

Equilibrium study of the adsorption of iron (II) ions from aqueous solution on carbons from wild jack and jambul

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ABSTRACT

Industrialization and urbanization often lead to an increase in the discharge of toxic metals into the environment, which results in damage to ecosystems and human health. A recent focus on the removal of metal ions from solution is the use of agricultural and vegetable materials through adsorption. In the present study, the sorptive potential of wild jack and jambul barks for Fe (II) ions has been investigated in a batch system. Equilibrium studies were performed to address various experimental parameters like pH, adsorbent dose and initial concentration for the removal of Fe (II) ions. The adsorption data was described by Langmuir model. The values showed that wild jack has a better sorptive potential than jambul and both the adsorbents can be used for the economic treatment of wastewaters containing iron (II).

Key words: Equilibrium Wild jack, Jambul barks, Fe (II) ions, Toxic metals.

INTRODUCTION

Water pollution is the introduction of chemical, biological and physical matter into large bodies of water that degrade the quality of life that lives in it and consumes it. Water is polluted in many ways like effluent of leather and chemical industries, electroplating industries and dye industries [1]. Several industrial and agricultural processes and mining activities have increased the concentration of toxic contamination in water and waste water around the world. The presence of heavy metals in the environment has led to a number of environmental problems [2]. The metal ions do not undergo biodegradation and many of them are soluble in aqueous solutions, therefore become more available for living systems and accumulate in the environment. Iron overload may lead to debilitating and life-threatening problems such as diabetes, heart failure, and poor growth. According to EPA, the acceptable value of iron in drinking water is 0.3 mg.L^{-1} [3].

Developing countries mainly suffer from water pollution; the expensive method of treatment is the main problems in these countries [4]. Biosorption, a biological method of environmental control, can be an alternative to conventional waste treatment facilities [5].

In this work, the adsorption of iron (II) ions was studied using low cost adsorbents by a batch technique with respect to the pH, initial concentration and adsorbent dose. The adsorbents used in the present study were carbon obtained from barks of wild jack (*Artocarpus hirsutus*) and jambul (*Syzygium cumini*) trees.

MATERIALS AND METHODS

Preparation of carbon

Carbon was prepared by treating air-dried barks of wild jack (WJ) and jambul (JB) trees separately, with con.H₂SO₄ in a weight ratio of 1:1. The resulting black product was kept in a furnace, maintained at 500 °C for 12 h followed by washing with water until free from excess acid and dried at 150 °C±5 °C. The carbon product was ground and was used as adsorbents for all the experiments.

Adsorbate

1000 ppm of iron(II) ions was prepared by dissolving 4.9785 g of ferrous sulphate in double-distilled water and making up to 1000 ml. The stock solution was diluted to obtain required standard solutions.

Analysis

The concentrations of iron in the solutions after equilibrium were determined by Solar A₂ Solaram Atomic Absorption spectrophotometer. The pH of the solution was measured with a systronics digital pH meter using a combined glass electrode. The shaking was carried out in a mechanical shaker.

Adsorption experiment

Batch mode experiments were conducted using 250mL Erlenmeyer flasks by contacting 50mL of the aqueous Fe (II) solution of different initial concentrations. The initial pH of the solution was adjusted before starting each experiment. The experiments were performed in a mechanical shaker for a period of 90 min at room temperature. The remaining concentration of Fe (II) ions in each sample after adsorption at different time intervals was determined by atomic absorption spectroscopy after filtering the adsorbent with Whatman filter paper No.40 to make it adsorbent free. The Fe (II) concentration retained in the adsorbent phase was calculated.

$$q_e = (C_i - C_e) V / W$$

Where q_e - Fe (II) concentration, C_i and C_e are the initial and equilibrium concentrations (mg/L) of Fe (II) solution respectively; V is the volume (L); and W is the mass (g) of the adsorbent.

RESULTS AND DISCUSSION

Effect of pH

The most important single parameter influencing the sorption capacity is the pH of adsorption medium. The initial pH of adsorption medium is related to the adsorption mechanisms onto the adsorbent surface from water and rejects the nature of the physicochemical interaction of the species in solution and the adsorptive sites of adsorbent. The pH of feed solution is an important controlling parameter in the heavy metal adsorption process and thus the role of hydrogen ion. To study the effect of pH on Fe (II) adsorption onto WJ & JB, the experiments were carried out using 1mg/l Fe (II) concentration with 0.2g/50ml adsorbent mass at room temperature(32 ± °C) for 90 min equilibrium time. The experiments (Fig. 1) showed that the optimum pH for the adsorption of iron (II) ions by WH and JB occur at 2.

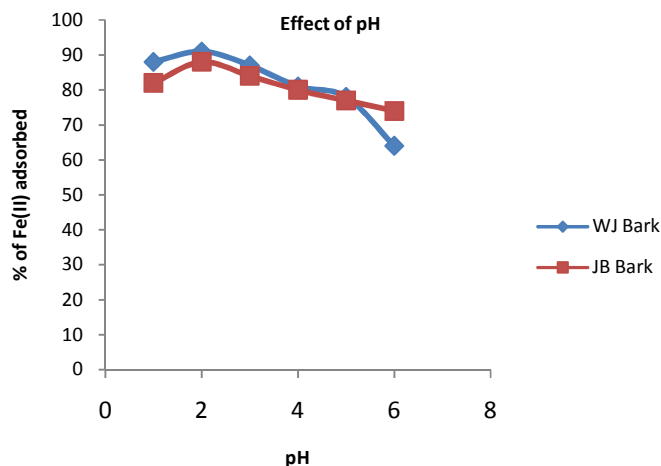


Figure 1. Effect of pH on the adsorption of Fe (II) by wild jack and jambul; initial concentration: 1 ppm

Effect of initial iron (II) concentration

The iron (II) removal on wild jack and jambul was studied as a function of its initial concentration (1 ppm, 2ppm, 3 ppm, 4 ppm, 5 ppm and 6 ppm) under optimized conditions, initial solution pH 2 and 0.5g/50 ml of adsorbents respectively. The amount of iron (II) retained on weight unit of adsorbent (q , mg/g) increase with the increasing of initial metal ion concentration from aqueous solution (Fig. 2a). At the same time, the percent of iron (II) removal (Fig. 2b) sharply decrease with the increasing of the initial concentration. This opposite trend is determined by the fact that at higher concentrations, the diffusion of iron (II) ions to the un-reacted functional groups is inhibited. Hence an optimum concentration of 1 ppm was chosen for subsequent studies.

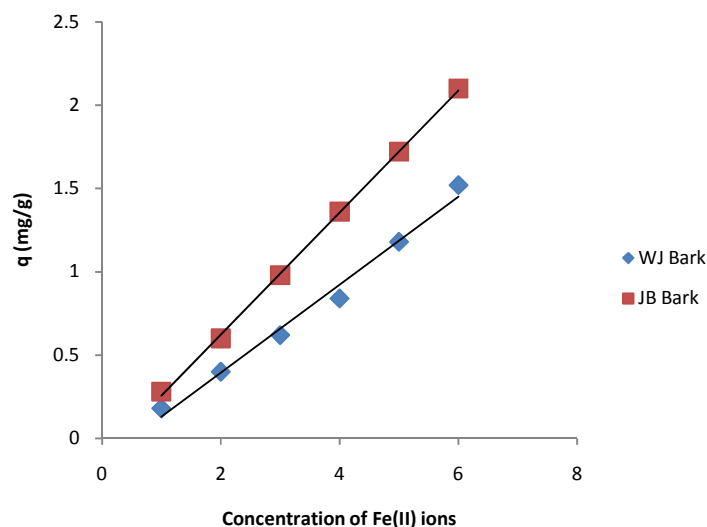


Figure 2a. Effect of initial concentration per unit weight of adsorbent on the adsorption of Fe (II) by wild jack & jambul; pH: 2

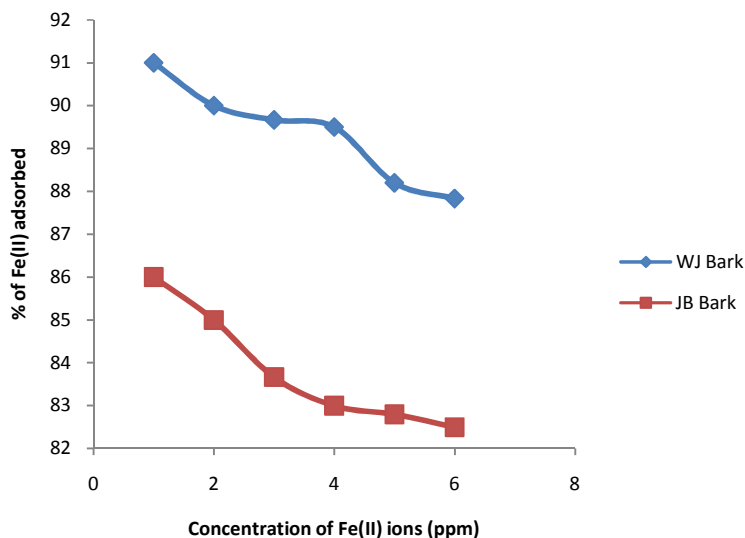


Figure 2b. Effect of initial concentration on the adsorption of Fe (II) by wild jack & jambul; pH: 2

Effect of adsorbent dose

The adsorption of iron(II) was studied by changing the quantity of adsorbents (0.1, 0.15, 0.20, 0.25, 0.30, 0.35 g/50mL) in the test solution while keeping the initial concentration(1mg/L), temperature and pH (2) constant for 90 min. The solutions were agitated in a shaker, filtered and the metal ion concentrations in the filtrate were measured. Fig. (3) shows that the adsorption of Fe(II) increases rapidly with increase in amount of adsorbent and reaches an equilibrium after a point. The maximum removal was obtained in the dosage of 0.25 mg/50 ml for WJ and 0.3 mg/50 ml for JB. Any further addition of the adsorbent beyond this did not cause any significant change in the adsorption. This may be due to overlapping of adsorption sites as a result of overcrowding of adsorbent particles [6].

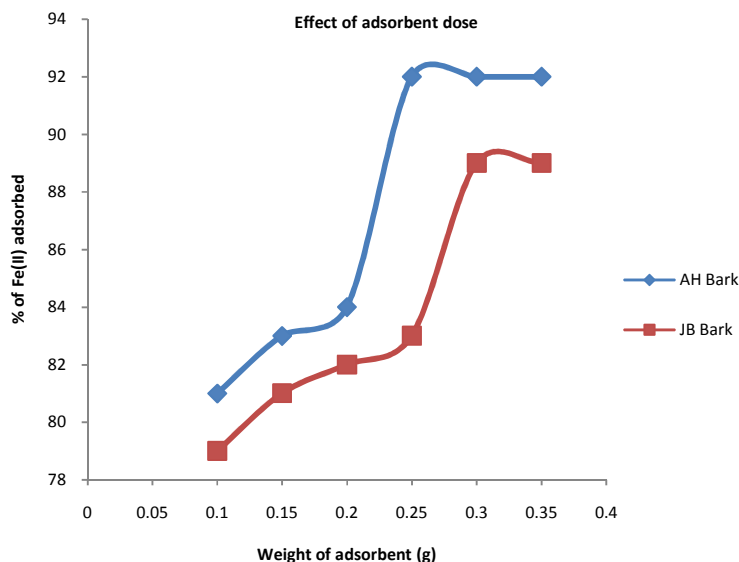


Figure 3. Effect of adsorbent dose on the adsorption of Fe (II) by wild jack & jambul; pH: 2

Equilibrium isotherm

The analysis and study of equilibrium data is very important in view to develop a model equation which can accurately represent the results and could be used for the design purposes. Langmuir isotherm model was used to describe the equilibrium characteristics of adsorption of metal onto WJ & JB respectively. The model developed by Langmuir [7] is given by the following linearised equation

$$C_e/q_e = 1/K_L \cdot q_m + C_e/q_m \quad \text{--- (2)}$$

Where q_e is the equilibrium metal ion concentration on the adsorbent (mg/g), C_e is the equilibrium metal ion concentration in the solution (mg/g) and K_L is the Langmuir adsorption constant (L/mg). It can be seen from fig. 4 that the Langmuir equation fitted well for both the adsorbents with R^2 values of 0.999. The values of the different Langmuir parameters are given in Table 1. The values show that wild jack has a better sorptive potential than jambul and both the adsorbents can be used for the economic treatment of wastewaters containing iron (II).

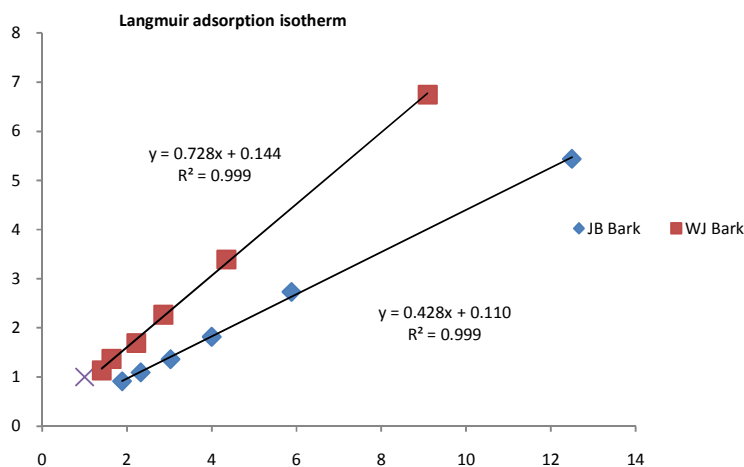


Figure 4. Langmuir adsorption isotherm for the adsorption of Fe (II) by wild jack & Jambul; pH: 2

Table 1 Langmuir adsorption parameters for the adsorption of Fe (II) ions onto wild jack & jambul

Adsorbent used	Dose (g)	K_L (L/mg)	q_m (mg/g)	R^2
Wild jack	0.25	9.0909	0.2570	0.999
Jambul	0.30	6.9444	0.1978	0.999

CONCLUSION

The efficiency of the adsorbents; carbon obtained from jambul and wild jack for the removal of iron (II) ions from aqueous solution was investigated. Parameters such as pH, dose and initial concentration were studied. The optimum pH for the removal of ferrous ions was found to be 2 at an initial concentration of 1 ppm for both the adsorbents. The equilibrium data fitted well with Langmuir adsorption isotherm. The results of the study showed that wild jack bark can be efficiently used as compared to jambul as a low-cost alternative for the removal of Fe (II) from aqueous solutions.

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