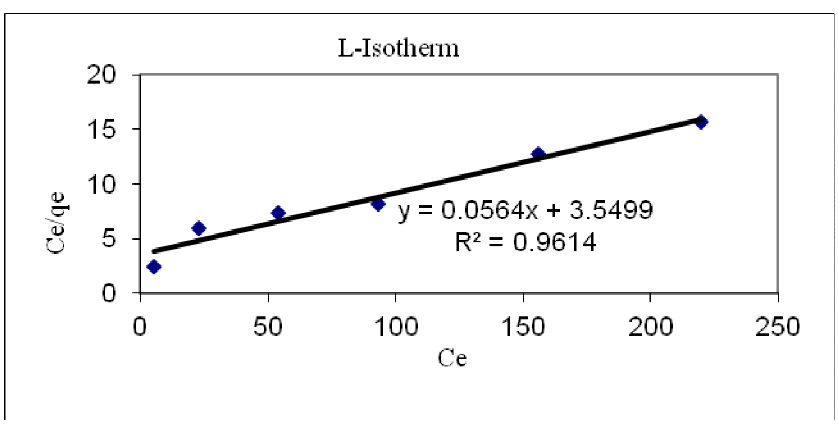

Figure 8: Langmuir isotherm for adsorption of cadmium

I. Freundlich Adsorption Isotherm Model:

Freundlich isotherm is analyzed based on adsorption Cadmium by using the same equilibrium data of Bagasse. Freundlich constants, K_f and n are obtained by plotting the graph between log q_e versus log Ce (Fig.9). The values of K_f and n are 0.863 and 1.87 respectively. It is found that the regression correlation coefficient obtained from Freundlich isotherm model for this adsorbent is 0.9814.

$$\ln q_e = \ln K_f + (1/n) \ln Ce \quad (4)$$

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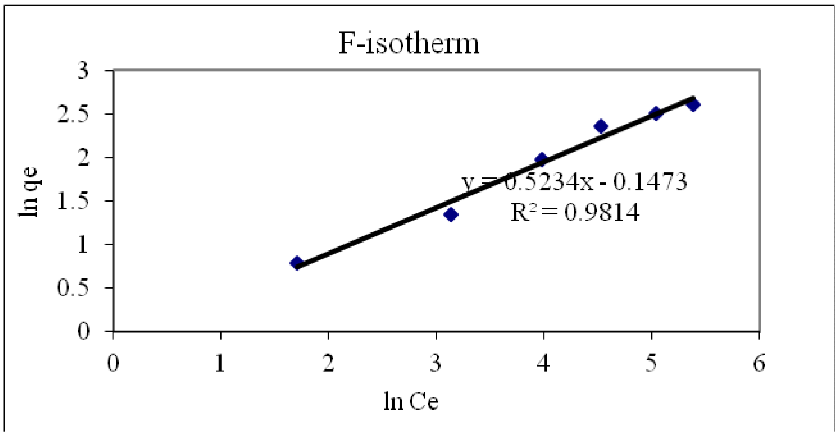

Figure 9: Freundlich isotherm for adsorption of cadmium

Table 1:

Adsorbent	% Removal	pH	L-Constants				F- Constants			
			Q	b	R_l	R^2	1/n	n	k	R^2
Saw dust	98	4	17.73	0.0158	0.38	0.9614	0.534	1.87	0.863	0.9814

IV.CONCLUSIONS

This study indicates that bagasse has rapid adsorption rate and good adsorption capacity for cadmium In this review, a wide range of agricultural waste materials, as low-cost adsorbent has been presented. The use of these low-cost adsorbents is recommended since they are relatively cheap or of no cost, easily available, renewable and show highly affinity for heavy metal removal. The process of adsorption requires further investigation in the direction of modeling, regeneration of adsorbent for enhanced efficiency and recovery. Further more interest should be concentrated by the researchers to predict the performance of the adsorption process for cadmium removal from real industrial effluents. The cadmium adsorption was found to be dependent on agitation time, pH and contact time, Temperature. The adsorption of cadmium was found to be fitted the Langmuir isotherm model, which suggests monolayer coverage of adsorbent surface. This work showed that bagasse could be used as a good adsorbent material for cadmium removal from dilute aqueous solution.

The results obtained were similar to or better than those already reported in the literature. Taking into account of bagasse is readily obtained from sugar industries and it is considered a waste product. This material is a low cost and environmentally friendly alternative material. In this way, its use should be seriously considered for this task.

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