Performance of *Tinospora cordifolia* (Chittamrit) for Defluoridation of Water

Athul Haridas, Harshan K G

Abstract— An adsorption batch study was carried out by using *Tinospora cordifolia* as a bio-adsorbent for the removal of fluoride from aqueous solution. In the batch study the adsorbent size, adsorbent dosage, initial fluoride concentration and the time of contact are considered. The adsorbent is dried using the sunlight and powdered using grinder and sieved through the 300µm, 150µm, 75µm sieves to obtain the corresponding particle size. Here we applied the adsorbent dosage as 1 g/l, 2.5 g/l and 3 g/l. The initial concentration of fluoride as 3 mg/l, 5 mg/l and 7 mg/l. 5,10,15,30 and 45 minutes are taken as time of contact. The batch study shows that 150 µm sized adsorbent removed fluoride efficiently with a contact time of 30 minutes.

Keywords — Adsorption, Bio-adsorbent, Concentration, Dosage, Fluoride, Removal, Time

1 Introduction

Water is the source of life and the necessary condition for the existence of life and economic development. The quality of water resources has been declining and deteriorating in recent years [8]. Fluoride is naturally found in many of the ground water sources. Consumption of water having excess fluoride over a prolonged period leads to a chronic ailment known as fluorosis. Fluorosis is a crippling disease affecting bones, teeth and soft tissues [5]. Fluoride enters into the human body through a variety of sources like water, food, air, medicine, and cosmetics. Among these, drinking water is the most common source which makes fluoride available to human beings. Fluoride is known to have both beneficial and detrimental effects on health, depending on the dose and duration of exposure. The maximum permissible recommended concentration of fluoride as F^- in drinking water is 1.50 mg/l. Low F^- content (< 0.60 mg/l) causes dental caries, whereas high (>1.20 mg/l) fluoride levels result in fluorosis. Hence, it is essential to have a safe limit of F^- concentration of between 0.60 and 1.20 mg/l in drinking water. The Bureau of Indian Standards (BIS) prescribed a limit between 1.0 and 1.5 mg/l. In India, about 62 million people are at risk of developing fluorosis from drinking high F^- water [6]. Low amount of fluoride is necessary in the prevention of tooth decay and the development of proper bone structure in humans and animals. It is considered to be a micronutrient for humans since it prevents dental caries by decreasing the rate of demineralisation of the dental enamel or reverses the progression of existing decay by promoting the rate of remineralisation. High doses of fluoride lead to the development of dental and skeletal fluorosis, depending on the concentration of fluoride in drinking water [12].

Crippling skeletal fluorosis, which is associated with the higher level of exposure, can result from osteosclerosis, ligamentous and endinous calcification and extreme bone deformity. Evidence from occupational exposure also indicate that exposure to elevated concentration of fluoride in the air may also be a cause of skeletal fluorosis [5]. The beneficial and the detrimental effects of fluoride naturally present in water were well established by the early 1940s. High levels of fluoride present in concentrations up to 10 mg/l were associated with dental fluorosis (yellowish or brownish striations or mottling of the enamel) while low levels of fluoride, less than 0.1 mg/l were associated with high levels of dental decay, although poor nutritional status is also an important contributory factor. The level of dental caries from seven at a fluoride concentration of 0.1 mg/l to around 3.5 at a fluoride concentration of 1.0 mg/l. As fluoride concentration increased further (upto 2.6 mg/l) dental decay continues to fall, but only slightly [5]. 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. "It is estimated that around 260 million people worldwide are drinking water with Fluoride 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 states, especially Rajasthan, Andhra Pradesh, Tamil Nadu, Gujarat and Uttar Pradesh [10].

Adsorption is the preferred technique for defluoridation at community and household levels in rural areas because of its low cost and ease of operation, high efficiency, easy accessibility, environmental benignity, and needless of operational skill and electric power to run, and since adsorbents can in principle be reused and recycled making it ideal for use in less-developed rural areas. It has the added advantage that it can be applied to a decentralized water supply system. The availability of different adsorbents in large amounts and low costs make them potential candidates for the defluoridation in remote areas [12].

The present paper is an attempt to explore a possibility to utilize a bio material as adsorbent, *Tinospora cordifolia* to remove fluoride from water. *Tinospora cordifolia* is an ayurvedic plant species locally knowns as chittamrit in Kerala, India with great avaliabilty.

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2 Materials and Methods

2.1 Preparation of Adsorbent

Tinospora cordifolia is the member of Meninspermaceae family. It is easily available. The stem of the *Tinospora cordifolia* is used as bioadsorbent was first washed with distilled water to remove impurities. It is dried in sunlight, and then it is powdered with the help of grinder and sieved through 300 micron, 150 micron and 75 micron to obtain the respected particle size of adsorbent.

2.2 Preparation of Fluoride Solution

The required sample solution is made up by diluting the Fluoride standard solution traceable to SRM (Standard Reference Material) from NIST (National Institute of Standards and Technology) NaF in H_2O, Made in Germany, EMD Millipore Corporation.

2.3 SPADNS Spectrophotometric Method

This method relies on the fact that when fluoride reacts with certain zirconium dyes, a colourless complex anion and a dye are formed. The complex, which is proportional to the fluoride concentration, tends to bleach the dye which therefore becomes progressively lighter as the fluoride concentration increases.

2.4 Batch Study

In order to study the effect of different controlling parameters like contact time, initial fluoride concentration, adsorbent size and adsorbent dosages on defluoridation capacity of *Tinospora cordifolia*, adsorption studies are carried out by a batch process. Batch experiments were conducted using a total sample volume of 1000 ml for each adsorption run. The samples were agitated in a reciprocating shaker.

3 Result and Discussions

3.1 Effect of Adsorbent size

The study of the effect of adsorbent size on the fluoride removal efficiency was carried out by using 75 µm 150 µm 300µm.

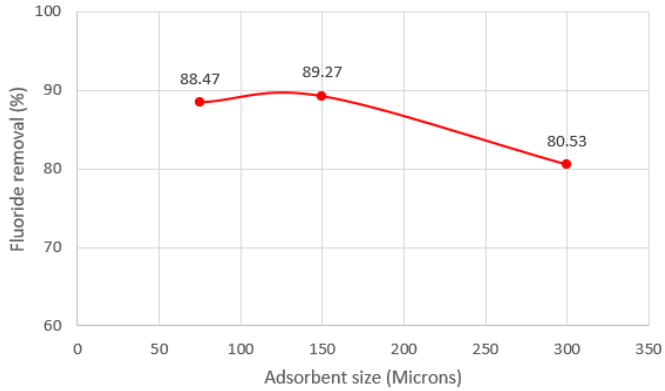

Fig. 1 Effect of Adsorbent size on the removal efficiency of Fluoride.

Figure 1 shows the effect of adsorbent size on the defluoridation capacity of the adsorbents. A maximum of 89.27% removal is obtained for the 150 µm sized adsorbent and 88.47% removal is obtained for 75 µm sized adsorbent, but considering the 300 µm sized adsorbent the removal declines to 80.53%.

3.2 Effect of Adsorbent Dosage

The study of the effect of adsorbent dosage on the fluoride removal efficiency was carried out with a dosage of 1 g/l, 2.5 g/l and 3 g/l. Figure 2 shows the effect of adsorbent dosage on the defluoridation capacity of the adsorbents.

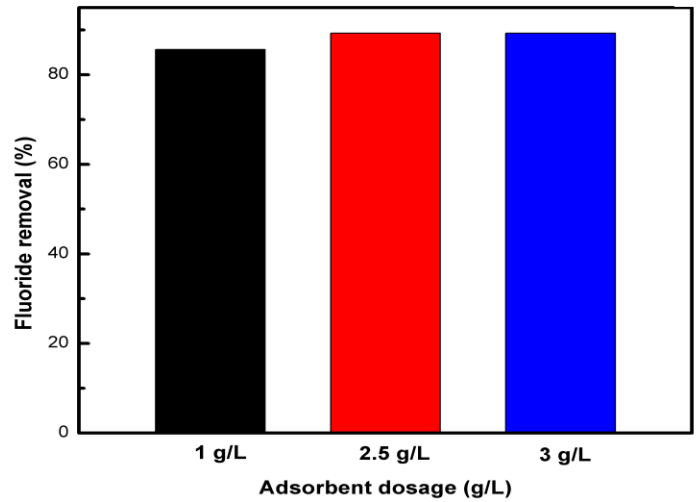

Fig. 2 Effect of Adsorbent dosage in g/l on the removal efficiency of Fluoride.

The 2.5 g/l and 3 g/l adsorbent dosage show 89.27% fluoride removal which is more than that of 85.63 % for 1 g/l adsorbent dosage. After 2.5 g/l dosage the removal is stable which means that 2.5 g/l adsorbent dosage gives us the optimum value.

3.3 Effect of Initial Fluoride Concentration

The effect of initial concentration on the extent of removal of the fluoride was studied by varying the concentrations from 3 mg/l, 5 mg/l and 7 mg/l. While keeping the adsorbent size as 150 µm and adsorbent dosage as 2.5 g/l. The results obtained were plotted as percentage removal of fluoride versus initial concentration of the fluoride ion in the solution as shown in Figure 3.

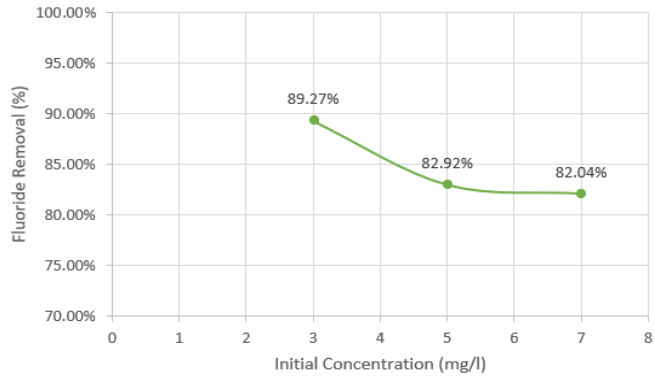

Fig. 3 Effect of Initial concentration in mg/l on the removal efficiency of Fluoride.

As can be seen from Figure 3, the percentage removal of the fluoride ion has decreased with an increase in initial concentration of the fluoride ion. A high removal of 89.27% was observed for an initial concentration of 3mg/l. 82.9% and

82.04% removal is observed in 5mg/l and 7 mg/l respectively.

3.4 Effect of Contact Time

The study of the effect of contact time on the fluoride removal efficiency was carried out by varying it from 5 to 45 minutes, keeping the adsorbent size as 150 µm, adsorbent dosage as 2.5 g/l and with an initial concentration of 3 mg/l. Figure 4 shows the effect of contact time on the defluoridation capacity of the adsorbents.

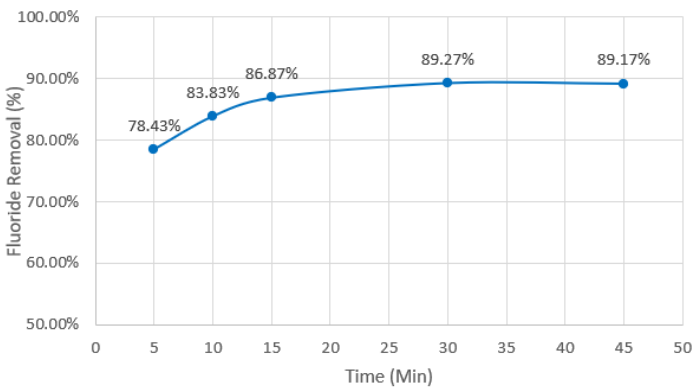

Fig. 4 Effect of time on the removal efficiency of Fluoride.

As contact time increases percent removal also increases initially and gradually attains almost an equilibrium condition in nearly 30 minutes. A maximum of 89.27% removal could be accomplished by *Tinospora cordifolia.*

4 Conclusion

The present work deals with the use of batch studies on adsorption of fluoride on *Tinospora cordifolia.* The optimum contact time for fluoride was found to be 30 minutes with the maximum efficiency of 89.27% at 2.5 g/l dosage. The 150 µm sized adsorbent shows more efficient than the other sized absorbent. The solution with initial concentration 3 mg/l removes fluoride from the solution. The bioadsorbent *Tinospora cordifolia* used for removal of fluoride from water in present study is easily available plant material, also plant possesses medicinal properties. By using this plant as adsorbent, it is very economical to do the defluridation process.

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