Adsorption of Iron from Aqueous solution using Almond shell as adsorbent

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ABSTRACT
Iron is normally found in spent pickle and from plating shops, steel mills, foundries, chemical milling, and wire drawing operations. It is also found in ground water. Iron in water is normally found in the ferrous state. Next to hardness, the presence of iron is probably the most common water problem faced by consumers and water treatment professionals. The secondary maximum contaminant levels (MCL) for Iron is 0.3mg/l. Iron may cause conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues. Hence to remove iron from water, a batch study has been conducted by adsorption process using activated carbon prepared from almond shell as adsorbent and the removal efficiency was found by varying the parameters such as dosage, time, pH and concentration. The removal efficiency was found to be more than 89%.This experimental study has been carried out to develop an economical method of iron removal, so that even small industries can adopt this method for their wastewater treatment and hence they can prevent the polluted water entering the stream.

1. INTRODUCTION

Iron is a natural constituent of the Earth's crust and is present in varying concentrations in all ecosystems. They are stable and persistent environmental contaminants since they cannot be degraded or destroyed Amir (2005). Human activity has drastically changed the biogeochemical cycles and balance of some metals. The main anthropogenic sources of Iron are various industrial sources, including toothpowder manufacturing industries, groundwater etc. These are also known to have adverse effects on the environment and human health and are toxic even at low concentration to human beings and other living beings.

The removal of iron from synthetic solution can be done by adsorption technique using powdered activated carbon. Though importance of this treatment is felt, its cost keeps the industrialists away from adopting the same. It is also a fact that till date no material proves to be a better adsorbent than commercial activated carbon Subashini,(2005). Since the cost of activated carbon and its reactivation cost are high, the technology of the activated carbon remains at an inaccessible distance and its application does not find a place. Hence an attempt has been made to employ a material, prepared from the Almond shell for the removal of iron.

During adsorption, the atoms within the structure of the adsorbent are attracted in all directions relatively equally, whereas the atoms at the surface exhibit an imbalanced attractive force, which the adsorbate molecules help to satisfy. The significant parameter, which popularizes an adsorbent, is the presence of a great amount of surface area; normally via the wall area or slots, capillaries or pores permeating its structure, in a very small volume and unit weight.

2. MATERIALS AND METHODS
2.1 ADSORPTION WITH ACTIVATED CARBON:

Certain organic compounds in wastewater are resistant to biological degradation and many others are toxic or nuisances (odor, taste, color forming) even at low concentration. Low concentration materials are not readily removed by conventional treatment methods. Nageeb, (2005) Activated carbon has an affinity for organics and its use for organic contaminant removal from wastewater is wide spread.

The larger surface area, a critical factor in the adsorption process, enhances the effectiveness of the activated carbon for the removal of organic compounds from wastewater by adsorption. The surface area of activated carbon typically can range from 500 - 1400 m2/g .The effect of chemical nature of the carbons surface is less significant than the surface area. This chemical nature or polarity varies with the carbon type and can influence attractive force between molecules.

2.2 EXPERIMENTAL METHODOLOGY
2.2.1 PREPARATION OF ADSORBENT:

The shell of Almond is a material which is thrown out as a waste. These wastes were collected and their size was reduced by breaking it into small size. Then they were dried in an oven at a temperature of 170°C for 24 hrs.(etcalf and Eddy(2000) It was then packed in an air tight in a cylindrical iron container with top completely sealed with an iron cover to prevent the entry of air during the process of charring. The sealed iron container was heated in a muffle furnace by slowly raising the temperature up to 600°C and maintained the same for 1 hour. The activated carbon thus prepared was subsequently washed with distilled water and oven dried.

2.2.2 BATCH ADSORPTION EXPERIMENTS:

Batch reactors (BOD bottles) have been employed in these experiments wherein predetermined quantities (150 ml) of desired concentration were agitated continuously with known amount of the activated carbon powder. Samples were taken and their residual iron monitored at regular intervals. The mixing arrangement was facilitated by Orbital Rotary Shaker. After a lapse of a prefixed contact time, 50 ml of sample was drawn from the samples and filtered using a whatman No.40 filter paper and was analyzed for its residual iron concentration.

To assess the influence of the following basic parameters on the adsorption process:
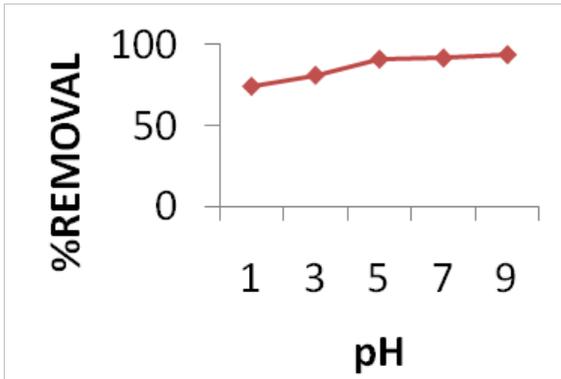
- Optimum pH Studies
  Bottles with different pH conditions were analyzed for residual iron concentration.
- Optimum dosage Studies
  Bottles with increasing doses of the adsorbent with fixed contact time were analyzed.
- Time adsorption studies to evaluate the kinetics of adsorption of iron.
  Bottles with optimizes pH and sorbent dosage were agitated for varied timings and then analyzes for residual iron.
- Isotherm study to evaluate the equilibrium characteristics.

3. RESULTS AND DISCUSSIONS
3.1 OPTIMUM pH STUDIES:

The hydrogen ion concentration (pH) of the influent affects adsorption. The optimum pH for removing iron using activated carbon powder from the Almond shell was determined by adjusting the pH of the solution. The optimum pH in the removal of iron was found to be 5.0 as in Fig.3.1
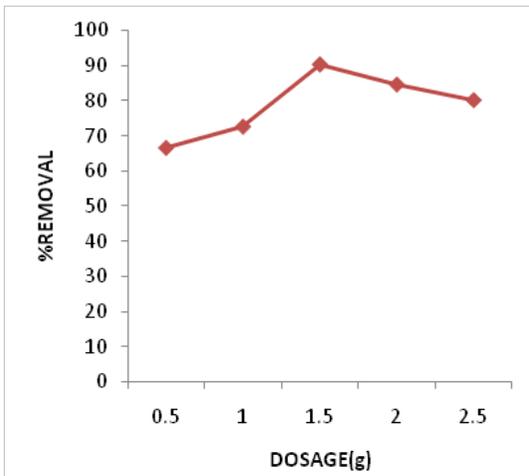
Fig. 3.1 Optimum pH studies

3.2 OPTIMUM DOSAGE STUDIES:
150 ml of synthetic iron solution with a concentration varying from (.05 mg/L to 1 mg/L) was taken in different conical flasks and treated with different dosages of carbon powder i.e. from 0.5g to 2.5g were added. From the results it was observed that the optimum dosage was 1.5g as in Fig.3.2
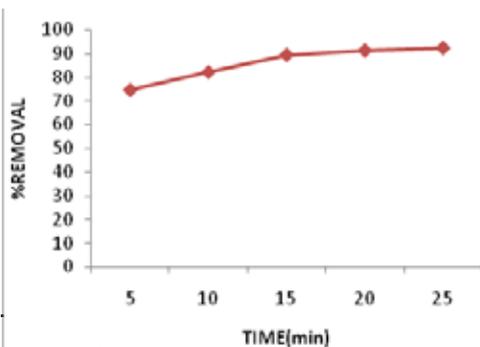
Fig. 3.2 Optimum dosage studies

3.3 OPTIMUM TIME STUDIES:
The flasks were agitated for a time interval of 5min.The time was varied from 5 minutes to 25 minutes. The residual iron concentration was analyzed using UV-Visible Double Beam Spectrophotometer. Optimum contact time was found to be 20 min for the synthetic solution as in Fig.3.3
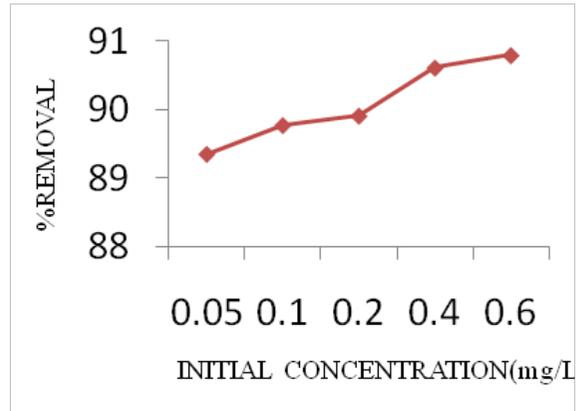
Fig. 3.3 Optimum time studies

3.4 OPTIMUM CONCENTRATION STUDIES:
The aqueous solution of concentration varying from 0.05mg/L to 0.6 mg/L were agitated by optimizing the pH, time and dosage and the optimum concentration was found to be 0.2mg/L as in Fig.3.4

Fig. 3.4 Optimum concentration studies

3.3 LANGMUIR ISOTHERM FOR THE ADSORPTION PATTERN:
Irving Langmuir devised a simple model involving a thermodynamic equilibrium to predict the fraction of solid surface covered by an adsorbate as a function of its gas pressure.. This was later extended to liquid systems, where the equilibrium involved concentrations in solution. The Langmuir model is discussed in most elementary texts on physical chemisry, and most reference books on adsorption will have an extensive treatment, including references to theoretical and experimental reports. In this model adsorbate and solvent molecules compete to adsorb on sites on the surface of the powder.

Fig.3.5 Langmuir isotherm showing adsorption of iron from almond shell
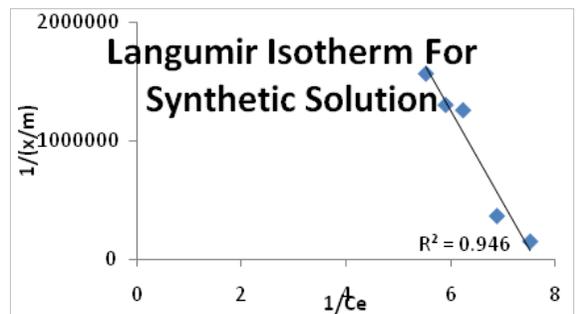
Waste treated	-	Synthetic iron Solution
Volume of treated solution	-	50 ml
Size	-	750 to 1000 micron
Original pH	-	5.0
Adsorbent	-	Almond shell
Initial concentration	-	0.2 mg/L

The essential characteristics of the Langmuir isotherms can be described by a separation factor R_L

Value of R_L

$R_L > 1$ unfavorable

$R_L = 1$ linear

$0 < R_L < 1$ favorable

$R_L = 0$ irreversible

$R_L = 0.33$

As the R L value lies between 0 and 1, it indicates favorable adsorption for iron uptake. The R2 value is less than 1 which also says that the adsorbent used is favorable for iron uptake as in Fig.3.5

CONCLUSION

The following conclusions were drawn from the present study on the ability of the Almond shell based activated carbon in removing iron from the synthetic solution.

For synthetic solution it was observed that the percentage removal of iron with increase in time of contact up to 20 minutes and after that there was no appreciable increase in the percentage removal. Hence the optimum contact time for the synthetic solution was taken as 20 minutes.

For synthetic solution, it was found that the percentage iron removal increases from pH 1-9. Optimum pH is 5.0 which is the

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