ISSN: 2581-8651
Vol-5, Issue-2, Mar-Apr 2023
https://dx.doi.org/10.22161/jhed.5.2.1
Peer-Reviewed Journal

Journal of Humanities and Education Development (JHED)

Mitigation of Fluoride Contamination from Drinking Water through Fluoride Removal Techniques: A Review

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Received: 19 Jan 2023; Received in revised form: 25 Feb 2023; Accepted: 03 Mar 2023

Abstract

Water is the most vital natural resource for the survival of human being and environment on the earth surface. But Fluoride contamination of water has become a widespread and serious problem all over the world including India. Supplying the right amount of fluoride to drinking water protects the teeth from decay and reduces the risk of cavities. Exposure to fluoride beyond the recommended level for longer duration causes both dental and skeletal fluorosis. Health is the most important issue for the citizens of any country and consequently healthy citizens are the perfect and biggest assets for a nation. This paper reveals the techniques of Eradication of excessive fluoride from water. Various alleviation programmes and strategies to regulator the fluorosis and to eliminate the fluoride from water have been piloted all over the world using defluoridation. Nalgonda procedure is one of the well-known strategies generally utilized for defluoridation of water as a part of developing nations, for example, India, Kenya, Senegal and Tanzania. Among different techniques utilized for defluoridation of water, the adsorption procedure is broadly utilized.

Keywords*— *Fluoride, Defluoridation , Adsorption, Reverse osmosis , Electro Dialysis

I. INTRODUCTION

Fluoride is non-biodegradable element that is the most phototoxic among contaminants. It accumulates in plants as well as in soil and water both from low to high concentration (Fornasiero, 2001). High concentration of fluoride is a serious issue in India also, as the main source of drinking water in India is groundwater in both urban and rural areas. Fluoride is a calcium seeking element that is considered to be a very beneficial for human health in minute quantity as it prevents dental carries. The fluoride intake in excess through air, water and food causes several health problems in human being including dental fluorosis and skeletal fluorosis. Major source of fluoride in human body is drinking water, that is why a maximum acceptable concentration of fluoride in drinking water has been determined by WHO i.e. 1.5 mg/l. Dental fluorosis may cause of mottled enamel and discoloration of teeth in children (Boulétreau et. al; 2006). Many natural and anthropogenic sources increase the fluoride contamination. It is produced in the water and soil naturally with the chemical degradation of the fluoride containing minerals. Volcano is the main natural source of fluoride in water and soil(Gaciri & Davies ,1993). The fertile structure of the soil is affected by high soil fluoride concentration by preventing decomposition of organic substances. After SO_3 and O_3, fluorine is generally regarded as the third most important air pollutant. The industrial sources of fluoride compounds are from the production and use of phosphate fertilizer and pesticide, the production of steel, glass, ceramic and glue, the processing of copper, nickel and phosphate and burning of coal. These industries emit the fluorine compound and these compounds reach the soil through many processes.

Steps to Remove Fluoride from water:

Defluoridation Techniques

The process of removal of fluoride ion from water is called defluoridation. Various methods are available for defluoridation to overcome the dangerous impact of fluorosis. Each approach has their limitations and advantages and worked effectively under perfect environment to remove fluoride.

There are some low costs methods for domestic use. On a community scale e.g.the Nalgonda process, Bone charcoal and Calcined clay. If a high fluoride removal is necessary then electrodialysis, activated alumina and reverse osmosis are preferred methods. For brackish water only reverse osmosis, electrodialysis and the Water Pyramid/Solar Dew method can be used (L.Feenstraet al.,2007)

Flow chart of different water fluoride removal techniques

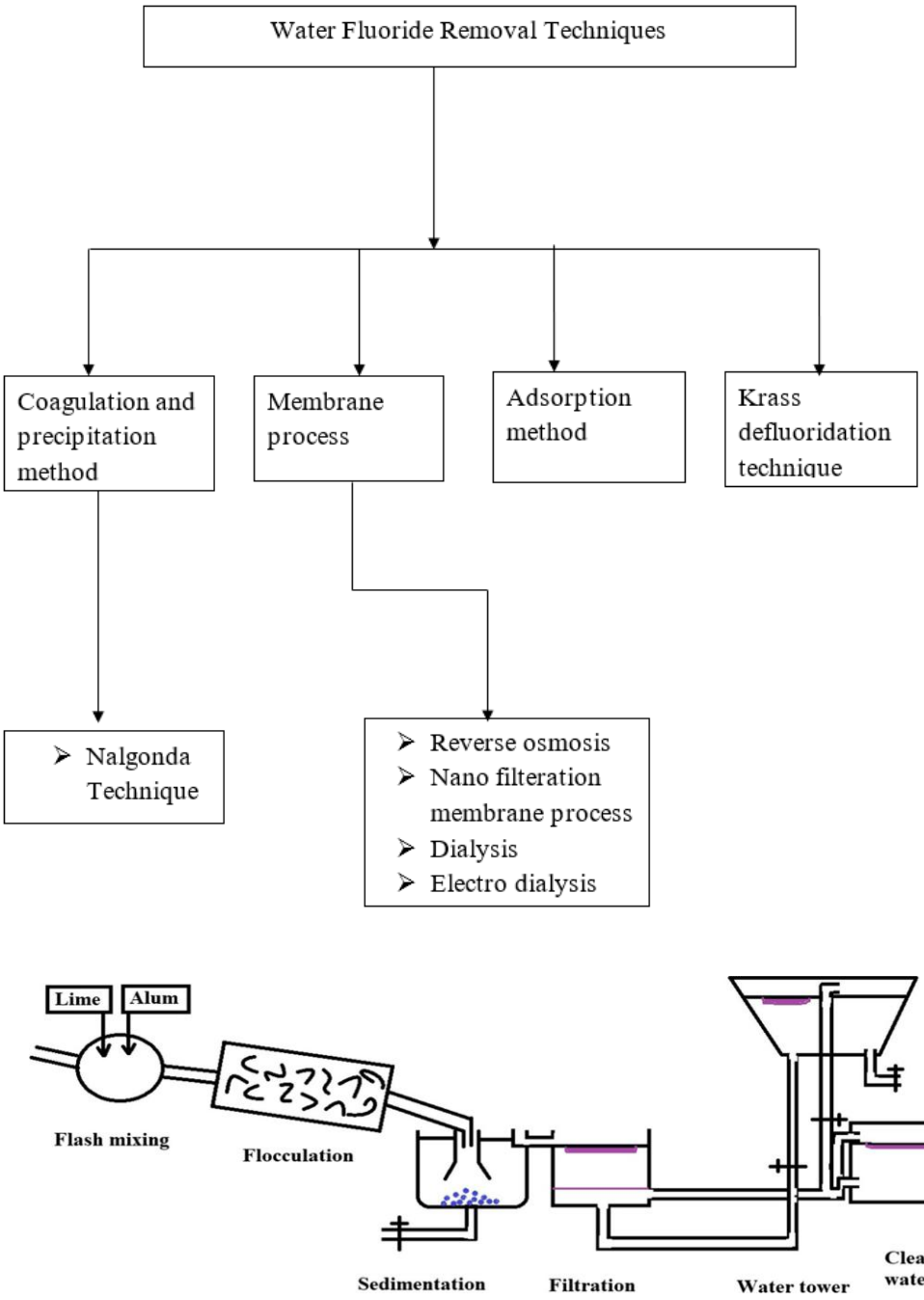

Fig. A conventional Nalgonda technique first time implemented in Andhra Pradesh, India (P Senthil Kumar,2019)

Nalgonda Technique (Nawlakhe et. al; 1978; Bulusu et.al; 1979)

In India, Nalgonda technique is a renowned technique to remove the fluoride ion from water. This is coagulation and precipitation method. National Environment Engineering Research Institute (NEERI) developed this technique in 1961 to serve at community and household level. Its low cost and simplicity makes it more useful. Aluminum salt, lime and bleaching powder are used in this method. Aluminum salt is responsible for the removal of fluoride from water. The bucket defluoridation system has also been designed for household utilizes. This process has capacity to defluoride 20 liters of water for one day utilization. After processing this method, the leftover fluoride in water ranges around 1 and 1.5 mg/l. This method should be adopted in case where alkanity seems high. This technique is a grouping of several processes which comprises flash mixing, chemical interaction, flocculation, sedimentation, filtration, disinfection and sludge concentration (Nawlakhe and Paramasivam 1993).

Membrane Process (Assefa, 2006; Gedam, 2012; Amor et. al; 1988)

The most normally utilized membrane processes are as:-

- Reverse Osmosis (RO)
- Nano Filtration Membrane Process
- Dialysis
- Electro Dialysis

Reverse Osmosis (RO) and Electro Dialysis are the most commonly adopted procedures for membrane process. In the late 1980s, reverse osmosis (RO) was considered as an alternative to conventional waste treatments due to its high removal capacities (Prihasto et al. 2009).Performance evaluation studies depict that the management of RO plants in rural areas of India is very difficult as it requires highly trained staff for maintenance and operation (Vasavada, 1998; Marriappan et. al; 2000). Electrodialysis is a simple and reasonable process with no defects, minimizing the precipitation risks of the bivalent salts present in the water during pre-treatment with low energy consumption (Inglezakis and Zorpas 2012), exhibiting removal of fluoride from brackish water.

Adsorption

Adsorption techniques have been quite accepted due to their ease of handling and accessibility of wide range of adsorbent materials. This method includes the water's entry through a contact bed where fluoride is removed by ion exchange or surface chemical reaction with the solid bed matrix. Activated charcoal, activated alumina, brick, bone char, fly ash, serpentine, red mud, clay, synthetic zeolites , neem bark powder, rice husk, kaolinite and ceramic etc. are some adsorbents capable of effectively removing of fluoride from groundwater. Adsorption is a process (Fig. 4) which is widely used for the defluoridation purpose in which materials like alumina, activated carbon, ion exchange resins, silica gel, natural materials like clay, mud and low-cost alternative adsorbents like fly ash, bone charcoal, etc., are employed (Johnston and Heijnen 2002; Joshi et al. 1992; Kalló 2001; Kamble et al. 2007).

Activated Alumina and activated carbon are the most utilized adsorbents. This method has capacity to remove fluoride upto 90% (Rubel & Woosely 1979). If alkanity is too high, Alumina activated method should not be adopted.

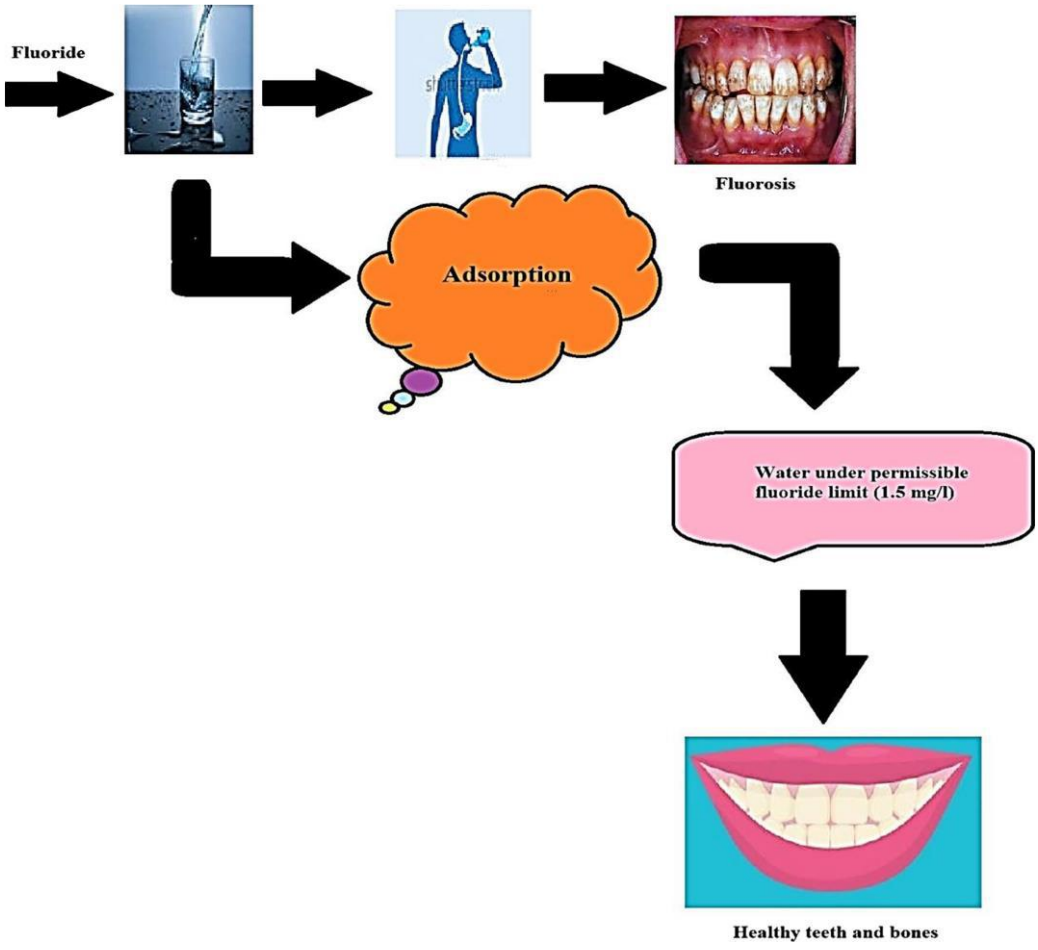

Fig. Adsorption—a simple technique for effective fluoride removal (P Senthil Kumar,2019)

In India, **KRASS Defluoridation Process** has been verified by CSIR and PHED of Rajasthan. Advanced Materials and Processes Research Institute, Bhopal has developed method of Nano Filter for the removal of fluoride from water that is based on Nano Adsorbent Technology. **(12May, 2018, Pioneer**) in this process, water filter modem is used for domestic defluoridation. This is very useful for rural areas in low cost. AMPRI has transferred it to M/s MWS Enterprises limited, Indore. In the first step, these filters are being provided to the residents of fluorosis affected Ashta village of district Sirauh in Madhya Pradesh.

CONCLUSION

Water fluoridation was initiated by few countries in order to prevent dental fluorosis caused by tooth decay. This is suggested that there are so many defluoridated techniques to remove the fluoride from water but only defluoridation of drinking water alone can not solve the problem.

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