

Removal of Iron and Fluoride by MSC Adsorbent from Groundwater

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Abstract— The problems related to groundwater contamination by iron and fluoride is common and serious all over the world, especially in developing countries. Excess amounts of these contaminants have created health problems. For this reason, the maximum permissible limit for iron given by WHO and BIS is 1 mg/l, however 0.3 mg/l is the desirable limit. For fluoride, the desirable limit as per WHO is 0.5-1 mg/l. While as per EPA and PHS the optimal levels of Iron and Fluoride in drinking water is 0.3 mg/l and 0.7 mg/l respectively. In this study, an effort has been made to remove iron and fluoride from groundwater using the process of adsorption. The experiments were performed on various parameters like dosage of adsorbent, pH, temperature and contact time to check their influence on adsorption. Adsorbent dosage of 4.7 g/50 ml at pH 5, temperature of 20°C and contact time of 420 minutes were considered as optimum.

Key words: Iron, Fluoride, Adsorption, groundwater

I. INTRODUCTION

Water is one of the most important, valuable, life saving and indispensable natural resource present in earth. It is a free gift of nature. However the availability of fresh water is very less. Groundwater, which is one of the purest forms of water, is mostly used for domestic purposes including drinking in developing countries like India.

Iron and Fluoride are two of most common contaminants that are present in groundwater. Iron present in water will get deposited in distribution pipes and will form iron bacteria, which will lead to contamination and reduce carrying capacity of the pipes. Iron containing water will stain laundry and utensils and will give astringent taste to water. Iron water will also effect proper boiler operations. Excess iron can also cause Cirrhosis, Liver cancer, Cardiac arrhythmias, Diabetes, Alzheimer's disease and different bacterial and viral infections [5]. Fluoride accumulates in body over time and is very harmful. It hampers development of brain and lowers the level of IQ in humans. Excess Fluoride in water causes fluorosis which can affect both children and adults. Fluoride causes dental carries in children below 5 years. Consuming water having excess Fluoride also leads to mottling of teeth where the enamel weakens and teeth becomes very sensitive. Fluoride accumulation inside human body also interferes with carbohydrates, lipids, vitamins, enzymes and mineral metabolism.

Iron and Fluoride contamination is an increasing problem across the globe. Developing countries like India face this issue often. In India, 1.1 lakh habitations suffer from high Iron concentration in groundwater. The highest iron concentration of 49 mg/l has been observed in a hand pump at Bhubaneswar. Globally African countries like Kenya, Egypt, European countries like Netherland, Ireland etc, Asian countries like Bangladesh, Cambodia, China face the problems of Iron contamination. Fluoride contamination

is also a major issue. India is one of the 23 countries facing this issue. In India 19 states suffer from Fluoride contamination and the highest concentration observed is upto 48.32 mg/l. Globally high concentration of Fluoride has been observed in India, America, European countries, Asian countries, East African countries, Turkey, Kenya and some parts of South Africa [9].

Due to serious effects of groundwater contamination by Iron and Fluoride and their occurrence in various parts of the world, the treatment of water for their removal is necessary. Though there are various processes available, adsorption and adsorptive filtration are most common and very effective methods for removal of these ions. Various researchers have been working on this for a very long time. Now days they are focussing on cheap and efficient materials like rice husk, eggshell powder, bauxite powder, lateritic soils, bleaching powder, powdered groundnut shell, maize husk, coconut shell powder, drum stick powder etc [32, 41, 30, 10, 20, 18, 33]. These adsorbents have also succeeded in removal of Iron and Fluoride.

In this study we have studied the removal of Iron and Fluoride present in same solution together by using a mixture of adsorbents together.

II. MATERIALS AND METHODS

A. Materials

Chemicals like Sodium fluoride (NaF), Ferrous ammonium sulphate (FAS), TISAB tablets by Extech Instruments, 1,10 Phenanthroline monohydrate, Hydroxylammonium chloride, Sodium hydroxide and hydrochloric acid were used in this study. Two different stock solutions of 100 ppm strength of Iron and Fluoride were prepared by dissolving 0.7022 g FAS and 0.221 g NaF in 1 l distilled water separately, respectively. Working solutions containing 2 ppm and 10 ppm Iron and Fluoride together were prepared from the stock solutions.

B. Preparation of Adsorbents

The adsorbents were prepared and cleaned before using as adsorbent. They were kept in contact with 0.1 N HCl at 20°C at 120 rpm for 24 hours in an orbital shaking machine. After 24 hours they were filtered and dried in an oven at 105°C again for 24 hours. They are then ready to be used.

C. Adsorption Experiments

All the experiments were carried out with 50 ml of solution containing both Iron (2 ppm) and Fluoride (10 ppm) in it. A known weight of the mixture of adsorbents were used along with the solution into a 250 ml beaker and then placed into an orbital shaking machine at 30°C at an agitation speed of 150 rpm to study the effects of various parameters on adsorption process. After desired contact time, this was filtered using Whatman filter paper No. 42 and then the filtrate was analysed for the concentration of Iron and

Fluoride. In the study related to effect of pH, the pH of the solution was varied by using 0.1 N HCl and 0.1 N NaOH. The filtrate was analysed by double beam UV-VIS Spectrophotometer for residual Iron and portable Fluoride meter by ExTech Instruments for residual Fluoride content.



Fig. 1: Synthetic Groundwater Samples Mixed With Adsorbent

D. Chemical Composition

Chemical composition by X-Ray Fluorescence was done to check the amounts of various radicals present in them. The XRF resulted in 34.34% and 51.65% CaO for first adsorbent and second adsorbent respectively.

III. RESULTS AND DISCUSSION

A. Effect of Adsorbent Dosage

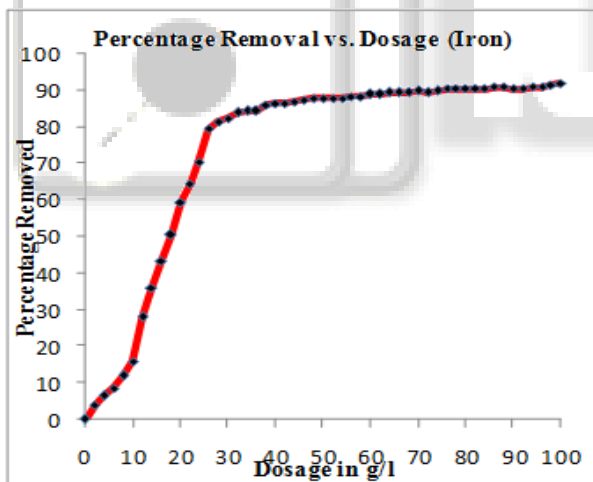


Fig. 2: Percentage removal versus dosage for Iron

The removal of Iron and Fluoride is very much dependent on the dosage of adsorbent used. In this study, experiments were performed by making a series of 50 ml synthetic groundwater sample each containing 2 ppm of Fe²⁺ and 10 ppm of F⁻. To each sample, different amounts of adsorbent was added from 0.1 g/50 ml to 5 g/50 ml. The beakers were then kept in the orbital shaking machine for 24 hours at 30°C and 150 rpm. It was observed that the maximum percentage removal for Iron and Fluoride reached to 92% and 93% respectively. However, it was noticed that after a dosage of 4.7 g/50 ml, there was no significant change in removal of Iron and Fluoride by the adsorbents. Also at this dosage the desirable limit of 0.3 mg/l and 1 mg/l respectively for both Iron and Fluoride was reached. Hence, this dosage was considered optimum for further use. The

reason for less significant removal after a particular adsorbent dosage maybe due to overlapping of active sites for adsorption at higher dosage.

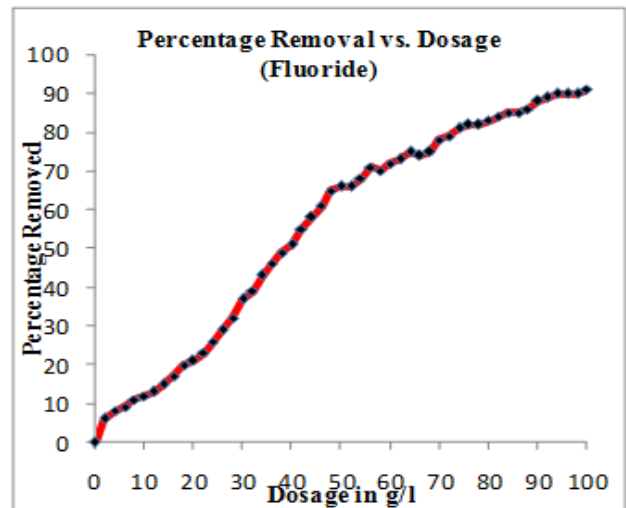


Fig. 3: Percentage removal versus dosage for Fluoride

B. Effect of Ph

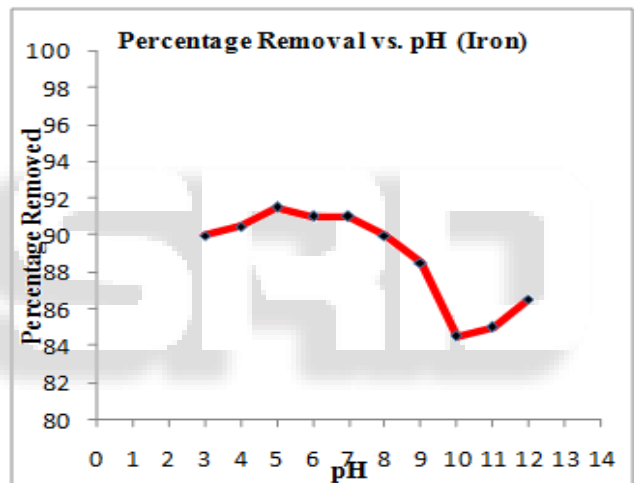


Fig. 4: Percentage removal versus pH for Iron

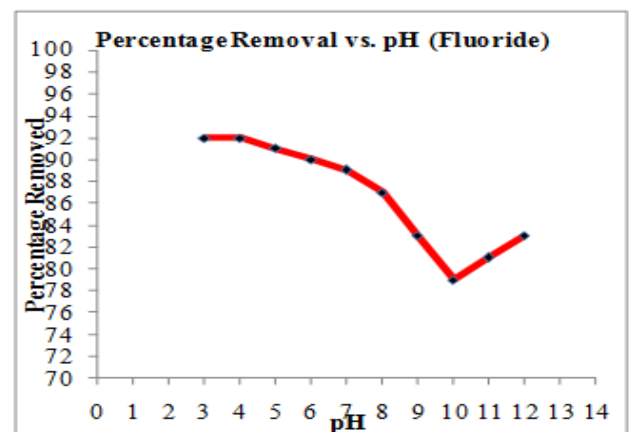


Fig. 5: Percentage removal versus pH for Fluoride

pH is a very important parameter which decides adsorption of Iron and Fluoride onto the adsorbent surface. In this present study, the effect of pH on the adsorption process was studied by varying the pH of synthetic groundwater from 3 to 12. In case of Iron, it was observed that as the pH increased, the removal of Iron also increased upto 7 and then decreased. However, in the case of Fluoride, it was observed

that the Fluoride removal decreased with the increase in pH. The maximum adsorption of Iron was found to be 90.5-91% in the pH range 4-7 whereas the maximum adsorption for Fluoride was 92-90% in the pH range 3-6. Hence, a pH of 5 was selected as optimum for further studies.

C. Effect of Temperature

Temperature is one of the most important controlling parameters in adsorption. Adsorption is generally exothermic and hence rate of adsorption decreases with increase in temperature. In this present study, we checked the effect of temperature in the removal of Iron and Fluoride by the adsorbents. Three different temperatures namely 20°, 30° and 40°C were selected to study the effect of temperature on the process of adsorption. Study showed that maximum removal of 90.5% of Iron and 91% of Fluoride occurred at 20°C. It was also observed that as the temperature increased, rate of adsorption decreased significantly to 88% for Iron and 79% for Fluoride. Hence, 20°C was selected to be the optimum temperature for further studies.

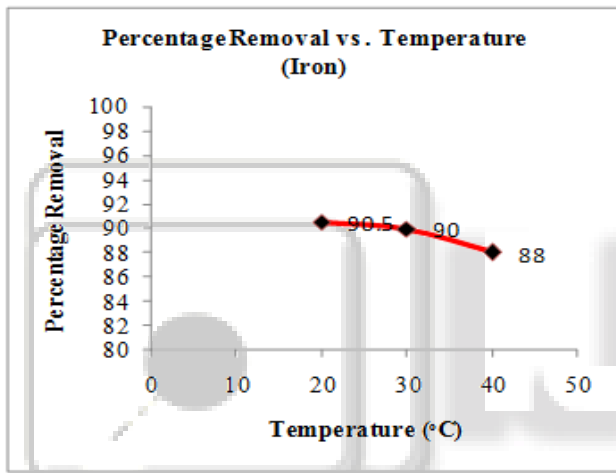


Fig. 6: Percentage removal versus Temperature for Iron

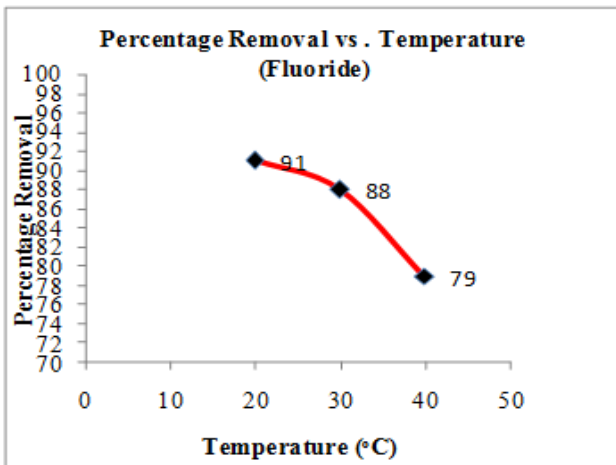


Fig. 7: Percentage removal versus Temperature for Fluoride

D. Effect of Contact Time

The effect of contact time between adsorbent and adsorbate is very important. Optimum contact time is very essential for proper adsorption of adsorbate onto adsorbent. In this study, we checked the time required for maximum adsorption of Iron and Fluoride by the adsorbents. It was observed that 90% of Iron was removed in the first 90

minutes and then further removal was very less. This is because the active sites for adsorption gets filled up and rate of adsorption decreases. Maximum removal was 92% in 140 minutes. For Fluoride however, only 63% was removed in the first 90 minutes and maximum removal was 92% in 520 minutes. However, the optimum contact time was selected to be 420 minutes because it had brought down the fluoride level to desirable limit as per standard. Since Iron and Fluoride coexists in the solution, therefore 420 minutes was the contact time selected as optimum for removal of both the species.

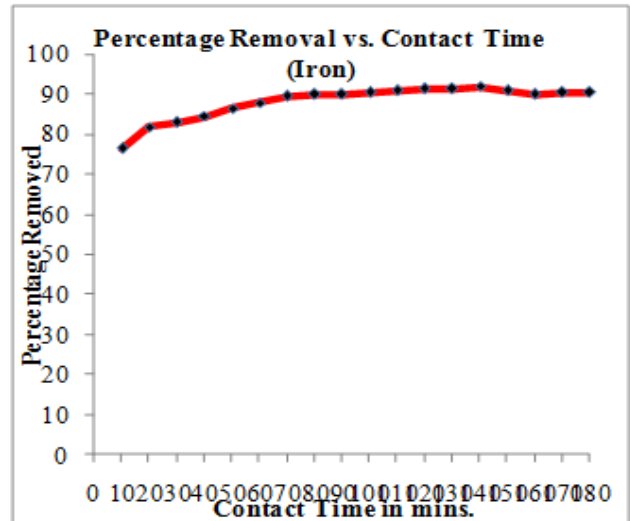


Fig. 8: Percentage removal versus Contact time for Iron

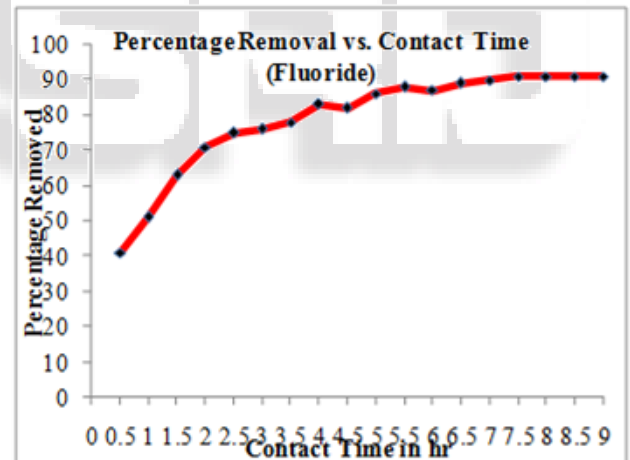


Fig. 9: Percentage removal versus Contact time for Fluoride

IV. CONCLUSION

The adsorbent materials were found very efficient for the removal of both Iron and Fluoride present in the synthetic groundwater sample. The removal was as high as 92% and 93% for Iron and Fluoride respectively. The dosage of adsorbent considered was 4.7 g/50 ml. The optimum pH was found to be 5, optimum temperature and contact time was considered as 20°C and 420 minutes respectively.

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