Effect on Activated Alumina Fluoride Removal Capacity in Presence of Chloride

A.B Gupta, Savita, Suja George and Poonam Mondal

Abstract--- *Due to high toxicity of fluoride to mankind, there is an urgent need to treat fluoride-contaminated drinking water to make it safe for consumption. Activated alumina (grade FB101) has been investigated as an adsorbent for defluoridation and it is found to have a good affinity for uptaking fluoride ions from water. It is a granular form of aluminum oxide (Al_2O_3) and has a very high internal surface area, which provides a large number of sites for adsorption to occur. The percentage removal of fluoride increased with increase in the dosage of activated alumina. A slight decrease was found in adsorption capacity in presence of chloride ions due to competition for the same surface sites. Therefore, for designing of realistic defluoridation units groundwater quality in terms of chloride ions is needed to be considered.*

Keywords--- *Activated alumina, Fluoride, Defluoridation, Adsorption*

I. INTRODUCTION

Water pollution and its treatment to avail safe drinking water is a serious concern regarding health prospective of common people. Fluoride is one of the major contaminants in water.

More than 50% of the districts of A.P., Rajasthan, Punjab, U.P., and Gujarat are being affected by cases of fluorosis [1].Groundwater is the major source of drinking water among rural population of India. Along with fluoride, chloride ions are also present profoundly in groundwater.

Adsorption, ion exchange, precipitation, Donnan dialysis and electrodialysis are some techniques of defluoridation [2, 3, 4]. However, adsorption is the most widely used method for the removal of fluoride from water .Many adsorbents have been studied regarding fluoride removal from drinking water system. Among them, activated alumina have been observed to hold very good potential for defluoridation [5, 6]. Because of its strong affinity for fluoride and its availability, activated alumina has been used as an effective and inexpensive adsorbent for fluoride removal [7]. It is observed that activated alumina (AA) has a relatively high selectivity for chloride ions also [8]. It has been stated that an increase in chloride ions shows a little decrease in fluoride removal efficiency [9].

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This paper presents the adsorption capacity of activated alumina and effect of fluoride uptake capacity of activated alumina in presence of chloride by varying initial fluoride concentrations.

II. MATERIALS AND METHODS

A. Materials used

The activated alumina (grade FB101) used for defluoridation studies were procured from Bharghava Industries Limited, Surat. The specifications of the alumina used in this study are given in Table 1.

Table 1

Specifications of FB101 grade Alumina

S No:	Particulars	Specification
1.	Particle Form	spherical
2.	Particle Size (mm)	0.4-1.2mm
3.	Water adsorption capacity at 30°C and 60%RH by weight	19.83
4.	Surface area sq.m/gm (minimum)	260
5.	Pore volume cc/gm	0.43
6.	Bulk density gm/cc	0.82-0.87
7.	Bed crushing strength %	99.8
8.	Loss on attrition	0.145
9.	Loss on ignition (250°C to 1000°C)	7.33
10.	Chemical analysis	
	Al_2O_3 by difference	92.34
	Na_2O	0.1
	Fe_2O_3	0.03
	SiO_2	0.03

(Source- Bharghava Industries Limited, Surat)

All chemicals were of analytical-reagent grade (AR) and were used without further purification. The fluoridated water was prepared by adding sodium fluoride (NaF) into distilled water in polypropylene vessels to get desired concentrations of fluoride. Fluoride stock solution was prepared by dissolving 221 mg of anhydrous sodium fluoride in 1000ml of distilled water. Test solutions were prepared by diluting the stock solution. Estimation of fluoride ion was

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done at 570nm by spectrophotometer as per standard methods prescribed in APHA (1978). A jar test apparatus was used for agitating the samples for one hour approximately at a speed of 100rpm.

Batch defluoridation experiments were carried out using specific dosages of activated alumina and treating varying concentration of fluoridated water samples.

B. *Effect of adsorbent dosage on varying fluoride concentration*

Dosage of 4.8g and 6.4g of activated alumina were taken in 500ml of distilled water with 12ppm and 16ppm of fluoride solutions and agitated for one hour to reach equilibrium. The solutions were filtered with Whatman 40 filter paper and the filtered samples were analyzed for fluoride and chloride.

C. *Effect on adsorption capacities of alumina in presence of chloride ions*

Activated alumina dosage of 4.8g and 6.4g was taken in 500 ml of distilled water with 4, 8, 12, 16ppm of fluoride concentrations. Chloride were added to the solutions in concentrations of 100, 200, 300 mg/l to assess the effect on fluoride adsorption capacity. All experiments were carried out in room temperature (25˚C).

III. RESULTS

A. *Fluoride uptake capacity of activated alumina at different fluoride ion concentrations*

The effects of sorbent dose on the defluoridation efficiency at two different initial concentrations of fluoride in the solution were analyzed. Table 2 and Table 3 shows the residual fluoride concentration and the fluoride removal capacity of water with a fluoride ion concentration of 12ppm and 16ppm, treated with two different dosage of AA in batch experiments. Nearly 60 to 70% of fluoride was observed to be removed from the solution when treated with activated alumina. The fluoride removal rate increased with increase in dose of AA, attributing to the fact that more adsorption sites were available for fluoride ions.

Table 2: Results of Batch Tests for 12 PPM Fluoride Solution

Activated alumina in gm	Residual fluoride ppm	Percentage removal of fluoride	Capacity of F removal (mg/ g)
4.8	4.42	63.2%	0.788
6.4	4.14	65.5%	0.613

Table 3: Results of Batch Tests for 16 PPM Fluoride Solution

Activated alumina in gm	Residual fluoride ppm	Percentage removal of fluoride	Capacity of F removal (mg/ g)
4.8	4.77	70.2%	1.169
6.4	4.76	70.3%	0.878

B. *Effect of fluoride uptake capacity in presence of chloride ions*

Fluoride contaminated ground water generally contains several other coexisting ions, which can compete with fluoride during the adsorption process. In order to investigate interference due to presence of chloride ions, activated alumina adsorption capacity was determined with varying concentrations of chloride on fluoride uptake of activated alumina at varying initial water fluoride concentrations of 4,8,12, and 16ppm.

The results for the uptake capacities for 4.8g and 6.4g of activated alumina treating varying fluoride concentrations in presence of 100,200,300 mg/l of chloride are presented in Figures 1, 2 and 3.

Anions are similar in charge, so they compete with fluoride ions resulting in their preferential sorption, thus reducing the overall adsorption of fluoride ions. However, the increase in amount of chloride from 100mg/l to 300mg/l did not caused any significant effect in the overall uptake capacity of fluoride ions for a specific dose of alumina. The slight decrease in fluoride uptake performance of activated alumina is due to the competition these anions for active sites on adsorbent surface.

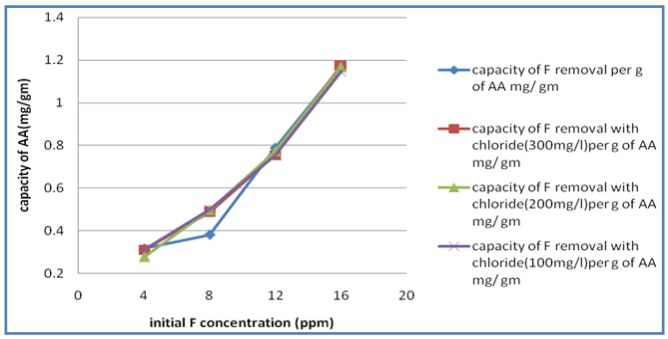

Figure 1: Adsorption Capacity of AA at a Dose of 4.8g

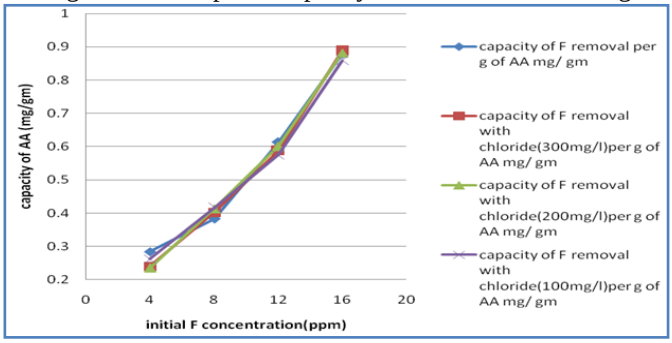

Figure 4: Adsorption capacity of AA at a dose of 6.4g

IV. CONCLUSION

Studies show that the activated alumina can remove approximately 60 to 70% of fluoride from water. So, it may be concluded that activated alumina grade FB101 has a high affinity for fluoride ions. A slight decrease in fluoride removal capacity was observed in presence of chloride ions. As, there

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is no significant influence of chloride anions on its defluoridation capacity, and hence activated alumina is a fluoride selective sorbent. But, the raw water may contain varying concentration of chloride according to the ground water resources of the concerned area. Therefore, the design of the alumina bed is needed to be decided according to the corrected fluoride uptake capacity corresponding to the raw water chloride concentration.

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