WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.074
Volume 7, Issue 5, 477-484. Review Article ISSN 2277– 7105

DEFLUORIDATION OF WATER BY NATURAL ADSORBENTS –A SCIENTIFIC REVIEW

***[1]Wasnik Vidya and [2]Patrikar V. G.**

[1]Associate Professor, Department of Swasthavritta and Yoga, Govt. Ayurved College Nagpur.

[2]Professor and HOD, Department of Swasthavritta and Yoga, Govt. Ayurved College Nagpur.

Article Received on
11 January 2018,

Revised on 31 Jan. 2018,
Accepted on 21 Feb. 2018,

DOI: 10.20959/wjpr20185-11284

***Corresponding Author**
Dr. Wasnik Vidya
Associate Professor, Department of Swasthavritta and Yoga, Govt. Ayurved College Nagpur.

ABSTRACT

Introduction: In india the most common cause of fluorosis is high fluoride content in drinking water. Water derived from the borewells and Wells which dug deep into the earth mostly contain the high concentration of fluoride and if the concentration of fluoride exceeds 2 ppm (part per million) it causes dental or skeletal fluorosis which is now became a worldwide problem. Various techniques have been tried to defluoridate the water i.e. Coagulation, Adsorption, Precipitation, reverse osmosis and electrodyalysis. There are some Indian medicinal plants which may have the property as bicarbon absorbent for fluoride. **Aim:** This study was aimed to review and study the literature about defluoridation of water and to find out the effect of herbal medicinal plants as a natural adsorbent in reducing the fluoride content of water. **Material and Methods:** The literature about water purification techniques and defluoridation of water was studied. The studies related to defluoridation of water with the help of natural sources like plants have been critically evaluated. Different defluoridation techniques i.e Ion exchange, Precipitation and Adsorption technique have been reviewed. **Result:** Vetiver root**,** Tamarind seed, clove these are the commonly used medicinal plant in India have the property as a bicarbon absorbent for fluoride. Drumstick i.e. Moringa oleifera, also plays an important role in reducing the fluoride content of water. **Conclusion:** Plants plays an important role in reducing the fluoride content of water and thereby provide a domestic and inexpensive way to defluoridate water and helpful for the prevention of Fluorosis.

KEYWORDS: Dental Fluorosis, Defluoridation, Vetiver root Tamarind seed, Drumstick etc.

INTRODUCTION

In India near about 17 states are indentified as endemic for dental or skeletal fluorosis of which approximately 25 million people are impacted and 66 million are at risk.[1] In india the most common cause of fluorosis is high fluoride content in drinking water. Water derived from the borewells and Wells which dug deep into the earth mostly contain the high concentration of fluoride and if the concentration of fluoride exceeds 2 ppm (part per million) it causes dental or skeletal fluorosis which is now became a worldwide problem.[2] In some countries like US the fluoride content of water is on lower side and they are purposefully trying to fluoridate water as it also causes health problems. A study conducted in Tibate in 2003, found that the high intake of fluoride i.e. 9 to 12 mg/day was associated with advanced skeletal fluorosis.[3] US health authorities also estimated that the daily dose of fluoride in fluoridated communities in the west ranges from 1.6 to 6.6 mg/day (DHSS 1991) which causes the early stages of fluorosis. This shows the proximity in doses causes advanced fluorosis in the east (9-12mg/day) and early fluorosis in the west (1.6 -6.6 mg/day).[3]

Developmental disturbance of dental enamel caused due to excessive exposure to high concentration of fluoride is called as Dental Fluorosis. The risk of dental fluorosis generally occurs between the age of 3 months and 8 years. At first, the tiny white streaks or specks are appear on the enamel of the tooth which is generally unnoticeable. In severe fluorosis tooth appearance is marred by discoloration or brown markings. The enamel becomes pitted, rough and hard to clean. The spots or stains occur due to fluorosis are permanent and going to be more darken over time.[4] If the overexposure continue it leads to the aesthetic changes in the permanent dentition.

Over exposure to the fluorosis also leads to the skeletal fluorosis which is difficult to diagnose at the early stages. There is always misdiagnosis regarding the early stage of skeletal fluorosis as the sign and symptoms are similar to the arthritis or osteoarthritis i.e. pain and stiffness in the joints.[5]

According to the executive director of Fluorosis Research and Rural Development Foundation A.K. Susheela, a large no. of patients are directed to the foundation since tests for fluoride were not a part of the routine blood and urine tests conducted at govt. hospitals.

Meanwhile the patient may develop the non skeletal fluorosis which affects the soft tissues in the body which leads to the other health problems in a very short time interval. [6]

Various techniques have been tried to defluoridate the water i.e. Coagulation, Adsorption, Precipitation, reverse osmosis and electrodyalysis. There are some Indian medicinal plants which may have the property as bicarbon absorbent for fluoride.

Fluorosis affected enamal

The severe Skeletal Fluorosis

Deans Index	
Classificatiom	**Criteria – description of enamel**
Normal	Smooth, glossy, pale creamy-white translucent surface
Questionable	A few white flecks or white spots
Very Mild	Small opaque, paper white areas covering less than 25% of the tooth surface
Mild	Opaque white areas covering less than 50% of the tooth surface
moderate	All tooth surfaces affected; marked wear on biting surfaces; brown stain may be present
Severe	All tooth surfaces affected; discrete or confluent pitting; brown stain present

MATERIAL AND METHODS

The literature about water purification techniques and defluoridation of water was studied. The studies related to defluoridation of water with the help of natural sources like plants have been critically evaluated. Different defluoridation techniques i.e Ion exchange, Precipitation and Adsorption technique have been reviewed.

Defluoridation of water: It is defined as the downward adjustment of the fluoride content of water to the optimal level. Various techniques have been tried to defluoridate the water throughout the world. Defluoridation technique can be broadly classified into four techniques as

1. Adsorption technique
2. Ion exchange
3. Precipitation
4. Other technique which include electro chemical defluoridation and reverse osmosis.

1. Adsorption technique

Adsorption is defined as the change in concentration at the interfacial layer between the two phases of a system by surface forces. Adsorption is a mass transfer operation in that a constituent in liquid phase is transfer to the solid phase. The adsorbate is a substance that is being removed from the liquid phase and transfer to the solid phase. The adsorbent is the solid, liquid or gas phase onto which the adsorbate is accumulated. The adsorption technique is depends on the following i.e

a. Surface area
b. PH
c. Nature of adsorbate
d. Temperature
e. Presence of mixed solute
f. Nature of adsorbent.

A study by A.S. Parikar and Mokashi shows that the seed of Moringa oleifera (Drumstick) which is commonly found in India and Sudan plays an important role in reducing the fluoride content of water. its active ingredient is dimeric protein. The protein powder is totally soluble in water and is stable. In this study the synthetic sample of water containing fluoride is prepared and used for experimental purpose of defluoridation of water. [7] 40 gm of Drumstic powder was added to 400 ml of 1NHNO3 for acid treatment and 0.5N NAOH for alkali treatment. The mixture was boiled for about 20 mints. Washing of the powder sample was carried out by using distilled water until maximum colour was removed and clear water was obtained. Finally it was dried again at oven at 50 0 c for 6 hrs.

- The nitric acid (1NHNO3) was used for acid washing of adsorbent.
- The sodium hydroxide (0.5 N NAOH) was used for alkali washing of adsorbent.
- For fluoride detection studies with spectrophotometer, various solutions were prepared.
- Reference solution was prepared by using conc. Hydrochloric acid (Hcl), SPADNS reagent zirconyl chloride, octahydrate reagent were used.

A study by P.S, Harikumar investigated the defluoridation capacities of the localy available plants like Vetiveria zizaniods, tamarind seeds, clove (Eugenia carryophyllata), Neem (Azadiracta indica), Acacia (Acacia catechu), Nutmeg (Myristica Fragrans) and coffee husk (cofea arabia).[8] In this the batch adsorption study was carried out. The batch experiments

were carried out in 250 ml stoppered bottles by agitating a pre weighted amount of the adsorbent with 50ml of the fluoride solutions.[9] The adsorbent were separated with the filter paper. The concentration of fluoride remaining in the filtrate was analyzed spectrophotometrically, using SPADNS reagent at 570 nm.[10]

2. Ion exchange technique

Different types of resins have been used in chloride and hydroxyl form. The fluoride exchange capacity of these resins depends on the ratio of fluoride to total anion in the water.

3. Precipitation Technique

In this method the chemicals like coagulants and coagulant aids and the subsequent precipitation of a sparingly soluble fluoride salt as insoluble fluorapatite are used for the removal of fluoride content of the water. Fluoride removal is accomplished with the separation of solids with the liquid. Alum, lime. Poly alluminium chloride, poly aluminium hydroxy sulphate and brushite are some of the frequently used materials in defluoridation of water by precipitation technique. The famous Nalgonda technique is the best example of precipitation technique.

Nalgonda technique

National environmental engeneering research institute (NEERI), Nagpur has evolved an echonomical and simple method for removal of fluoride which is refered to as Nalgonda technique(Nawlakhe et al 1974). In this process there is a addition of sodium alluminate (alum), lime and bleaching powder to the fluoride content water followed by flocculation, sedimentation and filtration. This technique is more useful for domestic as well as community water supply.

4. Other defluoridation techniques

The other techniques like reverse osmosis and electro dialysis are also used for the defluoridation of water. In RO (Reverse osmosis) the hydraulic pressure is exerted on one side of the semi permeable membrane which forces the water across the membrane leaving the salt behind. The relative size of the pollutant left behind depends on the pressure exerted on the membrane.

In electro dialysis: The membrane allows the ion to pass but not the water. The driving force is an electric current which carries the ion through the membrane. (Hall and Crow, 1993).

Defluoridation by electrolysis: The basic principal of the process is the adsorption of fluoride with freshly precipitated aluminum hydroxide, which is generated by the anodic dissolution of aluminum or its alloys in an electro chemical cell.

RESULTS AND DISCUSSION

It was observed that the root of Vetiver, Tamarind seed powder, Clove and Drumstick removed the Fluoride by 80%, 75%, 70% and 49.5% respectively from the water containing fluoride 2mg/L. Fig. 1 The fluoride removal efficiency is depends on the adsorption capacity of these plants.

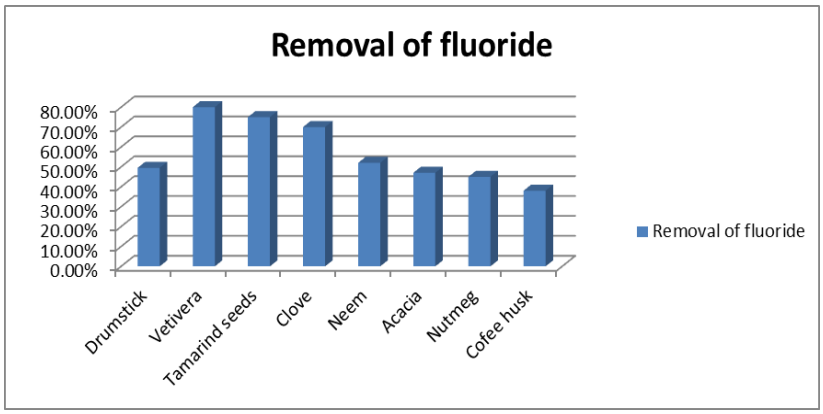

Fig.1Fluoride removal efficiencies by different plants.

Effect of Agitation time: Tthe rate of adsorption is constant after certain time period. In Fig.2 shows that the Vetiver root, Tamarind seed, Clove and Moringa Oleifera (Drumstick) removed the Fluoride content of the water as 54%, 51%, 51%, and 62% respectively. The adsorption rate goes on increasing with the time and at particular time it goes constant. No further adsorption takes place after this time. Near about after 120 to 150 minutes the adsorption of all these plants become constant.

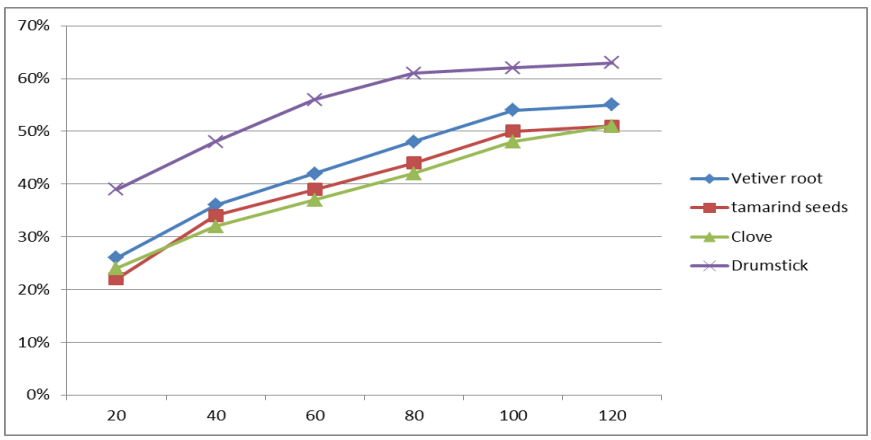

Fig. 2: Effect of Agitation time on Defluoridation of water.

Effect on adsorbent dose

If the weight of the adsorbent dose is increases the adsorption percentage also increases. Fig.3 shows that Vetiver root, Tamarind seed, Clove and drumstick remove the fluoride by 80%, 75%, 70% and 68% respectively. If the dose of adsorbent is higher, more the sorbent surface and therefore higher the rate of removal of fluoride. The removal of fluoride is increases with the dose of adsorbent but at particular dose and time it becomes constant i.e. there is no significant increase in the rate of adsorption. At a dose of 2.5gm/liter the vetiver root removes the fluoride about 80%.

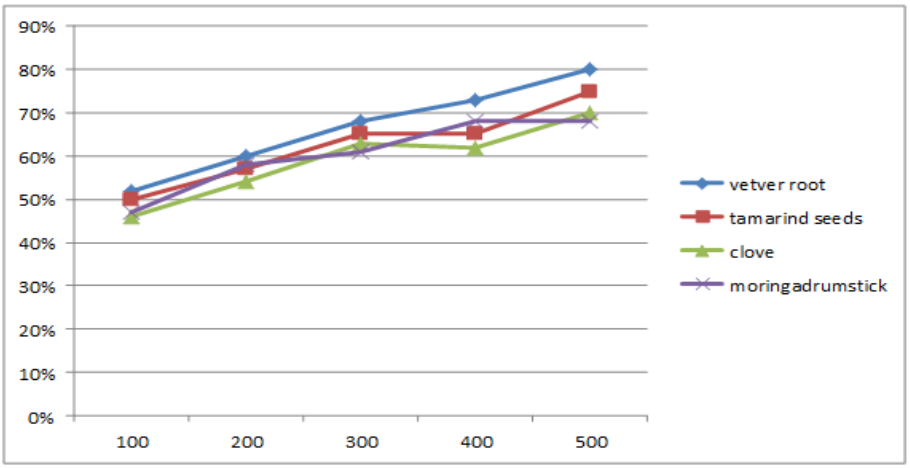

Fig. 3: Effect of Adsorbent Dosage on Defluoridation.

CONCLUSION

- Among all the studies done, Vetiver root, Tamarind seed and Clove was found to be better for the Defluoridation of water.
- Defluoridation of the water with the natural adsorbents like plants is the Economical and highly efficient process as compare to the other Techniques.
- Defluoridation by adsorption increases as the pH of water increases.
- The removal by Adsorption is optimum at adsorbent dose from 400 to 500 mg/lit.
- Adaptable to the domestic use.
- Thus helpful for the prevention of Fluorosis.

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