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IMPORTANCE OF FLUORIDE IN POTABLE WATER

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ABSTRACT

Throughout the world, one of the main sources of drinking water is groundwater. When it comes to connection with rocks, a variety of minerals dissolve. One such substance is fluoride. Because of long-term rock-water interaction, fluoride in water has a geogenic origin. Natural fluoride in water is produced by rocks and minerals that contain fluoride, such as fluorite, apatite, hornblende, mica, cryolite, etc. Even while the water we drink seems transparent and clear, it doesn't always imply it's safe to drink. There have been numerous reports of excessive fluoride concentrations in groundwater. Fluoride levels in groundwater that are too high are a global concern. Fluoride levels in groundwater that are above recommended levels are an international concern. In our nation, fluoride-related problems are not limited to a single area; rather, they exist nationwide. Arid and semi-arid regions are the main areas where increased concentration is reported. The body needs one milligram per litre of fluoride, according to the WHO and BIS. It has been previously observed that not only do lower and greater doses affect humans, but also animals and plants. It serves as a two-edged sword. Less than 1 mg/l is said to produce dental problems, more than 1 mg/l is said to cause dental fluorosis, and concentrations even higher than 3 mg/l are said to cause skeletal fluorosis problems in human beings. Studies carried out by other researchers have reported on several other worries, including poor IQ, stunted growth, altered DNA, etc.

INTRODUCTION

Groundwater is the major source of drinking water in most of the countries of the world which contains various ions in dissolved form. The concentration of these ions in high or low doses affects human beings in many ways. Fluoride is one of the major ions present in water **(Brindha and Elango 2011)**. Fluoride is a highly electronegative element of the halogen family in the periodic table **(Bishnoi and Arora 2005, Singh and Garg 2012, Pazand 2016)** which always form compounds with electropositive elements such as NaF and HF of the periodic table **(WHO 2006, Gupta *et al.* 2006, Singh and Garg 2012)**. Fluoride is reported to be present in the form of fluorite (CaF2) in igneous, sedimentary and metamorphic type rocks such as granite and gneisses which are abundant in arid and semi-arid regions **(Chae *et al.* 2005, WHO 2006, Singh and Garg 2012, Seema and Kidwai 2016)**. These types of rocks have been earlier reported in many countries such as India, Pakistan, Sri Lanka, China, south and West Africa, Thailand etc. **(WHO 2006, Singh and Garg 2012)**.

It is present in both shallow and deep aquifers **(WHO 2006).** The origin of fluoride is geogenicin nature. Dissolution of the rocks rich in fluoride such as apatite, biotite, mica, hornblende, fluorite, cryolite and fluorspar enhances the concentration of it in natural groundwater which is used for drinking **(WHO2006, Ramanaiah*et al.*, 2006, Babu *et al.*, 2006, Raju *et al.*, 2009, Singh *et al.*, 2013, Singaraja*et al.*, 2014).** However, fluoride is not present in the surface water but can also enter through anthropogenic activities.

It is required for bone mineralization and the formation of tooth enamel. The daily required quantity for human beings is 0.5 mg/L **(Singh *et al.* 2013)**. The acceptable limit for fluoride in water is 1 mg/L according to BIS and WHO. Less than 1 mg/l of Fluoride in

water makes the water deficient in its concentration. The concentration of fluoride both less than 1 mg/L and more than 1 mg/L are harmful for humans and can affect various physiological and biochemical activities of the human body. It also poses harmful effects on plants and animals.

Fluoride is present in dissolved form in drinking water in the form of compounds. Therefore, it doesn't change the colour, odour and taste of the water **(Singh and Garg 2012)**. Hence, the presence of fluoride can only be analyzed by monitoring it.

EFFECTS OF FLUORIDE

Dental caries occurs if the fluoride concentration is less than 1 mg/l in water which is reported to cause decaying of teeth. Dental fluorosis may occur if the concentration is more than 1 mg/L in water which is reported to cause the erosion of the enamel of teeth. It is the cosmetic effect that appears in the form of marked staining or pitting of the teeth. Endemic skeletal fluorosis may occur even at higher concentrations than 3 mg/l which is associated with osteosclerosis, bone deformity, ligamentous and tendenous calcification **(WHO 2006)**. Numerous other health effects are given in Table 1. Pictures 1, 2, 3 and 4 are given below depicting the dental carries, dental fluorosis, and skeletal fluorosis-like problems. Some of the health effects due to excess and low concentrations of fluoride are given in Table 1.

200 million people from 25 nations of the world are affected due to fluorosis **(Tiwari *et al.* 2016)**. Research on the analysis of fluoride in drinking water has been earlier conducted by various researchers in different countries including India. Various parts in different states of India are also reported to be affected by fluorosis due to higher concentrations of fluoride in water. In India, 16 districts of Andhra Pradesh, 2 districts of Assam, 5 districts of Bihar, 2 districts of Chhatisgarh, 7 districts of Delhi, 18 districts of Gujarat, 11 districts of Haryana, 4 districts of Jharkhand, 14 districts of Karnataka, 2 districts of Kerala, 8 districts of Maharastra, 13 districts of Madhya Pradesh, 18 districts of Orissa, 9 districts of Punjab, all districts of Rajasthan, 8 districts of Tamil Nadu, 7 districts of Uttar Pradesh, 7 districts of West Bengal are affected due to high concentration of Fluoride in water **(www.cgwb.gov.in)**. In Haryana: Bhiwani, Karnal, Mahendergarh, Rewari, Rohtak, Sirsa, Sonepat, Yamunanagar, Jind, Kaithal, Jhajjhar, Gurgaon, Hisar, Fatehabad, Faridabad, Kurukshetra and Panipat are the major districts which are fluoride in drinking water is reported to be beyond the BIS standard value **(www.cgwb.gov.in).** Brief information about the most affected regions all over the world which are suffering from fluorosis is given in Table 2

DIFFERENT METHODS ADOPTED ALL OVER THE WORLD TO ANALYZE FLUORIDE

Fluoride ion concentration can be detected by various methods such as

- SPADNS method by using spectrophotometer **(APHA 2005).**
- It can be analyzed by ion selective electrode method**(WHO 2006, Khaiwal and Garg 2006, Brindha and Elango 2011, Singh and Garg 2012)**.,
- Ion chromatography**(WHO 2006, Brindha and Elango 2011)**,
- Complexone method **(WHO 2006)** etc.

TABLE 1

HEALTH RELATED ISSUES DUE TO HIGH CONCENTRATION OF FLUORIDE IN DRINKING WATER.

Concentration of fluoride	Health related issues	References
1-1.5	Safe limit	WHO, BIS
<1	Dental carries	Babu *et al.* 2005, Garg *et al.* 2008
>1	Dental fluorosis	Chae *et al.* 2006
>3	Skeletal fluorosis	Raju *et al.* 2009, Alabdulaally*et al.* 2013, Singaraja*et al.* 2014
>4	Retarded growth, DNA alteration, low IQ in children, down syndrome, hypertension, hip fractures, crippling fluorosis, knee deformities, haematopoiesis, cancer, blood biochemistry, death at high doses	Lu *et al.* 2000, Machalioski*et al.*, 2000, Li *et al.* 2001, Xiang *et al.* 2003, Pizzo *et al.* 2007, Tang *et al.* 2008, Singh and Garg 2012, Ostovar*et al.* 2013, Brima 2014, Pazand 2016

Picture 3

Picture 4

Source of the picture 1, 2, 3 and 4:

https://www.google.co.in/search?q=pictures+of+dental+fluorosis

TABLE 2

HIGH CONCENTRATION OF FLUORIDE REPORTED IN DIFFERENT PARTS OF THE COUNTRY

Region	Maximum concentration (mg/l)	References
International scenario		
Argentina	18.2	WHO 2006
Brazil	2.3	
Canada	4.3	
China	13	
Ethiopia	14	
Germany	8.8	
Indonesia	14.2	
Israel	3	
Japan	7.8	
Pakistan	13.2	
Saudi Arabia	2.4	
Kenya	2800	
Niger	6.6	
Indian scenario		
Rajasthan	69.7	WHO 2006
Andhra Pradesh	2.1	
Punjab	7.46	CGWB 2013
Uttar Pradesh	5	CGWB 2015
Gujrat	4.5	CGWB 2016
Bihar	6	
Status in Haryana		
Rewari	48	WHO 2006
Bhiwani	12	CGWB 2016
Jhajjhar	6.86	
Jind	10	
Rohtak	1.86	
Fatehabad	2.74	
Gurgaon	4.26	
Hisar	4.04	
Kaithal	10	
Mahendergarh	14	
Mewat	2.07	
Palwal	2.1	
Panipat	2.23	
Sirsa	4.5	
Sonepat	16	

REMEDIAL MEASURES

- Several defluoridation techniques can also be adopted to reduce the concentration of fluoride in water. Dilution of groundwater with artificial recharge (Brindha and

Elango 2011) or mixing of drinking water having a high concentration of fluoride with some other water having a low concentration of fluoride.

- Defluoridation methods such as reverse osmosis, precipitation, membrane separation techniques, electrodialysis, electrochemical, distillation, Nalgonda technique, activated alumina, bone charcoal, clay and ion exchange processes can be used to reduce the fluoride concentration in water (WHO 2006, Brindha and Elango 2011, Waghmare and Arfin 2015).
- Rainwater harvesting should be increased to recharge the groundwater sources and to reduce the utilization of groundwater (Singh and Garg 2012).
- Reduction in the use of chemical fertilizers and more use of organic farming also helps in the reduction of Fluoride in water (Singh and Garg 2012).
- Monitoring of drinking water sources should be done regularly.
- Awareness programmes must be conducted by the government or NGO especially to aware our children on the local, district or regional level.
- NGOs and community-based societies should have to work together to take steps in the remediation of this problem.
- Several gels, mouthwashes, toothpaste, salts and tablets are available in the market to increase the intake of fluorite concentration where the availability of fluoride is reported to be low.
- Easy detection methods and Low-cost technologies must be encouraged for the availability of rural and urban population.

CONCLUSION

Problems due to fluoride concentration have been reported from all over the world including India. Various parts of the different states in the country are reported to be affected due to fluoride in drinking water. The presence of fluoride in water is not only geogenic or natural due to the presence of rock minerals but chemical fertilizers and industrial effluents percolate through soil also increasing its concentration in water. High concentration causes dental fluorosis and crippling skeletal fluorosis, especially in children who are more prone to this problem. Other severe health disorders are also reported due to high fluoride. Several defluorination techniques can be adopted to reduce the concentration

of fluoride. Various techniques such as the Nalgonda technique, reverse osmosis, adsorption method, ion exchange, precipitation, coagulation and electrodialysis can be adopted. Adoption of a particular method depends upon the source, initial concentration of fluoride and cost-effectiveness of the method.

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