ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

An Assessment of Efficiency of Non-conventional Adsorbents in Removal of Iron (II): A Study Done With Sugarcane Bagasse.

Sandhya Thatavarthy[1]*, and Anima Dadhich[2].

[1]Department of Chemistry, Gayatri Vidya Parishad College for Degree and PG Courses (A), Visakhapatnam, Andhra Pradesh, India.
[2]Department of Chemistry, GITAM University, Visakhapatnam, Andhra Pradesh, India.

ABSTRACT

An attempt has been made in the present study the adsorption potential of raw sugarcane bagasse, a solid waste, for the removal of iron (II) in a lab scale batch adsorption study. The effect of various parameters such as optimum pH, optimum time, optimum dose and optimum concentration on adsorption efficiency were studied. Iron (II) removal efficiency was found to be 80 to 87% in the range of 30 mg/L to 50mg/L of iron (II) concentration at pH 3 in 10 minutes contact time. An adsorbent dose of 9g/100ml was used for the removal of iron (II) from synthetic wastewater. Freundlich isotherm and Langmuir isotherm were applied to the above study.

Keywords: Adsorption, Fe (II), Sugarcane bagasse, Batch experiments.

**Corresponding author*

ISSN: 0975-8585

INTRODUCTION

The toxicity due to the presence of alarming concentrations of heavy metals that include Copper, Silver, Zinc, Cadmium, Gold, Mercury, Lead, Chromium, Iron, Nickel, Tin, Arsenic, Selenium, Molybdenum, Cobalt, Manganese, and Aluminum [1] has become a threat to the aquatic environment due to growing industrialization. These metals are non-biodegradable and tend to accumulate in the food chain posing the risk of health disorders [2]. It is a fact that some heavy metals that are essential component in metabolism are toxic when they present at high concentrations [3]. Iron is a vital metal for human but its presence in water at a concentration higher than the standard concentration (0.3 mg/l [4]) leads to many health problems such as diabetes, heart failure, and poor growth [5][6][7]. Iron is one of the substances that are common in effluents of many industries [8]. There are conventional methods to remove heavy metals from the contaminated water such as filtration, ion exchange, precipitation etc, [9] that are not economically feasible for small and medium scale industries. Hence, adsorption process using agricultural waste products is becoming a new alternative for wastewater treatment [10]. The major advantages of this technology over conventional ones include not only its low cost, but also its high efficiency, the minimization of chemical or biological sludges, the ability to regenerate biosorbents, and the possibility of metal recovery following adsorption [11]. A number of low cost agricultural wastes that are used as adsorbents for remediation of heavy metals from waste water, include banana peel, coconut shell, orange peel, rice husk, pecan shells, jackfruit, maize cob, sawdust, sugarcane bagasse, peanut hull, apple waste [12-18].

The aim of the present study is to assess the adsorption behaviour of sugarcane bagasse, a non-conventional adsorbent, in the removal of Fe (II) from the synthetic solution. In India the ramified sugar industry and sugarcane growing and using sugarcane bagasse appears to be cost effective. Sugarcane bagasse is the name given to the residual cane pulp remaining after sugar has been extracted. It is chiefly composed of cellulose 32 to 48%, hemicellulose 19 to 24% and lignin 23 to 32 % [19]. In this study, the effect of various parameters such as optimum pH of the aqueous solution, optimum contact time of biosorbent and aqueous solution, optimum dose and optimum metal ion concentration has been investigated. The adsorption isotherms namely Langmuir and Freundlich are deduced from biosorption measurements.

MATERIALS AND METHODS

Preparation of the adsorbent using sugarcane bagasse

Sugarcane bagasse was collected from the Chodavaram Co-operative Sugars Limited, Govada, Visakhapatnam district, Andhra Pradesh, India. It was then washed with tap water to remove impurities and then and sun dried. Finally, the dried bagasse was sieved to get the average adsorbent size of 1mm. The sieved sugarcane bagasse was then stored in a clean airtight plastic container.

Preparation of stock solution

All Analytical grade reagents were used. A stock solution of 1000mg/l of Fe (II) was prepared and standardized. Desired concentration of working solution was prepared by dilution the stock solution with double distilled water.

Batch experiments

The adsorption of iron on sugarcane bagasse was studied by batch experiments. A known volume of Fe (II) solutions with different initial concentrations was taken in a 250-mL conical flask at a particular pH (pH of the solution was adjusted using 0.1 N H_2SO_4 and 0. 1 N NH_3 solution) and agitated in a mechanical shaker at 150 rpm with a known dose of adsorbent for a specified contact time. After equilibration, samples were filtered using Whatman 42 filter paper and the concentration of iron was determined by treating with 1, 10 – Phenanthroline and measured the absorbance at 510nm using a UV – Visible spectrophotometer (Systronics, Model No.117).

RESULTS AND DISCUSSION

Effect of pH

Metal adsorption is associated with pH. The effect of pH on the adsorption of Fe (II) using sugarcane bagasse as an adsorbent was studied in the initial range of 1 to 3 (Fig.1). From the result it is clear that maximum adsorption of Fe^{2+} was observed at pH3.The effect of pH was not investigated beyond pH3 as the precipitation of Fe (II) as its hydroxide appeared. At low pH, Fe^{2+} ions had to compete with H^+ ions for adsorption sites on the adsorbent surface. As the pH increased, this competition weakens and more Fe^{2+} ions were able to replace H^+ ions bound to the adsorbent surface.

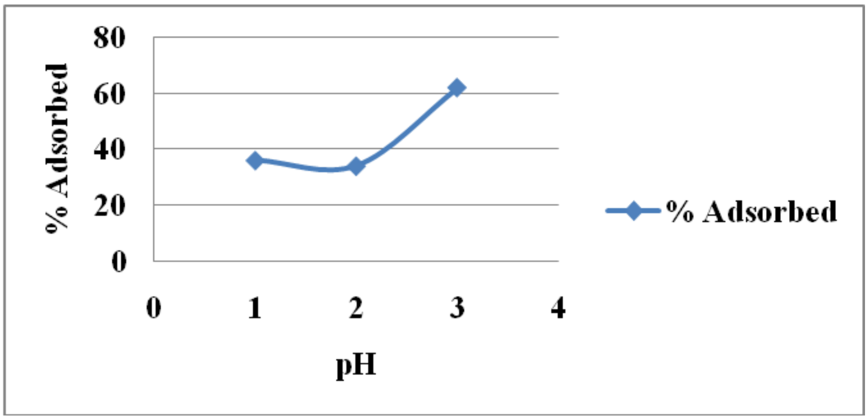

Figure 1: Effect of pH for iron (II) adsorption by raw sugarcane bagasse.
pH3, concentration = 50mg/L, Time= 10mts, dose = 1g/100ml

Effect of contact time

Contact time is one of the most important features in the batch experiments. The effect of time on the adsorption of Fe (II) using sugarcane bagasse as an adsorbent is studied in the initial range of 1 minute to 1 hour (Fig.2). It has been observed that maximum Fe (II) removal could be achieved at 10minutes.

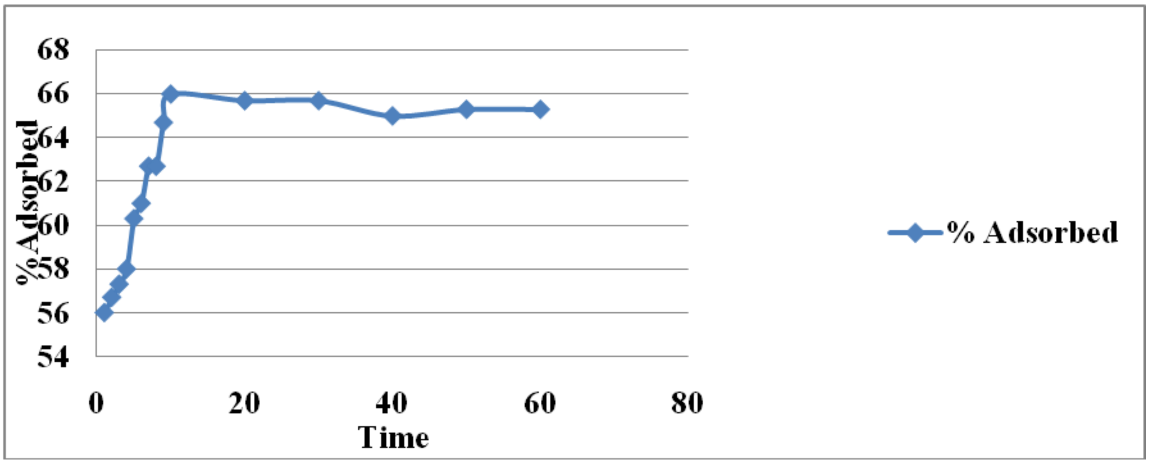

Figure 2: Effect of contact time for iron(II) adsorption by raw sugarcane bagasse
pH3, concentration = 50mg/l, dose 1g/100ml

Effect of dose

The effect of adsorbent dosage is one of the parameters that strongly affect the adsorption capacity. The percentage adsorption of Fe (II) was studied by increasing the adsorbent dose from 1g to 9g for 100ml of

ISSN: 0975-8585

Fe (II) solution at a concentration of 50mg/L (Fig.3). It can be observed that at a given concentration of Fe(II), the amount of removed Fe(II) ions increases with the increase of the adsorbent dose. The increase in percentage removal of Fe(II) with increasing the adsorbent dose is probably due to the fact that the adsorbent sited remain unsaturated during the adsorption reaction whereas the number of sites available for adsorption site increases by increasing the adsorbent dose.

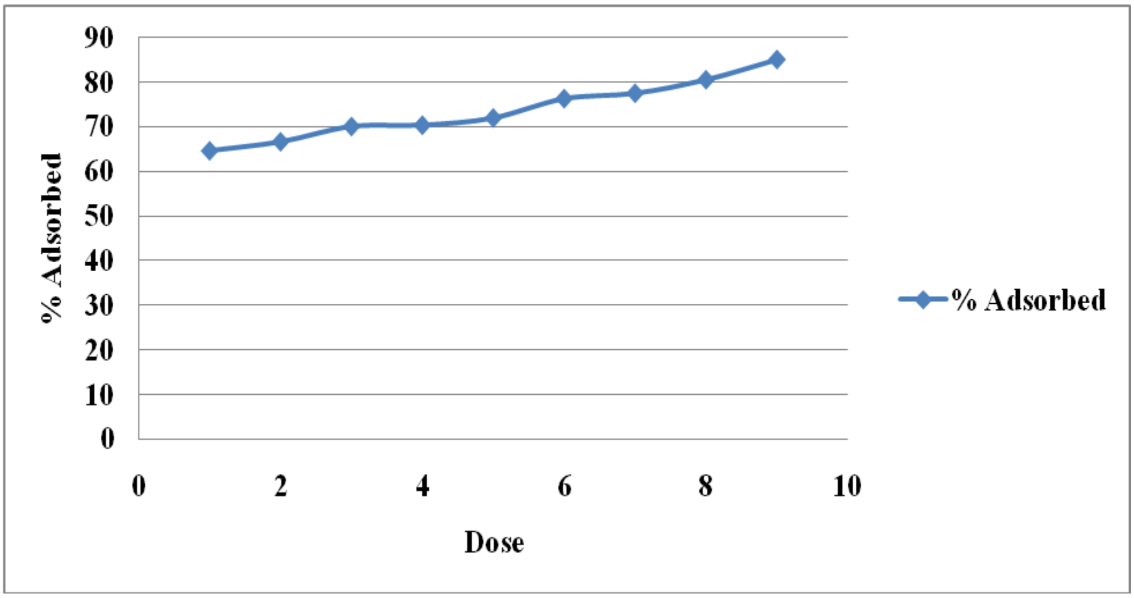

Figure 3: Effect of dose for iron(II) adsorption by raw sugarcane bagasse
pH3, concentration = 50mg/l, Time= 10mts

Effect of concentration

The metal uptake mechanism was particularly dependent on the initial Fe(II) concentration. The effect of concentration on Fe (II) adsorption by raw sugarcane bagasse was studied by varying the Fe (II) concentration from 10 to 500 mg/l (Fig.4). It was shown that in the range of 30mg/L to 50mg/L concentration, maximum adsorption of Fe (II) was observed. However, with increasing initial concentration, the amount of metal removal decreases. At low concentrations, Fe (II) was adsorbed to specific sites, while with the increase of Fe (II) concentration, the specific sites are saturated and the exchange sites are occupied.

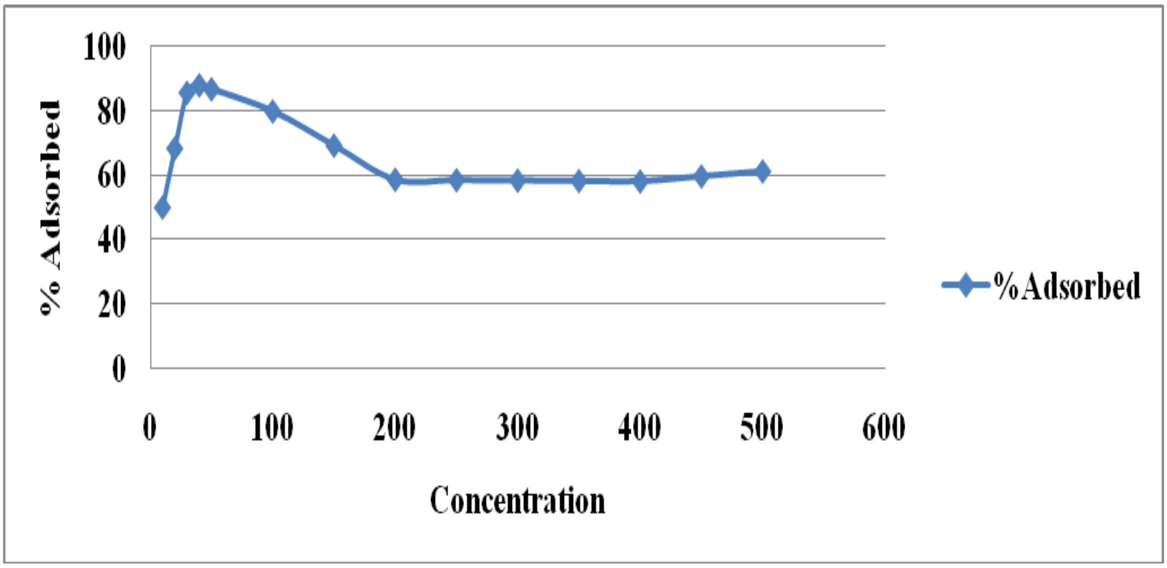

Figure 4: Effect of concentration for iron (II) adsorption by raw sugarcane bagasse
pH3, Time= 10mts, dose = 9g/100ml

Adsorption isotherms

To find out whether the present data fits into Langmuir isotherm[20] and Freundlich adsorption isotherm[21], the adsorption processes of iron (II) was studied by varying the concentration from 40 to 500 mg/L at a dosage of 9g/100ml and for a contact time of 10 minutes at pH 3 (Table 1). Langmuir and Freundlich equations are given in equation (1) and (2), respectively.

$$C_e/q_e = 1/q_m K_L + C_e/q_m \quad (1)$$
$$\log q_e = \log K_F + 1/n \log C_e \quad (2)$$

In both the cases, a satisfactory linear plot was obtained indicating the general validity of the data (fig: 5 and 6).Langmuir and Freundlich constants and correlation coefficients, R^2 derived from these plots are tabulated in Table 2 and 3. A Langmuir adsorption parameter R_L, a dimensionless equilibrium parameter also known as separating factor between 0 to 1 indicate favorable adsorption. (Table 2).The n value in Freundlich equation is greater than 1 indicates the physical adsorption of Fe(II) ions onto sugarcane bagasse (Table 3).

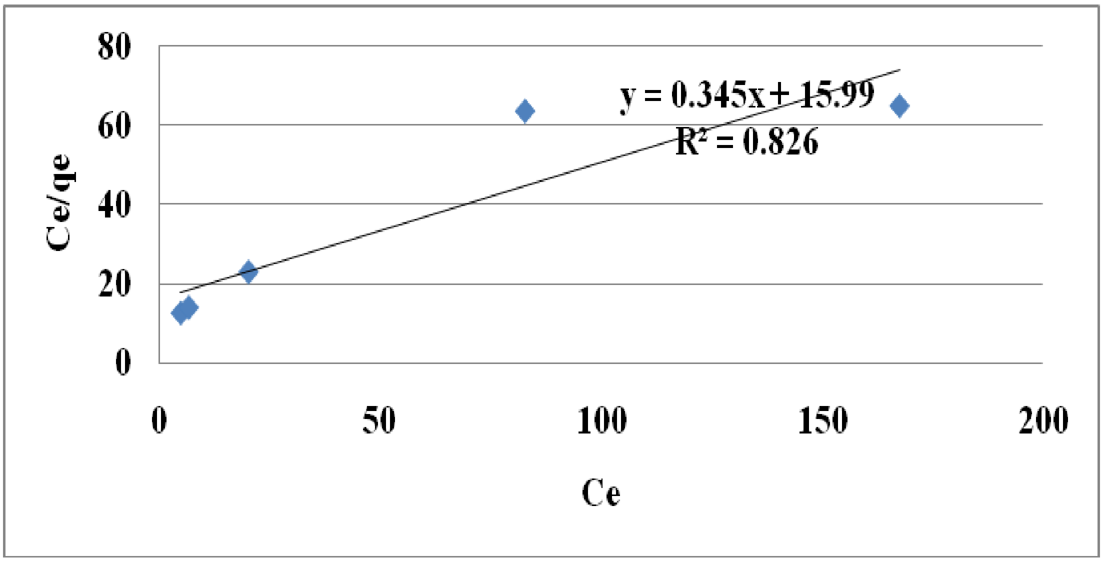

Figure 5: Langmuir adsorption isotherm for iron(II) adsorption by raw sugarcane biogases

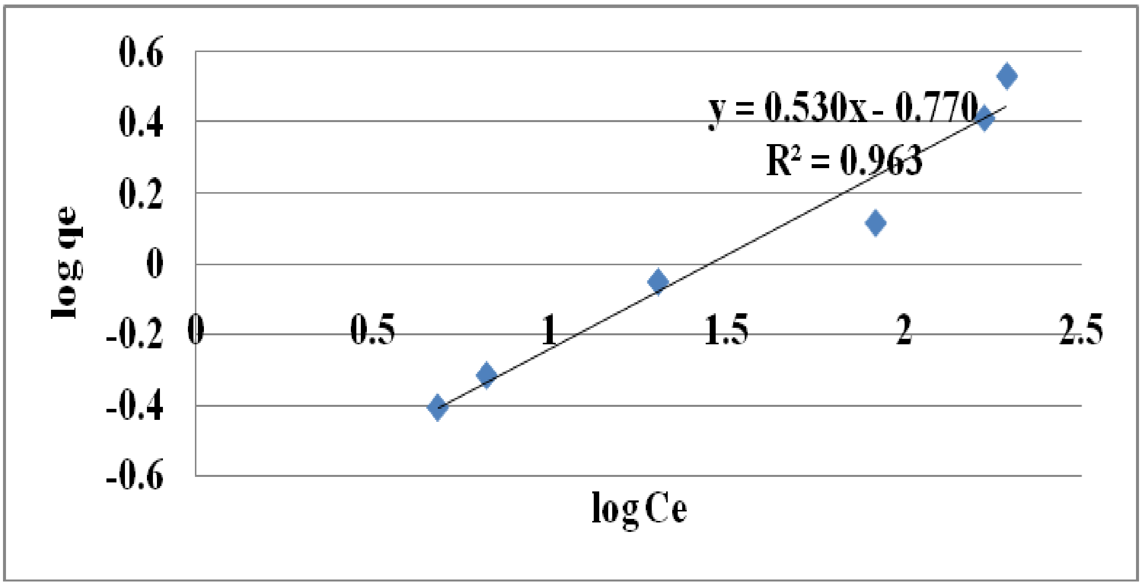

Figure 6: Freundlich adsorption isotherm for iron (II) adsorption by raw sugarcane bagasse

Table 1: Adsorption isotherm for the adsorption of Fe (II) on sugarcane bagasse
Time: 10 mins, pH 3 Dose: 9g/100ml

Concentration mg/L	%Adsorbed	Adsorbed concentration mg/L	Ce mg/L	qe mg/g	Ce/qe	log Ce	log qe
40	87.9	35.16	4.84	0.3907	12.388	0.6848	-0.4082
50	86.7	43.35	6.65	0.4817	13.8053	0.8228	-0.3172
100	79.8	79.8	20.2	0.8867	22.781	1.3054	-0.0522
200	58.6	117.2	82.8	1.3022	63.5847	1.918	0.1147
400	58.1	232.4	167.6	2.5822	64.9059	2.2243	0.412
500	61.2	306	194	3.4	57.0588	2.2878	0.5315

Table 2: Langmuir constant for the adsorption of Fe(II) on sugarcane bagasse

qm (mg/g)	KL(1/mg)	R2	R_L
2.8986	**0.0216**	**0.826**	**0.1927 to 0.9054**

Table 3: Freundlich constant for the adsorption of Fe (II) on sugarcane bagasse

Kf	n	R2
0.1698	**1.8868**	**0.963**

CONCLUSION

The percentage removal of Fe(II) ions depends on pH, contact time, dose and initial concentration. At 10 minutes contact time and initial Fe (II) concentration in the range of 40 to 50mg/L was found to be 80 to 87% at pH 3 and a dose of 9g/100ml. The removal efficiency was decreased when Fe(II) concentration was increased beyond 50 mg/L. The experimental data for the adsorption process fitted well to Langmuir adsorption model (R^2 = 0.826) and Freundlich adsorption isotherm model (R^2 = 0.963). The Langmuir adsorption capacity was determined as 2.8986 mg/g for Fe(II) adsorption. A dimensionless parameter, RL value in the present study was found to be 0.1927 to 0.9054, indicating favorable Langmuir adsorption. The n value in Freundlich equation was found to be 1.8868 indicating the physical adsorption of Fe(II) onto sugarcane bagasse. The investigation reflects the potentiality of the inexpensive solid waste, sugarcane bagasse, in remediation of pollutants.

REFERENCES

[1] Sonali R Dhokpande, Jayant P Kaware. Int J Eng Sci Innovat Technol 2013;2:304 – 309.
[2] Bailey ES, Olin JT, Bricka RM, Adrian D. Wat Res 1999;33(11):2469-2479.
[3] Gazso L.G. Central Eur J Occup Environ Med 2001;7:178 – 185.
[4] USEPA or United State Environmental Protection Agency. Technical Document: Acid Mine Drainage Prediction. 2012, 18 pages.
[5] Das B, Hazarika P, Saikia G, Kalita H, Goswami DC, Das HB, Dube SN, Dutta RK. J Hazard Mater 2007, 141, 834–841.
[6] Songyan Q, Fang M, PengH, Jixian Y. Desalin 2009;245:183–193.
[7] Tekerlekopoulou AG, Vayenas DVA. Desalin 2007;210:225–235.
[8] Masoud Rohani Moghadam, Navid Nasirizadeh, Zienab Dashti, Esmaeil Babanezhad. Int J Industr Chem 2013;4(19):1-6.
[9] Rich G, Cherry K. Hazardous waste Treatment Technologies 1987, 169.
[10] Ibrahim SC, Hanafiah MAKM, Yahya MZA. American- Eurasian J Agric Environ Sci 2006;1(3):179 – 184.
[11] Volesky B. Water Res 2007; 41:4017-4029.
[12] SD Castro Renata, Laercio Caetano and Guilherme Ferreira. Ind Eng Chem Res 2011;50:3446–3451.
[13] E Bernard, A Jimoh, and JO Odigure. Research Journal of Chemical Sciences 2013;3(8):3-9.
[14] M Ajmal, RA Rao, R Ahmad and J Ahmad. J Hazard Mater 2000;79:117–131.
[15] D Sud, G Mahajan and MP Kaur. Bioresour Technol 2008;99:6017.
[16] LVA Gurgel and LF Gil. Water Res 2009;43:4479.

[17] PD Johnson, MA Watson, J Brown and IA Jefcoat. Waste Manage 2002;22:471-480.
[18] E Maranon and H Sastre. Bioresour Technol 1991;40:73-76.
[19] N Reddy and Y Yang. Biotechnol 2005;23(1):22-27.
[20] Langmuir I. J Am Chem Soc 1918;40:1361–1403
[21] Freundlich HMF. The J Phys Chemy 1906;57A:384-470.