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Original Research Paper

Adsorption of Iron from Aqueous Solution Using *Limonia acidissima* Fruit Shell Activated Carbon as an Adsorbent

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ABSTRACT

The presence of iron is probably the most common water problem faced by consumers and water treatment professionals. Iron may cause conjunctivitis, choroiditis and retinitis if it contacts and remains in the tissues. Hence, to remove iron from water with the methods available, adsorption has gained popularity due to several advantages. A batch study adsorption has been conducted by adsorption process using activated carbon prepared from wood apple (*Limonia acidissima*) fruit shell as an adsorbent and the removal efficiency was determined by optimizing the parameters such as dosage, time, pH and concentration. The maximum removal efficiency was found to be more than 60%. This experimental study proves to be an economical method of iron removal since the developed product is a waste product. Even, small industries with iron-bound wastewater can adopt this method of treatment and hence, prevent the polluted water entering streams.

INTRODUCTION

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 groundwater. Iron in water is normally found in the ferrous state. Iron is a natural constituent of the Earth's crust and is present in varying concentrations in all ecosystems (Amir 2005). It is a stable and persistent environmental contaminant since it cannot be degraded or destroyed. Human activity has drastically changed the biogeochemical cycles and spoiled the balance of some metals. The main anthropogenic sources of iron are various industrial sources, including present and former mining activities, steel producing industries, foundries and smelters, and diffuse sources such as piping, constituents of products, combustion by-products, etc.

MATERIALS AND METHODS

Treatment of iron: 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. Since, the costs of activated carbon and its reactivation are high, the technology of activated carbon remains at an inaccessible distance, and its application does not find a common place. Hence, an attempt has been made to employ a material, prepared from the wood apple fruit shell for the removal of iron.

Adsorption and 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 popularises 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.

Adsorption with activated carbon: Certain organic compounds in wastewaters are resistant to biological degradation and many others are toxic or nuisances (odour, taste, colour 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 their 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 can typically range from 500-1400 m^2/g.

The effect of chemical nature of the carbon 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.

Preparation of adsorbent: The shell of wood apple is a material which is thrown out as a waste. These wastes were collected and their size was reduced by breaking into small size. They were dried in an oven at a temperature of 170°C for 24 hrs (Metcalf & Eddy 2000), and packed in an airtight 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 for 1 hour. The activated carbon, thus, prepared was subsequently washed with distilled water and oven dried.

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 prefixed contact time, 50 mL of sample was drawn from the samples and filtered through Whatman No. 40 filter paper and analysed for its residual iron concentration. Following basic studies were made to assess influence of various factors on the adsorption process.

Optimum pH studies: Bottles with different pH conditions were analysed for residual iron concentration.

Optimum dosage studies: Bottles with increasing doses of the adsorbent with fixed contact time were analysed.

Time adsorption studies to evaluate the kinetics of adsorption of iron: Bottles with optimized pH and sorbent dosage were agitated for varied timings and then analysed for residual iron.

Isotherm study: To evaluate the equilibrium characteristics.

RESULTS AND DISCUSSION

Optimum pH studies: The pH of the influent affects adsorption. The optimum pH for removing iron using wood apple fruit shell activated carbon powder was determined by adjusting the pH of the solution. The optimum pH in the removal of iron was found to be 5.0.

Optimum dosage studies: 150 mL of synthetic iron solution with a concentration varying from 0.05 to 1 mg/L was used in different conical flasks and treated with different dosages of carbon powder i.e., from 0.5g to 2.5g. The flasks were agitated for 5 min. The residual iron concentration was analysed using UV-visible double beam spectrophotometer. From the results, it was found that the optimum dosage was 1.5g, and optimum contact time 20 min for iron solution.

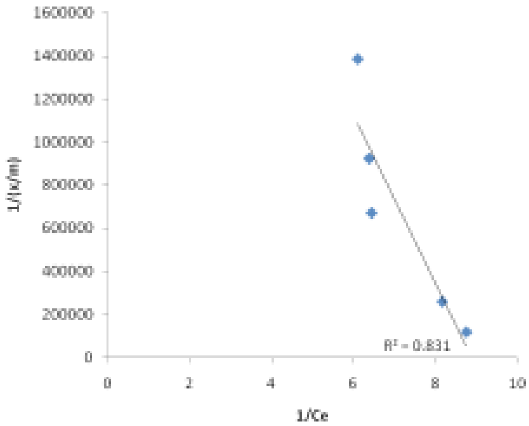

Fig.1: Langmuir isotherm for synthetic iron solution.

Langmuir isotherm for adsorption pattern: Waste treated: Synthetic iron solution; Volume of treated solution: 50 mL; Size of carbon: 750 to 1000 micron; Original pH: 5.0; Adsorbent: Wood apple fruit shell based activated carbon; Initial concentration of iron: 0.2 mg/L; Value of R_L: $R_L > 1$ unfavourable, $R_L = 1$ linear, $0 < R_L < 1$ favourable, $R_L = 0$ irreversible, $R_L = 0.33$

As the R_L value lies between 0 and 1, it indicates favourable adsorption for iron uptake (Fig. 1). The R^2 value is less than 1 which also indicates that the adsorbent used is favourable for iron uptake.

CONCLUSION

It was observed that the percent removal of iron increased up to contact time of 20 minutes, and after that there was no appreciable increase in the removal. Hence, the optimum contact time for the synthetic solution was taken as 20 minutes. The percent iron removal was optimum at pH 5.0, which is the original pH of the solution. The optimum concentration of iron was 0.2 mg/L with the dosage of 1.5 g of carbon.

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