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"Merits and Demerits of different technologies of defluoridation for drinking water"

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Abstract: *The problem of excess fluoride in ground water was detected in many states of India as early as 1930s.Till 1999 as many as 17 states have been identified with the problem of excess fluoride in ground water sources. After view of problems related fluorosis many methods used for removal of excess of fluoride from drinking water in India. In this paper compile all the merits and demerits of some defluoridation methods including Nalgonda method, Activated Alumina, bone char, fly ash, brick and reverse osmosis methods etc.*
Key words*: Fluorosis, defluoridation methods, Adsorption, India.*

I. Introduction

India is among the many countries in the world, where fluoride contaminated ground water is creating health problems. Safe drinking water in rural areas of India is predominantly dependent on groundwater sources, which are highly contaminated with fluoride, the concentration in 17 States being 1 to 48 mg/L. About 62 million people including 6 million children are affected with dental, skeletal and non-skeletal fluorosis. Although concentration of fluoride in drinking water up to1 mg/1 is said to be beneficial for the formation/calcification of dental resistant enamel and for the stabilization of the skeleton structure but at level slightly above 1.5 mg/1, mottling of teeth has occasionally been reports. At still higher-level teeth may become damaged, even severely; at 3-6 mg/f per liter, skeleton fluorosis, due to significant effect on the bone may be observed. When fluoride concentration in a water supply is excessive i.e. the level of fluoride consistently and significantly above 1.5 mg/1 over long period of time, serious considerations should be given to introduce some from of remedial measures. If some form of control is consider necessary, one or more of the following options may be applicable:

1. Provision of new or alternative source of water containing acceptable levels.
2. Blending of the existing water supply with another one containing lower level of fluoride.
3. Provision of bottled water.
4. Treating the water level at the "Point of use" at domestic level in small treatment devices i.e. domestic defluoridation unit.
5. Treatment of water at community level i.e. conventional treatment or hand pump attached package treatment.

The permissible limits of fluoride concentration in drinking water prescribed by various organizations (Gopal Krishnan S. et al, 1991)-

- **World Health Organization (International standard for drinking water) 0.50 (mg/l)**
- **US Public Health Standard 0.8(mg/l)**
- **The committee on public health engineering manual and code of practice, Government of India. 1.00(mg/l)**
- **Indian Council of Medical Research recommendations 1.00(mg/l)**
- **ISI recommendations 1.50 (mg/l)**

Defluoridation of drinking water-

Defluoridation is process of removal of fluoride ion in drinking water. All the defluoridating method may broadly be classified in two categories namely Additive methods and Adsorptive methods. In additive methods, certain reagents are added and optimum conditions for the defluoridation are maintained. A fluoride ion present in water react with the reagents added and forms an insoluble complex and was removed ad flocs. In adsorptive methods, a bed of greater surface activity is chosen and water is passed through the bed. Due to surface activity, the Journal of Engineering Research and Studies E-ISSN0976-7916 JERS/Vol. III/ Issue I/January-March, 2012/111-119 fluoride ions gets preferentially adsorbed on the bed surface thereby causing a reduction of fluoride ion in the exit stream (Patil A. R. & Kulkarni B. M. 1990). The different method so far tried for the removal of excess fluoride from water can be broadly classified into three basic types:-

1: Chemical additive method (Nalgonda method etc.)
2: Contact precipitation Method (Activated alumina, Bone char method etc.)
3: Ion Exchange /Adsorption Method (Adsorption with Red mud, fly ash, bricks etc.)

Some defluoridation methods are shown in the table with their Merits and Demerits -

S.No.	Method	Merits	Demerits
1.	Nalgonda Technique	1. It can be used at domestic and community level 2. The chemicals are the same as those used in municipal / urban water supply schemes. 3. It is cost effective 4. Defluoridated water meets the standards laid down by the Bureau of Indian standards. 5. No regeneration of media. 6. Simplicity of design, construction, operation and maintenance 7. Local skills can be readily employed. 8. Highly efficient removal of fluoride from high levels of 1.5 to 20 mg/l to desirable levels. 9. Only man power is needed for domestic equipment. 10. Low technology, Adaptable at point of use and point of source level. 11. Beside fluoride turbidity, colour, odour, pesticides and organic substance are also remove in this method.	1. The daily operations require a trained and conscientious operator. 2. The major cause for concern with the lime and alum technology in that if the dose of alum is not adhered to, thee is a possibility of excess aluminium contaminating the water The maximum concentration of aluminium permitted is 0.03 mg to 0.2 mg/liter of water according to BIS, as an excess is suspected to cause Alzheimer's disease. 3. High chemical dose. 4. Dose depending on f-level. 5. Daily addition of chemical and stirring in point of source unit. 6. It has been found that some of the fluoride, which has been captured in the flocs, is released slowly back to the water. 7. The process removes only a smaller portion of fluoride form of precipitant and converts a greater portion of ionic fluoride into soluble aluminium fluoride complex ion. 8. Due to use of aluminium sulfate as coagulant, the sulfate ion concentration increases tremendously and in few cases, it crosses maximum permissible limit of 400 mg/l, which causes cathartic effect on human beings. 9. Discarding the sludge from the Nalgonda process is a serious environmental health problem. The sludge is toxic as it contains the removed fluoride in a

			concentrated form Sludge disposal is a problem. 10. Regular analysis of feed and treated water is required to calculate the correct dose of chemicals to be added. 11. Conducted in laboratory.
2.	Activated Alumina Technology	1. Effective and economical. 2. It requires minimum contact time for maximum defluoridation. It is indigenously available and cheap. 3. Percentage of regeneration is considerably high.	1. Expensive process. 2. Reactivation of filter material is cumbersome and can be done only with the help of trained persons. 3. Can result in high residual aluminium in output water ranging from 0.16 ppm to 0.45 ppm. 4. Periodic regeneration. 5. Skilled personnel for plant operation. 6. Suitable grades may not be indigenously available in less developed countries. 7 The process is pH specific and works effectively only in certain pH range. 8 If Activated Alumina is fitted on hand-pump and remains nonoperational due to any reason for 2- 3 days or longer, the alumina bed becomes hot bed for microorganism. 9. This treatment is not effective if TDS exceeds 1500 mg/L. 10. It requires time to time regeneration as after some time Activated alumina is exhausted. 11. The regeneration steps result in an aqueous solution containing fluoride. On the other hand, if the spent alumina is discarded, the cost of the defluoridation increases. Apart from that, spent alumina may leach out fluoride ions when it comes in contact with alkali.
3.	Bone Char method	1.Low cost technology 2.Locally available media 3. After defluoridation water is odourless, clean, and ready for human consumption. 4. The fluoride removal capacity of the product is 1000mg/lit.	1. May impart taste and odour and result in organic leaching if not prepared properly. 2. Requires regeneration periodically. 3. Affected by high alkalinity. 4. May not be acceptable in some countries.

4.	Brick Method	1.Low cost technology 2. After defluoridation water is odorless, clean, and ready for human consumption.	1. May not be universal applicable. 2. Exhausted bone char is regenerated by caustic soda. Since acid dissolve bone char, extreme care has to taken for neutralizing caustic soda.
5.	Reverse osmosis Method	1. Can remove other ions. 2. Remove biological impurities.	1. Skilled operation. 2 Interference by turbidity. 3. High cost. 4. Wastage of raw water.
6	Red Mud Method	1. Low cost technology. 2. Skilled person not require. 3. Effective absorbent especially at high concentration.	1. The process is highly dependent on pH and works best only in a narrow pH range. 2. High concentration of total dissolved salts (TDS) can result in fouling of the alumina bed. 3. Presence of sulfate, phosphate or carbonate results in ionic competition. 4. The process has low adsorption capacity, poor integrity and needs pretreatment. 5. The regeneration is required after every 4–5 months and effectiveness of adsorbent for fluoride removal reduces after each step of regeneration.
7	Fly Ash Method	1. Low cost technology. 2. Skilled person not require.	1. May not be universal applicable. 2 Interference by turbidity. 3. Effect on alkalinity.

II. Conclusion

It has been observe that many methods are used for removal of excess of fluoride in the drinking water but every method have their merits and demerits .no one method can accept properly for every area for defluoridation because some method are expensive where some can generate further problems. So, according to the requirement like area, concentration, availability of resources etc. any one method can be select for removal of excess of fluoride from the drinking water.

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