Removal of Iron from Drinking water by using Low Cost Natural Adsorbents

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Abstract— In Kerala most of the water used for industrial, commercial or domestic uses comes from either ground water or surface water. The drinking water condition have great effects on human's daily life, especially in rural and remote areas where access to good quality water is very critical. Valappad is a small village on the Chavakkadu coast of Thrissur. A large population of this area are facing serious drinking water issues due to the presence of high level of iron content. The normal drinking water contain permissible limit 0.3mg/l but the Valappad ground water contains 2mg/l of iron concentration. Adsorption method for removal of iron from drinking water is more economical and effective in rural villages. Amla Tree Bark (ATB) and Banana Peel (BP) have been using as a natural low coast adsorbent for the removal of Iron from drinking water. A batch adsorption study was conducted to check the efficiency of ATB and BP and the studies were conducted to investigate the effect of various operational parameters such as Adsorbent dose, pH, Contact time and Initial iron concentration on the treatment efficiency.The maximum removal efficiency of iron from synthetic water was observed in the pH range 4-6 by both adsorbents. The study of Freundlich and Langmuir adsorption isotherms were carried out. Amla tree bark shows higher iron removal efficiency than the Banana peel.

Key words: *Adsorption, Adsorption isotherms, Amla tree bark, Banana peel,Batch adsorption, Drinking water, Iron removal*

1 INTRODUCTION

Drinking water is a basic requirement for life. Relatively a small quantity is needed for sustain life and much more is needed for domestic, industrial or commercial uses. In Kerala many rural and remote areas are facing serious drinking water issues due to presence of different kinds of impurities.The people of Valappad in Thrissur are depends on well water for drinking and other purposes, which is relatively easily available. But they are suffering a lot for accessing good quality of water due to the presence of iron in well water. Various methods are adopted to remove heavy metals from water including chemical, biological, physical treatments. However these methods are quite expensive and difficult. Hence there is need of easy and cost effective method to remove heavy metals including iron from water[1].The adsorption method is consistently found to be economical and suitable because of its treatment and cost efficiency[2].The major advantage of using adsorption technique is that it gives the relevant

level of energy saving from much efficient waste water treatment system that is operating for less hours which is widely attractive because the biomass waste is inexpensive and widely available[3].This study is trying to introduce low cost ATB and BP as a natural adsorbent for the removal of iron from water. In this present study iron removal from synthetic solution by using amla tree bark and banana peel were examined and effect of various parameters as adsorbent dose, pH, contact time and initial iron concentration were also carried out by ploting freundlich and langmuir adsorption isotherms.

2. OBJECTIVES

- To prepare adsorbents using bark of Phyllanthus Emblica (Amla) tree and banana peel
- To determine the iron removal efficiency of Amla tree bark and Banana peel from drinking water.
- To find out the effect of various experimental parameters on iron removal.
- To study the different adsorption Isotherms

3. MATERIALS AND METHODOLOGIES

3.1 Raw materials

Amla Tree Bark (ATB) and Banana peel (BP) are the important materials used for this study.

3.2 Reagents

Hydrochloric acid, Hydroxylamine Hydrochloride, 1, 10 Phenonthroline, Amonium acetate, Ferrous ammonium sulphate are the chemicals used,

3.3 Instruments

UV-VIS spectrophotometer, Mini rotary shaker, pH meter and heating mantle are the instruments used for this study.

3.4 Preparation of adsorbents

The amla tree bark and banana peel were washed with tap water and is then followed by distilled water so that the mud, trash etc. removed easily and oven dried at 80℃ for 24 hours. Completely dried bark were grounded and again washed with double distilled water till colour of water disappears. Washed adsorbent was again oven dried at 100℃ for 4 hours [4] finally sieved to prepare fine powder of 150-300 µm particle size and stored.

3.5 Preparation of synthetic iron solution

Preparation of iron (1000mg/L) was prepared by dissolving calculated amount of Ferrous ammonium salts in distilled water and also Sulphuric acid

3.6 Collection of Sample

Valappad is a small village on the Chavakkadu coast of Thrissur district in south Indian state of Kerala. The samples were collected from wells at Valappad of Thrissur district.

3.7 Batch adsorption studies

Batch adsorption analysis was done by adding dried adsorbents in to the sample. The sample was constantly stirred and after that the filtered sample was analysed using spectrophotometer [5].

4. RESULTS AND DISCUSSION

4.1 Initial Characteristics of sample

The initial characteristics such as turbidity, alkalinity, acidity, TDS, hardness and other characteristics was measured for ground water and given in table 4.1. Standard was referred by IS: 10500:2012.

Table 4.1 Initial Characteristics of Ground water at Valappad

Characteristics	Unit	Acceptable limit	Permissible limit	Results
Turbidity	NTU	1	5	11.3
Electrical Conductivity	us/cm	…..		233
pH		6.5-8.5	No Relaxation	6.5
Total Dissolved Solids	Mg/L	500	2000	179.4
Acidity	Mg/L	…..	…..	20
Alkalinity	Mg/L	200	600	70
Total Hardness	Mg/L	200	600	82
Chloride(as Cl)	Mg/L	250	1000	24
Iron (as Fe)	Mg/L	0.3	1	2
Dissolved Oxygen	Mg/L	4	8	7

4.2 Effect of Adsorbent dose

The effect of adsorbent dosage on the removal of iron by Amla tree bark and Banana peel were studied as in Fig. 4.1 .The weight of ATB and BP was varied from 0.5g/L to 4g/L keeping all the other experimental variables, pH 6.5, Initial iron concentration 5mg/L, and contact time 60 minutes. From the figure, it was seen that the percentage removal of the iron increase with increasing the adsorbents doses from 0.5 g/L to 2.5 g/L and further increment of the adsorbent dosages did not give more increase in the percentage of the iron particle removed from the solution. In this way, 2.5 g/L dose of the adsorbents were utilized in all study. The increase in the percentage of the metal ion removal with increase in adsorbent dose is due to the greater availability of the exchangeable sites or surface area at higher concentration of the adsorbent. Non-significant increase observed when the adsorbent doses were increased from 2.5/L g to 4 g/L, suggests that after a certain dose of adsorbent, the maximum adsorption is attained and the amount of ions bound to the adsorbent and the amount of free ions remains constant even with further addition of the dose of adsorbent[6].

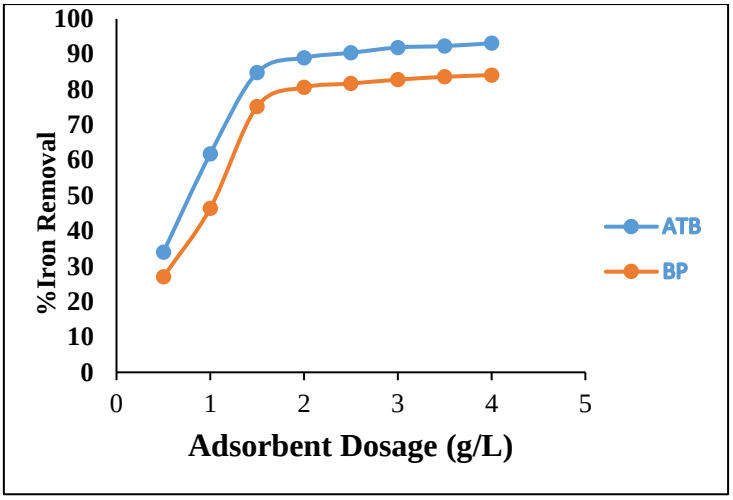

Fig.4.1 Effect of Adsorbent dosage

(Experiment condition: Initial concentration 5mg/L, pH 6.5, Time 60 min, Agitation=150 rpm)

4.3 Effect of pH

Effect of pH were studied for the pH ranging from 2 to10 and the results obtained were shown in the figure 4.2.The initial concentration 5mg/L, dosage of adsorbent 2.5g/L, shaking time 60 minutes and agitation speed were kept at 150 rpm respectively. The results obtained were shown that the pH has an important influence in the removal of iron from the solution. The percentage iron removal increases with increase in the pH from 2 to 6.5 and it shows a sudden fall in pH from 6.5 to 10.There for at low pH values ATB and BP showed very low tendency for removal of iron due to protonation of its functional group or competition of H^+ with metal ions for binding sites [7]. ATB and BP shows a maximum percentage removal of iron at a pH 6.5.

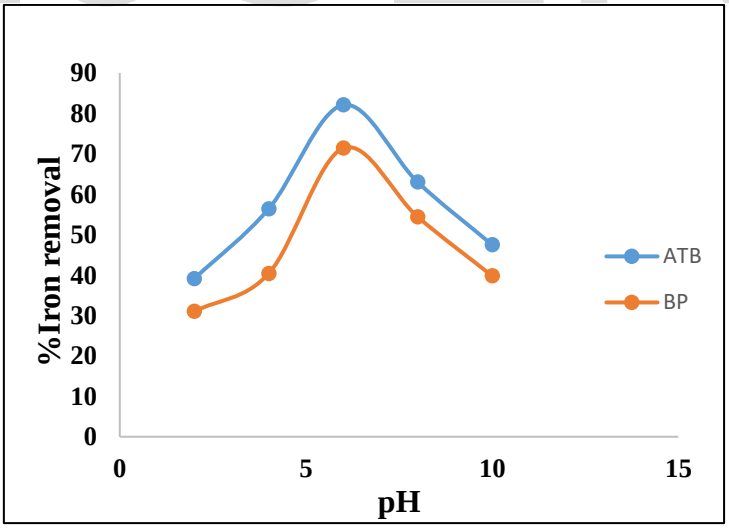

Fig 4.2 Effect of pH

(Experiment condition: Initial concentration 5mg/L, Adsorbent dosage 2.5 g/L, Time 60 min, Agitation=150 rpm)

4.4 Effect of Contact time

The effect of contact time were studied for different contact times varies from 30 minutes to 240 minutes with adsorbent dose 2.5g/L, pH 6.5,initial iron concentration 5mg/Land the

agitation 150 rpm respectively. The percentage removal of iron from the synthetic solution was shown in the figure 4.3.The maximum adsorption was obtained within the 90 minutes of shaking. After that the percentage removal of iron from synthetic solution did not give greater increment because as the contact time increased the active sites on the adsorbent were filled [4].

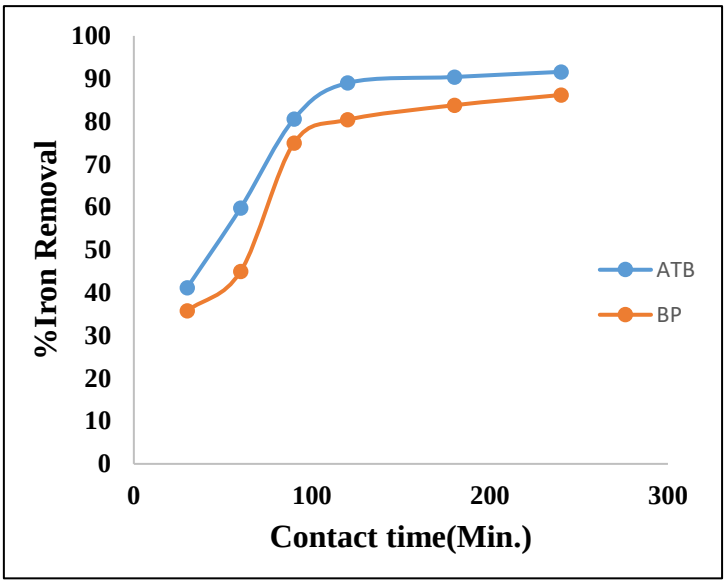

Fig 4.3 Effect of contact time

(Experiment condition: Initial concentration 5mg/L, Adsorbent dosage 2.5 g/L, pH 6.5, Agitation=150 rpm)

4.5 Effect of Initial iron concentration

Different initial concentration 2mg/L to 10 mg/L was studied as shown in fig 4.4 and higher capacity of adsorption found in lower concentration of iron [8]

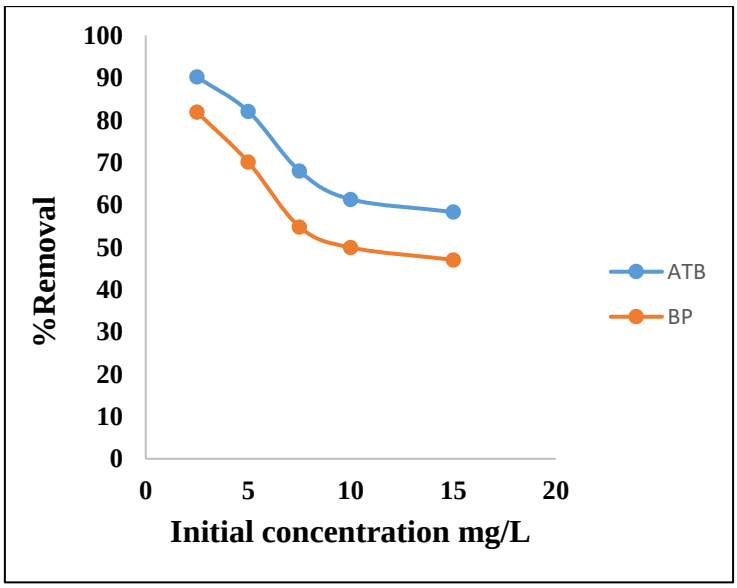

Fig 4.4 Effect of Initial ion concentration

(Experiment condition: Contact time=60 min, Adsorbent dosage 2.5 g/L, pH 6.5, Agitation=150 rpm, Volume of sample=100ml)

4.4 ADSORPTION ISOTHERMS

An adsorption isotherm is a graphical representation showing the relationship between the amount adsorbed by a unit weight of adsorbent (e.g. activated carbon) and the amount of adsorbate remaining in a test medium at equilibrium. It maps the distribution of absorbable solute between the liquid and solid phases at various equilibrium concentrations. The Freundlich and Langmuir isotherms were plotted based on the percentage removal of iron obtained from batch study.

Isotherm model for ATB

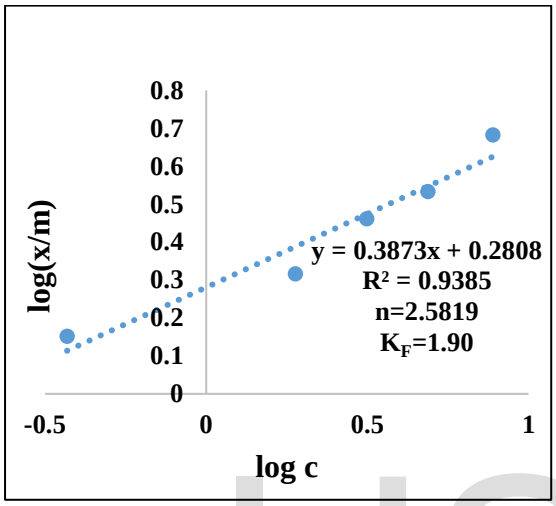

Fig 4.5 Freundlich isotherm ATB

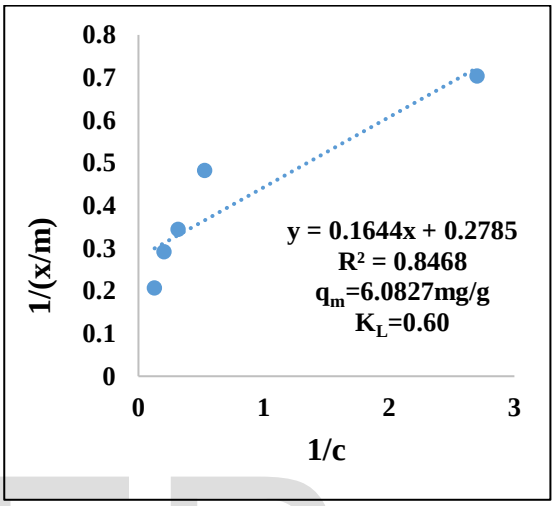

Fig 4.6 Langmuir isotherm ATB

The R^2 value obtained in Freundlich (R^2 =0.9385) is more than the Langmuir (R^2=0.8468).The data followed Freundlich isotherm than the Langmuir isotherm. The study predicted that the nature of surface adsorbent was heterogeneous

Isotherm model for BP

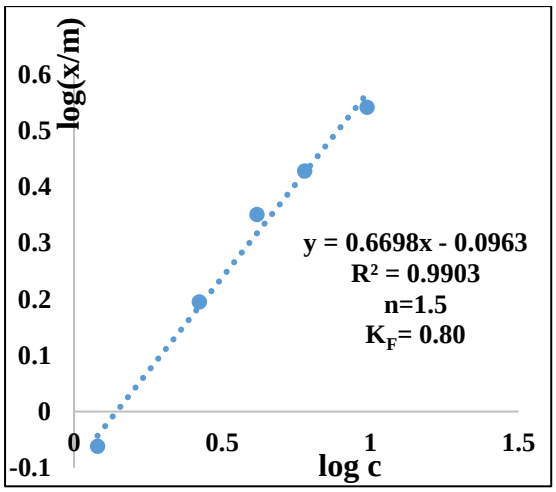

Fig 4.7 Freundlich isotherm for BP

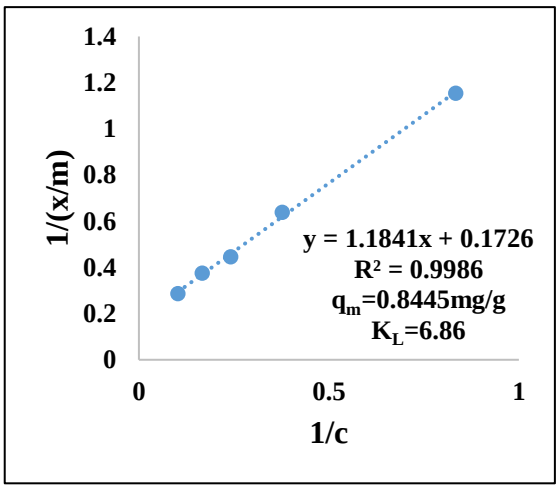

Fig 4.10 Langmuir isotherm for BP

The correlation factor obtained in Freundlich (R^2 =0.9903) is less than the Langmuir (R^2=0.9986).The data followed Langmuir isotherm than the Freundlich isotherm. Hence we can predict that the nature of surface adsorbent was homogeneous and suitable for adsorption.

5. CONCLUSION

The study shows that the Amla tree bark and Banana peel have significant effect on the iron removal. The optimized values for both the adsorbents were adsorbent dose 2.5mg/L, contact time 120 minutes and pH range 4-6 respectively. Low initial ion concentration shows higher percentage removal efficiency. On comparing both the adsorbents ATB shows more efficiency in removal of iron.

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