

Removal of Iron (II) Ion from Aqueous Solution Using Waste Tea Leaves

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ABSTRACT

Adsorption is an interesting procedure for the expulsion of toxins from water and wastewater since the procedure is practical, effortlessly adoptable. In this examination tea leaves were appeared to be a successful and minimal effort adsorbent. Evacuation of iron (II) from watery arrangements was contemplated utilizing bounteously accessible tea leaves waste under different trial conditions. The expulsion of iron (II) ion on tea leaves waste was considered under different sorption parameters, for example, contact time, impact of pH and initial concentration of metal ions on the adsorption limit. The most extreme expulsion effectiveness of 81% was accomplished at pH 8.0 for Iron (II) at equilibrium conditions. Adsorption qualities showed by tea leaves waste were acceptable and the isotherms were in similarity with both Langmuir and Freundlich isotherms.

Keywords: Adsorption; Fe (II) ions; waste tea leaves; adsorption isotherms.

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I. INTRODUCTION

Heavy metal toxicity due to industrial waste water and other natural assets have posed a great chance to the environment and public fitness [1]. The contamination of waste waters and surface waters through toxic heavy metals is an international-extensive environmental hassle. Heavy metals like Fe, Zn, Cu, and Ni as are regarded to have toxic results at very low awareness in addition to very excessive awareness [2]. Iron (Fe), in particular, is one of the maximum commonplace environmental contaminants due to its wide use in various commercial resources, inclusive of mining sports, metallic producing industries, foundries and smelters, and diffuse assets which include piping, parts of merchandise, and combustion by-products, etc. its accumulation inside the our bodies may additionally causes numerous pathological states including oxidative stress, attacking organ systems on the cell stage and inflicting tissue damage [3]. Because of financial and environmental elements, the elimination and recovery of heavy-steel ions from industrial waste water were a tremendous challenge in most business branches.

The elimination of heavy metal from waste water may be executed via unique techniques inclusive of: (i) precipitation as hydroxides, carbonates or sulfides and subsequent liquid-solids separation via gravity settling, and flotation or filtration, (ii) sorption (adsorption, ion alternate), (iii) membrane processes, (iv) electrolytic restoration and (v) liquid-liquid extraction [4-7]. In any case, each approach has its merits and snags in application and they're frequently bound with the guide of specialized and financial inconvenience. Among this adsorption is thought about as most extreme promising technique for disposal of overwhelming metal from water and waste water because of its effortlessness, accommodation, and inordinate end execution. The adsorption framework with actuated carbon has wind up the circumstance of gigantic enthusiasm of numerous researcher as a result of its viability of the end of substantial steel particles at indicate amounts [8,9]. However, the technique has no longer been used substantially due to its excessive price [8]. therefore, there is growing studies interest in the use of alternative low-value adsorbents like agricultural waste sawdust [10], cocoa issues, shell [11], rice husk [12], changed sawdust of walnut [13], papaya wood [14], maize leaf [15], rice husk ash and neem bark [16], fly ash [17] and so forth. Inside the current year cognizance has been at the tea waste. Tea waste is a reasonably-priced material so it's utilizing in commercial wastewater flowers would be handy. About 39 million kg of tea is produced in Bangladesh each year. The placement of Bangladesh tea manufacturing in 2006 is inside the 10th position [18]. As soon as tea is ready, even at the domestic degree, the leaves are then discarded and considered as waste. Tea leaves waste act as herbal adsorbents and have the capacity to adsorb a number of heavy metal ions. The main purpose of the present study is to investigate the adsorption ability waste tea leaves for removal of Iron (II) ion from aqueous solution. Using a batch adsorption mode, different experimental conditions, such as pH, contact time, and concentration for the maximum removal of Iron (II) ions were investigated and optimized.

II. EXPERIMENTAL METHOD

Preparation of adsorbent:

Tea waste collected from tea stalls were washed with cold water (29 times) and boiled with hot distilled water (31 times) up to color removal. After color removal it was dried in hot oven at 100°C for 16 hours. The dried material converted into powder formed by mortar and screened to size 0.1 - 0.25 μm and 0.25 - 0.50 μm . Again this powder dried at 100°C for 6 hours and then stored in reagent bottle at room temperature. Now it was ready to use as an adsorbent.

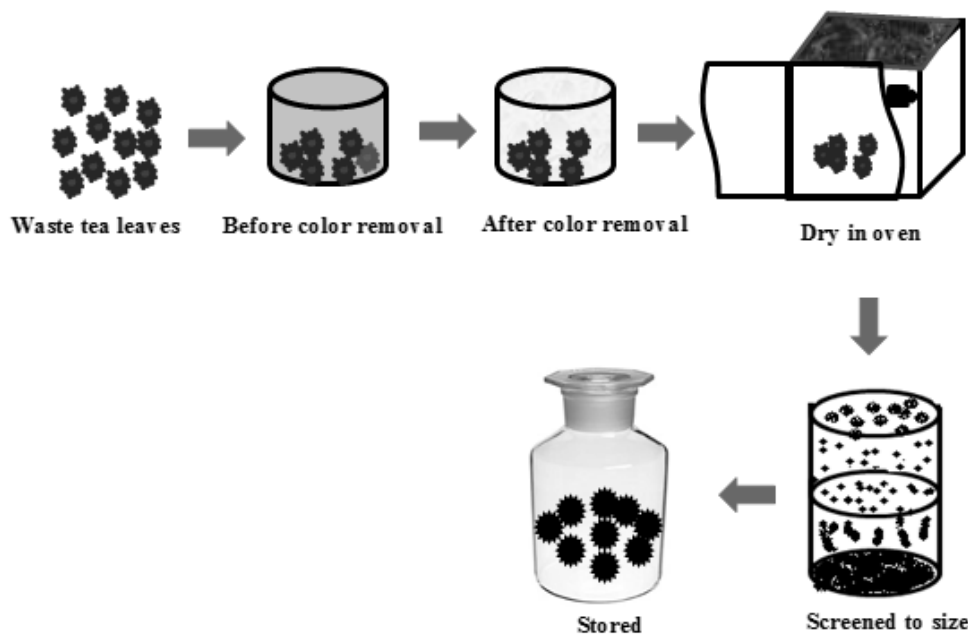


Figure2.1: Schematic diagram for preparation of adsorbent

Determination of Optimum pH for Study:

Adsorption of metals was studied as the function of pH keeping the concentration constant by batch adsorption test. 0.3g of tea leaves was taken in reagent bottles and 50 mL of 200 mg/L iron solution with pH 2 to pH 12 were added to each bottle. Iron solution with different pH was adjusted by drop wise addition of HCl and NaOH solution. The bottles were shaken for 4 hrs at room temperature. After shaking, the solution was centrifuged and pH values of the solutions were monitored by using pH meter.

Preparation of metal ion solutions:

Exact amount of $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ was taken in a beaker, and was dissolved it in 20 mL of dilute H_2SO_4 . This solution was transferred in 1000.00 mL volumetric flask and made the solution up to mark of the flask with distilled water.

Analysis of iron (II):

Pipette out 10 ml of iron solution into a conical flask. It was diluted to about 50 mL with distilled water and 15 mL of syrupy sulphuric acid and phosphoric acid mixture was added. 3-4 drops of diphenyl- amine indicator was added. The solution was slowly titrated whilst stirring constantly with the standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution until the solution was assumed a bluish-green color near the end point. Continuously $\text{K}_2\text{Cr}_2\text{O}_7$ solution was added dropwise and maintaining an interval of a few seconds between each drop until the addition of one drop caused the formation of permanent intense purple or violet blue color.

III. RESULT & DISCUSSION

Optimum pH:

pH of the aqueous solution plays a very important role in the adsorption of metal ions. The adsorption efficacy depends on pH value of the solution. A series of experiments at different pH values were conducted to explore the optimum pH value for conducting adsorption experiments. 0.3 mg of the waste tea leaves adsorbent of 0.1-0.25 mm particle size along with 50 ml solutions of 200 mg/l of Fe (II) concentration was adjusted to different pH values ranging from 2.0 –12.0 and were equilibrated for 4 hours. The solutions were centrifuged and

analyzed for ΔpH . The approximate null pH was obtained at 2, 3, 8 respectively. The results of the experiment are shown in Figure 3.1.

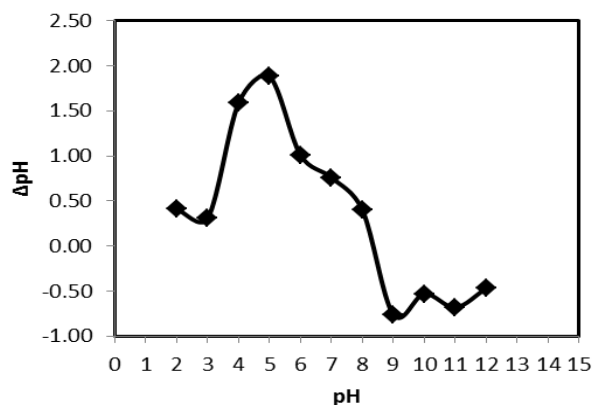


Figure 3.1: Effect of pH of Fe (II) solution at the equilibrium position of the adsorption process.

Maximum 81% removal was observed at pH = 8 as shown in the figure 3.2. The adsorption of metal cations depends on the nature of metal ions, adsorbent surface and species of the metals. At higher pH values, Iron (II) removal was inhibited, possibly because of the competition between hydrogen and Iron ions in the sorption site.

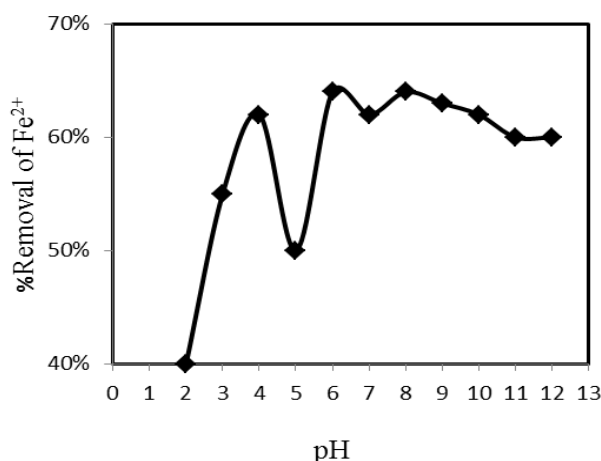


Figure 3.2: Effect of pH on the removal of Fe (II) ion from the Fe (II) solution by tea waste adsorbent

Effect of equilibrium time at different pH:

Adsorption of Fe (II) was studied at different equilibrium times by agitating 200 ml of Fe (II) solutions in the concentration 200 mg/l at pH 2.0, 3.0, 7.0, 8.0, respectively with 1.2 mg of adsorbent. After equilibrating for different time periods, the solutions were centrifuged and analyzed for Fe (II) content. Fe (II) adsorption as a function of time and different pH are shown. From Table 1, it was evident that the equilibrium time was dependent of initial Fe (II) pH. The removal of Iron (II) vs. time plot in Figure 3.3 was not smooth and non-continuous suggesting the possible multilayer coverage of metal ions on the surface of the adsorbent.

Table 1: Adsorption of Fe (II) at different pH and equilibrium time.

Agitation time in minute	pH of Iron (II)			
	pH = 2	pH = 3	pH = 7	pH = 8
	Removal of Iron (II) (x/m)	Removal of Iron (II) (x/m)	Removal of Iron (II) (x/m)	Removal of Iron (II) (x/m)
15	0.233	0.283	2.050	1.317
30	0.383	0.350	2.200	1.350
45	0.450	0.367	2.190	1.400
60	0.467	0.317	2.350	1.417

75	0.417	0.383	2.450	1.330
90	0.417	0.400	2.500	1.370
105	0.450	0.400	2.470	1.40
120	0.483	0.417	2.500	1.450
135	0.483	0.433	2.550	1.483
150	0.500	0.433	2.600	1.500
165	0.517	0.450	2.600	1.516
180	0.550	0.450	2.650	1.530
195	0.550	0.467	2.710	1.550
210	0.567	0.500	2.770	1.550
225	0.583	0.500	2.770	1.550
240	0.583	0.533	2.770	1.550

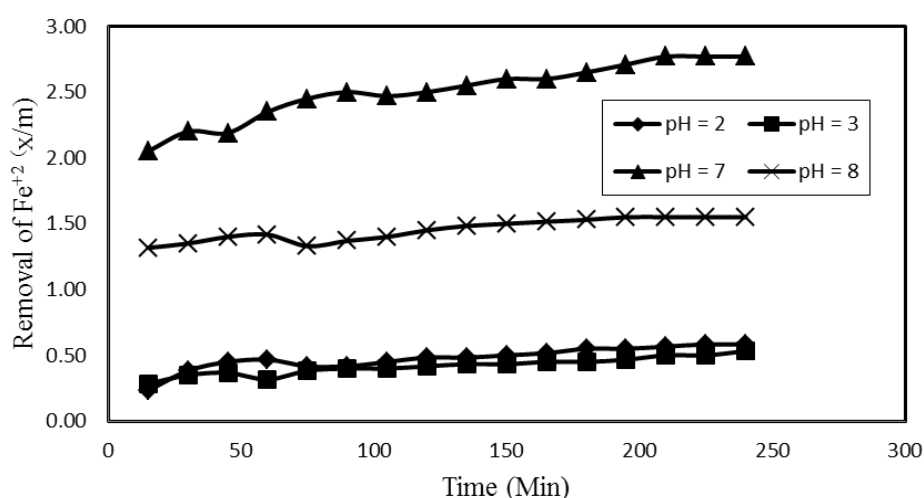


Figure 3.3: Variation of removal of Fe (II) by tea waste adsorbent with different time interval at different pH and for the concentration of Fe (II) 200 ppm.

Effect of equilibrium time and initial metal ion concentration:

To investigate the optimum equilibrium time, experiments were carried out by agitating 200ml of different concentrations of Iron (II) solutions ranging from 50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L and 300 mg/L which are maintained at pH 8.0 and with 1.2 g of adsorbent. After equilibrating for different time periods from 15-240 min, the solutions were centrifuged and analyzed for Fe (II) content and the removal in each case was determined. Equilibrium time from the Table 1 was found to be 180-225 min.

Table 2: Adsorption of Fe (II) at different concentrations and equilibrium time.

Agitation time in minute	concentration of iron (II)					
	50 ppm	100 ppm	150 ppm	200 ppm	250 ppm	300 ppm
	Removal of Iron (II) (x/m)	Removal of Iron (II) (x/m)	Removal of Iron (II) (x/m)	Removal of Iron (II) (x/m)	Removal of Iron (II) (x/m)	Removal of Iron (II) (x/m)
15	0.701	1.403	1.052	1.317	0.969	1.870
30	0.720	1.553	1.085	1.350	1.019	1.920
45	0.730	1.603	1.169	1.400	1.052	1.953
60	0.730	1.653	1.185	1.417	1.119	2.004
75	0.802	1.653	1.202	1.330	1.136	2.054
90	0.820	1.703	1.403	1.370	1.152	2.054
105	0.840	1.603	1.436	1.40	1.169	2.021
120	0.852	1.653	1.519	1.450	1.202	2.071
135	0.952	1.703	1.571	1.483	1.235	2.088

150	0.991	1.853	1.603	1.500	1.253	2.104
165	1.002	1.904	1.820	1.516	1.303	2.121
180	1.069	1.954	1.854	1.530	1.386	2.138
195	1.121	2.004	1.903	1.550	1.386	2.154
210	1.152	2.004	2.004	1.550	1.386	2.154
225	1.152	2.004	2.004	1.550	1.386	2.154
240	1.152	2.004	2.004	1.550	1.386	2.154

From Table 2, it was evident that the equilibrium time was dependent of initial Fe (II) pH. The removal of Iron (II) vs. time plot in Figure 3.4 was not smooth and non-continuous suggesting the possible multilayer coverage of metal ions on the surface of the adsorbent.

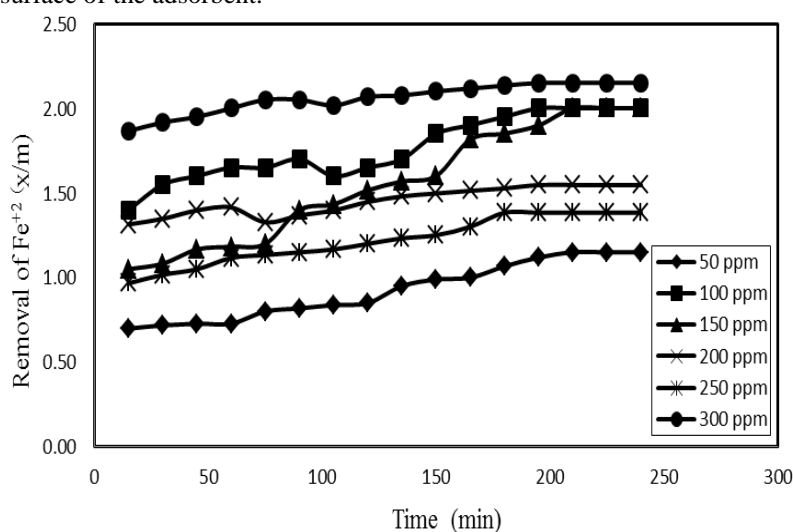


Figure 3.4: Effect of contact time on the removal of Fe (II) at different concentration

Adsorption isotherms:

Isotherms relate metal uptake per unit weight of adsorbent to equilibrium adsorbate concentration in the bulk fluid phase. The Langmuir isotherm was based on the assumptions that maximum adsorption corresponds to a saturated monolayer of adsorbate molecules on the adsorbent surface, the energy of adsorption was constant and there was no transmigration of adsorbate in the plane of the surface. The Langmuir isotherm was expressed in the following formula:

$$\frac{C_e}{q_e} = \frac{1}{bQ_0} + \frac{C_e}{Q_0}$$

Where C_e is the equilibrium Concentration (mgL^{-1}), q_e is the amount removal at equilibrium time (mg/g), Q_0 and b are Langmuir constants related to adsorption capacity (mg/g) and energy of adsorption (L/mg), respectively. Data for Langmuir plot are given in Figure 3.5 that indicates that adsorption followed Langmuir isotherm.

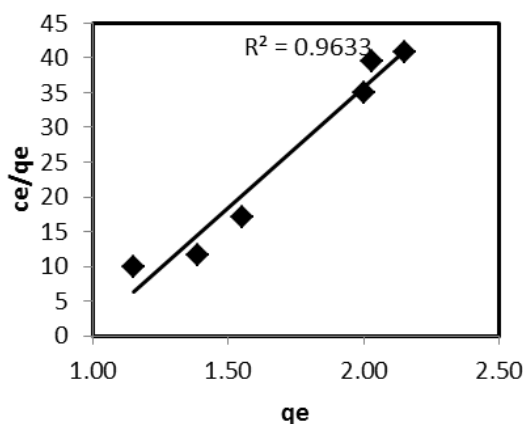
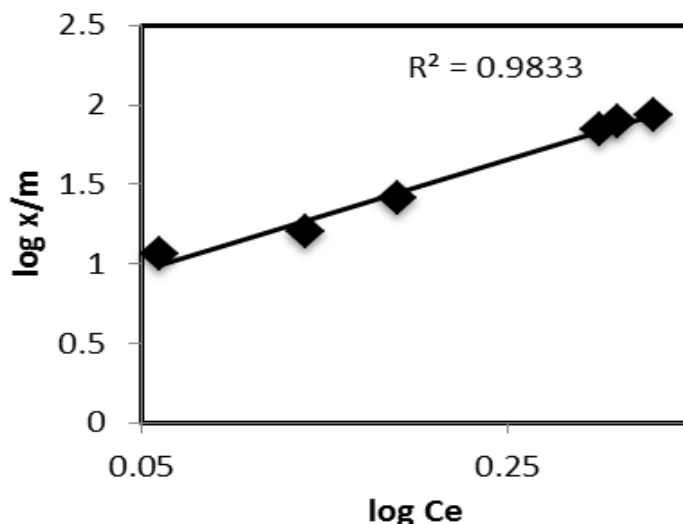


Figure 3.5: Langmuir isotherm showing initial concentration vs. equilibrium concentration.

The Freundlich isotherm is generally used for mathematical description of adsorption in aqueous system and describes heterogeneous surface energies indicated the favorability of adsorption. The equation is expressed in logarithmic form as:

$$\log x/m = \log k_f + \log c_e$$

Where x/m is the amount adsorbed in mgL^{-1} , C_e is the equilibrium concentration (mgL^{-1}), K_f and n were Freundlich constants. K_f [mg/g] was the capacity of the adsorbent and n indicated the favorability of adsorption. This isotherm was applied for the adsorption of Fe on waste tea leaves adsorbent and plot of $\log x/m$ vs $\log C_e$ is shown in Figure 3.6. The linearity of the plot shows that adsorption followed Freundlich isotherm.

**Figure 3.6:** Freundlich adsorption isotherm for the equilibrium concentration and adsorption rate.

IV. CONCLUSIONS

Tea waste is a reasonably-priced and effective adsorbent for the elimination of Fe (ii) ions from aqueous solution without requiring any pretreatment. Test outcomes confirmed that maximum removal of Fe (II) ion via tea waste at top of the line situation (8 pH, 180-225 min. contact time, 200 - 300 ppm concentration) become acquired properly. Settlement of the experiment through curves with the version predictions become found. This experimental research on adsorbents could be quite beneficial in growing the ideal generation for the elimination of heavy metallic ions.

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