Defluoridation of Drinking Water–Fluoride Wars

G. Gayathri, M. Beulah, H. J. Pallavi, and K. Sarath Chandra

Abstract Fluorine is also known as two-edged sword. At lower doses, it influences tooth by inhibiting tooth caries, while in high doses, it causes dental and skeletal fluorosis. It is known that some quantity of fluoride is important for the formation of tooth enamel and mineralization in tissues. The present work aims at providing safe and potable water to rural areas where this element has created a menace. This work also suggests the use of few adsorbents such as paddy husk and coir pith which are affordable and removes fluorine to greater extent. The study concludes that materials which are used as adsorbents and can be safely inculcated as fluorine removal adsorbents which help people to have safe potable water.

Keywords Fluorine · Potable water · Ground water · Contamination

1 Introduction

Fluorine is the most electronegative element in the periodic table and has much impact confiding on its application. The component is transfigured together in distinction with compounds that are electrovalent and covalent. By growing the size of the apatite crystals and their solubility, low doses of fluoride stimulate the skeletal system. Approximately, 95% of the fluoride is in hard tissues and even after other bone constituents have achieved a steady state, it seeks to be in harden indurate [1].

Health impacts from prolonged intake of fluoride-contaminated water are:

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- < .5 mg/L: dental problem
- 0.5–1.5 mg/L: inhibits dental health
- 1.5–4.0 mg/L: dental fluorosis;

The furnishing of fluoride free (<1.5 mg/L) potable water can curtail the pathological state associated to fluoride malignancy [2]. The supply of water from rivers for drinking to the residents of distant villages is impervious due to the huge capital obligation for changing technology. The easy and affordable strategy to have secure drinking water is the therapy of high fluoride polluted(>1.5 mg/L) ground water. Accordingly, the defluoridation of potable water is the only feasible alternative choice to get the better of immoderate fluoride in drinking water [3]. Lots of work has been conducted on various methods of extracting fluoride from water and detection of fluoride as the root of fluorosis [4].

The methods are.

(1) Precipitation–coagulation.
(2) Sorption
(3) Ion-exchange
(4) Membrane separation
(5) Electrochemical methods.

In India, fluoride in the water affects Tamilnadu, Uttar Pradesh, Andhra Pradesh, Bihar, Chhattisgarh, Haryana, Orissa, Rajasthan, Madhyapradesh, Punjab, Karnataka, and West Bengal. This involves about 10,000 villages impacting 35 million people [5]. In the table below, the fluoride content of the water in some villages is given.

There are multiple causes of water accumulation of fluoride concentration. Tilling up of shallow aquifers has contributed to low levels of groundwater, so that aquifers containing excessive fluoride are in volume [6] (Table 1).

Fluoride Distribution in Karnataka State

In Karnataka, in ground water, fluoride varies from 0 to 8 mg / l. Groundwater usually displays values within the acceptable limits of the Bureau of Indian Drinking Water

Table 1 Fluoride concentration in distinct states of India [2]

Place	Fluoride in PPM
Himachal Pradesh	0.2–6.5
Jammu and Kashmir	0.2–18
Rajastan	>1.5
Haryana	0.2–0.6
Bihar	0.35–15
Orissa	8.2–13
Maharashtra	0.7–6.0
West Bengal	12.0
Chhattisgarh	15–20

Table 2 Concentration distribution of fluoride in Karnataka

Place	Fluoride in mg/lt
Gulbarga	4.6
Raichur	4.18
Bellary	3.32
Tumkur	1.82
Chitradurga	2.29
Kolar	2.21

Requirements from the districts of Belgaum, Bidar, Dakshina Kannada, chickamagulur, Kodagu, Hassan, Udupi, Shimoga, and Uttar Karnataka. Parts of the Bellary, Bijapur, Chitradurga and Gulbarga, Kolar, Mandya, Mysore, and Raichur districts have elevated levels of fluoride content above the permitted limits [7] (Table 2).

Sources of Fluoride and Optimum Intake

There is no across the board optimal level for the daily intake of fluoride that enhances shielding against tooth decay while diminishing other risks, but the permissible limit is 0.05–0.07 mg of fluoride. Sources of fluoride for human consumption include tea, meat, fish, cereals, and fruits. Fluoride is also imbibed from toothpaste and other oral solutions. The concentration of fluoride in farm crops and other foodstuffs is listed below in Table 3. Though fluoride ingestion into the body is through various sources, the optimum intake can be achieved by limiting its levels in water rather than in food. Therein lies the importance of defluoridation of drinking water. High fluoride impacts have been reported in ground waters of over 23 countries. The problem of acute fluorosis in 19 states is faced by developed and developing countries, including India. Fluorine is one of the most common inorganic natural pollutants present in ground water in India (Table 3).

In India the need of the hour is defluoridation rather fluoridation. In thousands of villages in our country, fluoride level is so high that the water is unsafe to drink. More than 25 million people in our country are affected by fluorosis [8]. Using some materials as adsorbents like Amla was performed & inferred it can be a effective adsorbent [9]. Bagasse dust (BD), bagasse flyash (BF), aluminum treated bagasse flyash (ABF), buffalo bone powder (BP) and clam shell powder is used for groundwater containing fluoride (SP) [4]. One of the inborn substitutes for defluoridation of water is Moringa Oleifera., optimal dose of adsorbent was determined. From the

Table 3 Fluoride concentrations (mg/g or mg/kg) in agricultural crops and other edible items [3]

Food	Amount (g)	Fluoride (mg)	Food item	Amount (Kg)	Fluoride (mg)
Rice	100	3.5	Wheat	1	4.6
Tea	100	1.41	Rice uncooked	1	5.9
Coffee	100	5.0	Apple	1	5.7
Noodles	100	4.6	Rock salts	1	200–250

results obtained, it can be concluded that Moringa Oleifera can become an affordable alternative for defluoridation of water [10].

2 Materials and Methods

The present work aims at emerging an affordable and safe method of defluoridation which can reach any common lame person. Affordable and non-toxic adsorbents that are locally available are used and batch tests are performed. Husk Paddy powder. Coir pith powder of mixed different proportions is used for conducting experiments.

2.1 *Physical and Chemical Characteristics of Adsorbents*

Paddy husk. An enhanced adsorbent paddy husk is used as an adsorbent in this present work [11]. The impact of different parameters like adsorbent dosage, pH, initial concentration of fluoride ions, contact duration, presence of other interfering anions was studied [13].

Coir pith. The coir pith is the soft component that connects the coir fiber in the husk. The structure and properties of the coir pith vary depending on the maturity of the coconut, the method of unsheathing and disposal, the time period between extraction, usage, and environmental factors.

The Advantages of Coir Pith Are

- High water holding capacity
- Excellent moisture retention
- Greater physical resiliency.
- Excellent aeration providing enhanced root penetration.

2.2 Methodology

Paddy husk was crushed in a grinder to get a uniform grain size 1.6–1.8 mm. Sieve analysis was performed to obtain the size consistency. Coir pith was crushed in a grinder to get a steady grain size of 1.6–1.8 mm.

Batch Experiments

50 ml of water was applied to the specified concentration of adsorbent. The initial CF concentration was about 2.5 mg/l. The mixture was perturbed by the application of magnetic stirrer and fluoride concentration was determined using SPADN method. The investigation is recurred at various time interims for two adsorbents in application. The results are compiled and charted. It is floated that the initial fluoride strength substantially turned down and nearer to the allowable standards (Figs. 1 and 2).

At different time intervals and different flow rates, batch measurements are performed. In batch tests, the length of time for which non-toxic and inexpensive adsorbents are used is the only parameter monitored (Fig. 3).

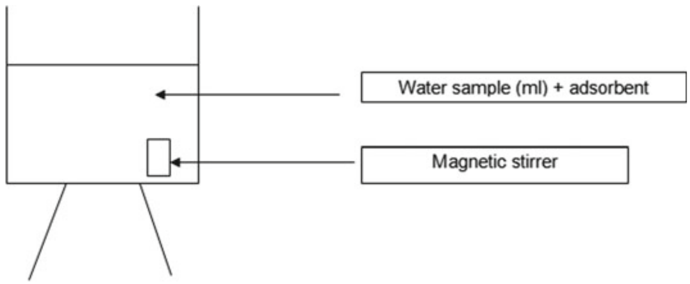

Fig. 1 Batch experiment, experimental setup

Fig. 2 Spectrophotometer UV

Fig. 3 Magnetic stirrer

3 Results and Discussions

This work concludes the defluoridation of water which included a detailed study and assessment and application of different adsorbents to contain fluoride in drinking water.

3.1 Results of Batch Experiments

Paddy husk 1.6–1.8 mm grain powder was taken and fluoride was analyzed and found that 1 gm of paddy husk powder decreased from 2.5 to 0.95 mg/l. As a material for defluoridation, paddy husk may also be used. But it slightly imparts colour to the defluoridated water that has not been taken and certified to undergo batch processing. Different quantities of paddy husk powder of 0.5 and 1 gm were added and a batch process was conducted. Fluoride was tested and it reduced by 0.5 gm of paddy husk powder from 2.5 to 1.15 mg/l.

Coir pith powder 1.6–1.8 mm grain powder was taken and allowed to undergo batch experiment. Various amounts of 0.5 gm and 1 gm of coir pith powder were added and the batch process was performed. Fluoride in 0.5 gm of coir pith powder was measured and decreased from 2.5 to 1.4 mg/l. Fluoride was calculated in 1 gm of coir pith powder and the decrease was observed from 2.5 to 0.9 mg/l. Coir pith may thus also be used as a material for defluoridation. However, it imparts color slightly to flourine removed water, which is not detrimental to health, but color removal methods can be suggested (Tables 4 and 5).

Table 4 Batch experiment results using paddy husk as adsorbent

Sl. No.	Initial Cf in mg/l	Final Cf in mg/l		Adsorbents/paddy husk (g)		Time in sec
1	2.5	2.4	1.26	0.5	1.0	900
2	2.5	1.8	1.1	0.5	1.0	1800
3	2.5	1.71	1.0	0.5	1.0	2700
4	2.5	1.15	0.95	0.5	1.0	3600

Table 5 Batch experiment results using coir pith as adsorbent

Sl. No.	Initial Cf in mg/l	Final Cf in mg/l		Adsorbents /coir Pith (g)		Time in s
1	2.5	2.2	1.5	0.5	1.0	900
2	2.5	1.7	1.3	0.5	1.0	1800
3	2.5	1.5	1.0	0.5	1.0	2700
4	2.5	1.4	0.9	0.5	1.0	3600

3.2 Results of All Used Adsorbents Are Graphically Tabulated as Follows

The above figure shows the fluoride intensity in water, Where Cf decreased rapidly for about 15 min and for 60 min steadily reached a constant value. By using a higher dose of adsorbent and performing a batch experiment, a constant value of 1.4 mg / hence coir pith can be used as one of the adsorbents for the defluoridation of drinking water. But, after the defluoridation process, it imparts color along with little turbidity. By using activated charcoal, rice bran, rice husk and bran and husk mixture, various techniques have been developed and suggested by Researchers for color removal (Figs. 4 and 5).

The above figure indicates that the fluoride concentration rapidly decreased for 15 min when particle 1.6–1.8 mm paddy husk was used and batch testing was

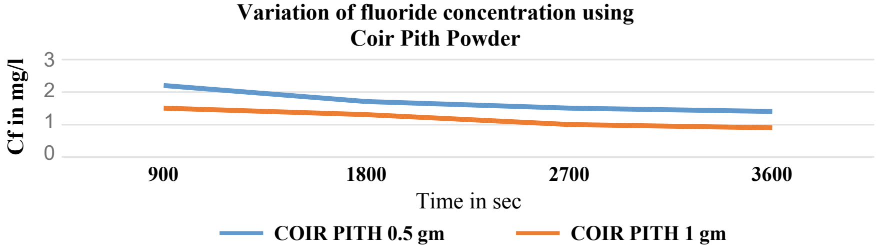

Fig. 4 Differentiation of fluoride intensity in water Cf in batch investigation with time t. Cf = 2.5 mg/l, particle size = 1.6–1.8 mm, added adsorbent mass = 0.5 g, 1.0 g, 1.5 g.adsorbent-coir pith

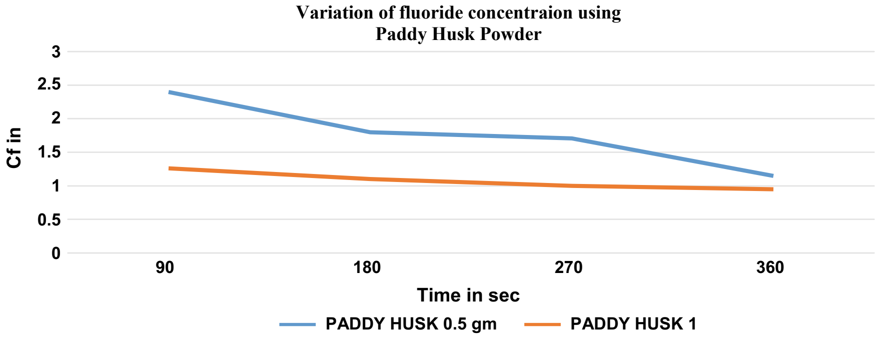

Fig. 5 Differentiation of fluoride intensity in water Cf in a batch investigation with time t. Cf = 2.5 mg/l, particle size = 1.6–1.8 mm, added adsorbent mass = 0.5 g, 1.0 g, 1.5 g. Paddy husk is adsorbent

performed and obtained a constant value of 1.1 mg/l at 2900 s. After defluoridation, the water achieved a constant value with an initial concentration of 2.5 mg/l, indicating that it could be used as a defluoridating agent. In grammes, weights of distinct proportions were introduced and variation was observed. During the process, the water is defluoridated but methods are to be developed for color removal.

4 Conclusions

The aim of this work is to establish a rural-level system for drinking water defluoridation. Several methods for extracting fluorine have been developed that require costly and sophisticated equipment. These cannot be met by the common man at the rural stage. Consequently, an attempt was made to test the defluoridation study. Thus, also in rural areas, fluorine removal is feasible at a significantly affordable rate. The removal capability has also improved as the particle size has improved. This technique is readily available for simple adsorbents. Paddy husk and coir pith have been shown to be efficient for defluoridation. When used as an adsorbent, the fluoride concentration has decreased and is therefore sufficient for this phase.

The desirable grain size of coir pith powder was obtained and it was found to be a cost-implementative method of minimizing drinking water fluorine. In addition, both adsorbents with the greatest defloridizing potential are ideally matched to the adsorbent used in the batch experiment. However, for defluoridation, all adsorbents may be used, but methods for color removal and turbidity must be created.

Therefore, this research can show that many such adsorbents can be used for drinking water defluoridation. At domestic and rural levels, this can be used. The method is so simple that no expensive, non-available chemical substances are needed. Fuel is not required, and this is eco-friendly. Such methods of using adsorbents are both non-toxic and safe.

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