REMOVAL OF FLUORIDE FROM DRINKING WATER BY USING LOW COST ADSORBENT

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Abstract

Millions of people rely on drinking water that contains excess fluoride. In fluoride endemic areas, especially small communities with staggered habitat, defluoridation of potable water supply is still a problem. In this study, adsorption potential of granular activated carbon (GAC) from charcoal and coconut shell is investigated for defluoridation of drinking water using continuous fixed bed column. The influence of various operative parameters such as concentration of fluoride, bed height, flow rate, and adsorption capacity of both the adsorbent is carried out.The fluoride removal from synthetic sample is found up to 72% for fluoride ion concentration of 4mg/L.

Keywords: *Adsorption, Defluoridation, fixed bed column study, Granular charcoal, and coconut shell activated carbon.*

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1. INTRODUCTION

Fluoride is known to be a natural contaminant for ground water resources globally. Fluorine, a fairly common element of earth crust, is present in the form of fluorides in a number of minerals and in many rocks [1]. The ingestion of excess fluoride can cause fluorosis which affects the teeth and bones. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletalproblems. Paradoxically, low levels of fluoride intake help to prevent dental caries [3].Research of several researchers during the last 5–6 years has proved that life-long impact and accumulation of fluorides cause not only human skeletal and teeth damage, but also changes in the DNA-structure, paralysis of volition, cancer, etc. [2]. Mainly two factors are responsible for contamination of ground water with fluoride:one is geological and second is anthropogenic. Although both geological and manmade sources contribute to the occurrence of fluoride in water, the major contribution comes from geological resources [4]. In the 3rd edition of the World Health Organization (WHO) guidelines on drinking water, it maintains its guideline on the appropriate fluoride concentration at 1.5 mg/L (WHO 2008). "It is estimated that around 260 million people worldwide (in 30 countries) are drinking water withFluoride content more than 1.0 mg/L. In India alone, endemic Fluorosis is thought to affect around one million people and is a major problem in 17 of the 25states, especially Rajasthan, Andhra Pradesh, Tamil Nadu, Gujarat, and Uttar Pradesh [6]. So Fluoride removal from water is an important mission of Environmental Engineers.

Activated carbon is a good adsorbent to remove fluoride as it has a large surface area and hence a large surface for the adsorption of fluoride. The more will be the surface, the more will be adsorption, and more will be the removal. Activated carbon is usually formed from charcoal. The main raw material used for activated carbon is any organic material with higher carbon content (coal, peat, wood, coconut shells). Granular activated carbon media is commonly produced by grinding the raw material, adding an appropriate binder to give it re-compacting, hardness and crushing to the correct size [11]. The carbon-based material is transformed to activated carbon by thermal decomposition in a furnace by using a controlled heat and atmosphere. The resultant product has an extremely large surface area / volume, and a network of submicroscopic pores where adsorption takes place. The walls of the pores give the surface layer molecules that are essential for adsorption. Remarkably, one pound of carbon (a quart container) gives a surface area equivalent to six football fields [12].

Adsorption is one of the significant techniques in which fluoride adsorbed onto a membrane, or a fixed bed, is packed with resin or other mineral particles [5]. This method is mainly used because it is cost effective, easy to operate and eco-friendly in nature [7]. The technique is also popular due to its availability of a wide range of adsorbent.This paper is an attempt to explore a possibility to utilize waste material adsorbents coconut shell and charcoal to remove fluoride from aqueous solution. The effects of contact time, particle size, GAC dosage and flow rate on fluoride removal are studied.

2. MATERIALS AND METHODS

The raw materials, reagents, and preparation method used in experimentation work are discussed below:

2.1 Reagents and Chemical Used

The SPANDS reagent is of AR (Analytical Reagents) grade and procured from Savant Instruments Pvt. Ltd, Hyderabad. Chemical NAF and Charcoal and coconut shell GAC are procured from LOBA Chemie, Mumbai. All chemicals are used as received in all experiment and distilled water is used.

2.2 Adsorbent

The coconut shell and charcoal is utilized as adsorbent in the study. Activated carbon of size less than 150 mm is used for column studies.

2.3 Preparation of Stock Solution

Stock solution of fluoride is prepared by dissolving 0.221 gm of standard sodium fluoride in one liter of distilled water. This stock solution is used to prepare required concentration of fluoride solution.

2.4 Equipment

The equipment used to detect fluoride ions is spectrophotometer. (Chemito UV2100)

2.5 Fixed-Bed Column Studies

The sorption studies are carried out in a glass column of 2.5 cm diameter and bed height of 25 cm. Four sets of column study are performed. A glass-wool plug is used in the bottom of the column to support the adsorbent bed and prevent the outflow of particles. In each set, for a given initial fluoride concentrations (2, 4, 6 and 8 mg/L) the downward flow rates are varied and maintained at (2 ml/min, 4ml/min, 6ml/min, and 8ml/min) corresponding to each of the various concentration values. The GAC of both the material is filled in the glass column in equal amount as 2+2 cm, 3+3cm, 4+4 cm. The top of the column is connected to an overhead tank containing the feed solution. The effluent is collected and analyzed for fluoride concentration. Packed bed experiments are carried out at room temperature.

3. RESULTS AND DISCUSSIONS

3.1 Effect of Bed Height

For optimization of adsorbent depth, the columns are filled with an increment of 2 cm in all four columns subsequently. The depth which gives maximum removal is the optimum bed depth. Accumulation of F ion in the fixed bed column is largely dependent on quantity of absorbent inside the column. It is observed that the removal of fluoride ion increases with an increase in the amount of adsorbent up to 6 cm depth thereafter it shows little decrease or remains constant. In present study the maximum fluoride removal has take place at 6 cm bed height and results are shown in fig. 1.

3.2 Effect of Flow Rate

For optimization of flow rate the optimized bed height 6 cm is kept constant. Flow rate is adjusted to 2 ml/min, 4ml/min, 6ml/min, and 8ml/min in four columns. The flow rate which gives maximum removal of fluoride ion is the optimum flow rate. It is observed that the removal of fluoride increases with increase in contact time to some extent. Further increase in flow rate does not increase the fluoride removal efficiency. This rapid initial increase in adsorption subsequently gives the way to a very slow approach to equilibrium and saturation is reached at flow rate 4 ml/min. The results are shown in fig. 2.

3.3 Final Analysis

Final analysis is carried out by using synthetic sample of 4mg/l fluoride concentration and using above optimized parameters i.e. bed depth = 6cm and flow rate = 4ml/min at normal temperature is kept constant and analyzed over single column. Finally by using both the adsorbent in equal quantity (granular charcoal activated carbon and granular coconut shell activated carbon) proved that it can efficiently remove 72% of fluoride from drinking water.

Table 1 Fluoride removal efficiency at initial conc. 4 mg/l

Sr. No.	Flow Rate	Adsorbent dose	Initial Conc.= 4.13 mg/l	
			Removal mg/l	Efficiency %
1	2 ml/min	3cm+3cm	1.09	26.39
2	4 ml/min	3cm+3cm	1.89	45.76
3	6 ml/min	3cm+3cm	2.97	71.91
4	8 ml/min	3cm+3cm	2.85	69.01

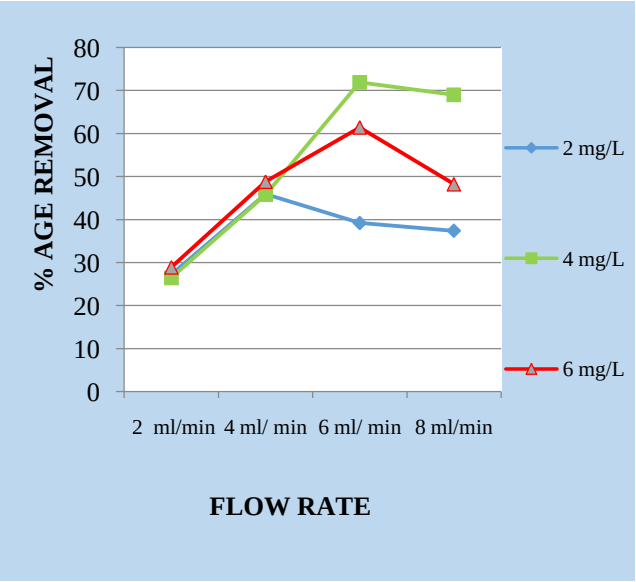

Fig. 1 Effect of flow rate at Adsorbent dose 6 cm

Table 2 Fluoride removal efficiency at varying adsorbent dose and flow rate

Sr. No.	Flow Rate	Adsorbent dose		
		2cm + 2cm	3cm+ 3cm	4cm + 4cm
		Removal Efficiency %		
1	2 ml/min	34.87	26.39	23.92
2	4 ml/min	38.60	44.76	44.27
3	6 ml/min	43.64	71.91	60.81
4	8 ml/min	45.18	69.01	57.51

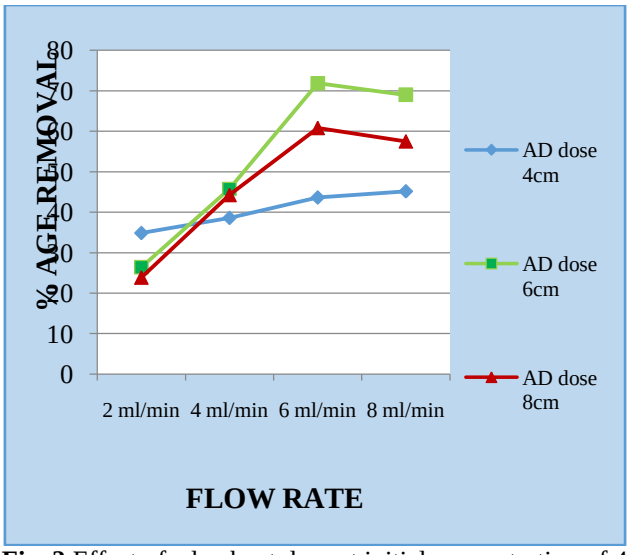

Fig. 2 Effect of adsorbent dose at initial concentration of 4 mg/L

4. CONCLUSION

Maximum fluoride removal from synthetic solution is found to be 72% by using granular charcoal and coconut shell activated carbon. Percentage removal is different for different fluoride concentrations best removal is observed at fluoride concentration of 4 mg/l and adsorbent dose of 6cm at 4ml/ min flow rate.

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