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Research Paper :

Flouride in drinking water : A challenge to public health

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ABSTRACT

The menace of high fluoride concentration in ground water resources has now become one of the major health related geo environmental issues in many countries of the world. Our country is also confronting the same problem, where the high fluoride concentration in ground water resources and the resultant disease "FLUOROSIS" is widely distributed in nearly 150 districts of 15 states. In Madhya Pradesh during recent years, the problem of fluoride has reached an alarming proportion. The continued consumption of fluoride in excess to 1.5 mg/l either through water, air or food items for a long time may cause dental, non-skeletal and skeletal fluorosis. If it is significantly high in drinking water, it may cripple one for whole life. Fluorosis is one of the incurable diseases and perhaps, the prevention is the only known solution. Today, it has posed serious adverse health effects in many parts of the Indian union. In this paper it is attempted to identify its sources, impact on human health and to develop a strategy to tackle fluorosis in the country.

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Water is prime natural resource and physiological necessity to mankind. Therefore, drinking water must not carry harmful chemicals as well as biological contaminants. Some of the chemicals like fluoride, iron, arsenic, cadmium, chromium, lead, selenium and nitrates in water are not known to be beneficial. On the contrary, they may produce serious, adverse physiological changes when exist beyond permissible concentration. Fluoride is one of such chemicals, which has posed a great threat to human health in the country. Fluoride is major contaminants of the ground water in many parts of India. About 25 million people are affected with fluoride toxicity today. Fluoride is widely dispersed in nature, and is a common constituent of most soils, rocks, plants and animals. First-ever case of fluorosis was detected by the farmers of Andhra Pradesh State among cattle (bullocks used for ploughing land) during early 1930's. Sharatt *et al.,* 1973 published the first report of endemic fluorosis in India. Since then endemic fluorosis has been identified in 17 states of the Indian union and is known to be prevalent for the last six decades without receiving much attention to tackle it. In 1994, a National survey of drinking water in India indicated that over 43.5 million people living in 1.42 lakh habitations spread over 200 districts are at health risks due to water quality problems and fluoride was identified as one of the major contaminants.

Due to its high electro negativity, it forms only fluorides and no other oxidation states are found (Hem, 1992). It is essential to maintain fluoride concentration between 0.6 to 1.2 ppm in drinking water (ISI 1983 and WHO, 1994). The water is naturally fluoridated due to the earth's crust being rich in fluoride bearing minerals (Sushella and Ghose, 1990). The National drinking water mission was launched in 1986-1987(Ministry of Rural Development, 1993) and under this mission defluoridation technique has been developed but still many areas are in dire need of attention from the authorities. Nawlakhe *et. al.,* 1995 reported ground water quality of rural areas in Shivpuri district of Madhya Pradesh, India and observed fluoride and nitrate to be the problem parameters in order of dominance. Choubia *et al.,* 1995 studied the presence of fluoride in Dungarpur district of Rajasthan. They reported that maximum number of domestic water sources have high fluoride contents. Kataria *et al.,* 1995 studied bore well water quality in BHEL area of Bhopal with reference to nitrate, nitrite, fluoride. The pollution of the water has extremely serious implications.

Somashekar *et al.,* 2003 have investigated ground water potential and fluoride levels in the water of Hosadurger, Taluk, Karnataka, (India). Khoshoo, 1989, Kortin, 1979, GCDWK, 1979, Pathak and Badre, 1999, Rao and Venkateshwarulu, 2000 also studied the effect of fluoride on human health.

In this paper an attempt has been made to compile the information on the matter available elsewhere in the literature and experience gained for developing a strategy.

Occurrence :

Fluoride occurs significantly in rocks, plants and crops, drugs, industrial processes etc.

Rocks and soil :

A large group of minerals containing minor fluorine is made up of the fluorocarbonates, fluorosulphates, fluorophosphates, fluoroarsenates, and fluorocolumbates. The fluoride contents in rocks range between 0.1 and 1.0 g/kg. The main primary fluoride containing minerals are fluorspar, cryolite, and appetite. But in most of the soils, it is associated with mica and other clay minerals. Sodium and magnesium fluorides are also found as natural minerals. The fluoride contents in mineral soils have been found between 0.2 and 0.3 g/kg. It may range from 7 to 38 g/kg in soils, which have developed from fluoride minerals. Organic soils bear low fluoride.

Fluorine in the combined state constitutes 0.078% of the earth's crust. Fluorine with its abundance in the cosmos is indicative of its widespread occurrence and has been estimated as follows :

Minerals	Fluoride ppm	Minerals	Fluoride ppm
Meteorites	28-30	Alkali rocks	1200-8500
Dunite	12	Shale	740
Basalt	100	Sandstone	270
High Calcium	520	Deep sea clays	1300
Granite	-	Deep Sea Carbonates	540

Plant, animal matter and other edible items:

Besides rocks and soils, food items especially agricultural produce are heavily contaminated with fluoride, which enters into the human body through various food items.

Fluoride contents in different food items have also been studied. However, the data available in India is rather scanty. The available data indicate decreasing order of fluoride content in various food items as in cereals, followed by leafy vegetables, pulses, fish, meat and fruits. Leaves contain fluoride between 3 and 14 ppm, while in those parts of the plant having little phosphorus, *viz*., buds, fruits and wood, it has been found to be less (Table 1).

Tea has the highest fluoride content (112 mg/kg) among the various food items. Betal leaf (7.8 - 12.0 mg/kg), areca nut (3.8 - 12.0 mg/kg and tobacco (3.1 - 38.0 mg/kg) also have very high fluoride content. Fluoride content in Indian spices vary between 0.9 and 14.4ppm

Fluorosis in India and abroad :

As the problem of fluorosis was not in the thrust area of health care services, fluorosis remained a law priority issue. Since the inception of National Drinking water Mission, The problem of fluoride in drinking water and the control of fluorosis gained attention of the health and water supply authorities. There are many parts of the world where the exposure of fluoride is significantly high. It is known to cause fluorosis and it posed a grave public health problem in India (Traces-18ppm) and some other countries of the world *viz*., North America (0-68), Alabama (1-34), California (0-7), Colorado (0-5), Florida (0-2.5), Italy (0-7), Portugal (0-23), Spain (0-6), China (0-13), Korea (0.8-10), South Africa (Traces-53), Tanganyika (traces-95), India (traces-18) and Japan (traces-20)

Although, the number of Fluorosis endemic in various states have indicated in Table 2, even than there might be more habitations affected in these State. The information emerging from house to house epidemiological surveys in some areas is rather shocking as up to 75% of the population in many villages are severely affected, crippled and is virtually leading a vegetative life.

The crucial concern of epidemiologist is the identification of causes of the disease and to develop strategies its prevention and control. The field researches conducted in India on fluorosis have influenced the policy planning both in water supply and health sectors to focus on prevention and control of fluorosis through provision of sustained supply of safe water, improved nutritional standards and awareness in the present generation and among the population.

Health spectrum of fluorosis:

High fluoride (>1.5 mg/I) may cause various types of fluorosis manifestations including mottling of teeth called /dental fluorosis and skeletal fluorosis. The manifestations of non-skeletal fluorosis are often overlooked due to the misconception that fluoride affects only bones and teeth. Fluorides in excess can cause several ailments, *viz*., neurological, muscular, allergic, gastrointestinal complaints and flatulence in expectant and lactating mothers, hardworking young adults, urinary tract infections and headaches. Intake of high fluoride (> 3.0 mg/I) can result in skeletal fluorosis and other skeletal abnormalities and beyond 10 mg/I over a long period can result in crippling fluorosis. Population affected by skeletal fluorosis in the country is estimated as 50 lakh, which are approximately 90% of the total affected world's population.

It has been observed that the prolonged use of drugs containing sodium fluoride is known to cause skeletal fluorosis. Fluoride dust and fumes generated from certain industries may be a dangerous as consuming fluoride through food, water and drugs, and complexes the problem of water and food borne fluorosis. Infant mortality has

Table 1 : Fluoride content in agricultural crops and other edible items

Food Item	Sengupta and Pal (1971)	Fluoride(in ppm) Lakdawala and Puneker (1973)	Chari *et al.* (1975)	Rajya Laxmi (1982)
Cereals				
Wheat	4.6	2.59-3.3	-	-
Rice	5.9	3.27-14.03	2.9.31	-
Bajra	-	1.72-2.23	2.82	74.0
Maize	5.6	-	-	-
Pulses and legumes				
Bengal gram	6.2	3.84-4.84	-	14.8
Green gram dal	2.5	2.34-4.84	-	21.2
Red gram dal	3.7	2.34-4.84	-	52.8
Soyabean	4.0	-	-	-
Leafy vegetables				
Spinach	2.0	0.77-4.14	-	-
Cabbage	3.3	1.28-2.29	-	-
Amaranth leaves	5.8	4.91-7.17	-	-
Lettuce	5.7	-	-	-
Mint	4.8	-	-	-
Bathua leaves	6.3		-	-
Chowlai leaves	-	1.79-7.33	-	-
Other vegetables				
Cucumber	4.1	2.57-3.58	-	-
French beans	-	1.07-1.96	-	-
Tomato	3.4	1.00-2.08	0.33	-
Brinjal	1.2	1.62-2.48	1.24	-
Ladies finger	4.0	2.2-3.62	1.74	-
Snake gourd	2.3	2.16-3.44	0.75	-
Roots and tubers				
Beet root	4.2	-	-	-
Carrot	4.1	1.9-4.9	-	-
Potato	2.8	1.27-2.92	-	-
Onion	3.7	1.00-3.00	-	-
Sweet potato	3.2	-	-	-
Fruits				
Banana	2.9	0.84-1.58	0.84	
Dates	4.5	-	-	-
Grapes		0.84-1.74	-	-
Figs	4.2		-	-
Mango	3.7	0.8-1.80	-	-
Apple	5.7	1.05-2.2	-	-
Guava	5.1	0.24-0.52	-	-
Nuts and oil seeds				
Almond	4.0	-	-	-
Cashew nut	4.1	-	-	-
Coconut	4.4	-	-	-
Mustard seeds	5.7	-	-	-
Groundnut	5.1	-	-	-
Beverages				
Tea(Dry leaves)	-	39.8-68.59	-	-
Tea infusion (1 g boiled for 5 min. in 125 ml water)	-	18.13-56.19	-	-
Tea infusion (1 g in 125 ml) of hot water	-	11.13-37.34	-	
Aerated drinks	-	0.77-1.44	-	-
Coconut water	-	0.43-0.60	-	-
Foods from animal sources				
Mutton	-	3.0-3.5	-	-
Beef	-	4.0-5.00	-	-
Pork	-	3.0-4.5	-	-
Fishes	1.0-6.5	-	-	-

Table 2 : Fluoride occurrence in Indian States

State	No of Habitations with excess Fluoride	State	No of Habitations with excess Fluoride
Andhra Pradesh	7548	Meghalaya	33
Bihar	12	Maharashtra	39
Gujarat	2378	Orissa	1138
Karnataka	860	Punjab	700
Kerala	287	Rajisthan	16560
Madhya Pradesh	201	Tamilnadu	527
Haryana	334	Uttar Pradesh	1072
Himachal Pradesh	488	West Bengal	21
Delhi	46		
Total			32244

Table 3 : Relation between concentrations of fluorides and biological effects

Concentration of fluoride (mg/ltr)	Medium	Effect
1.5 to 4.0	Foods and water	Mottling and staining of teeth. Bone deformity
4.0 to 7.0	Foods and water	Dental carries and minor skeletal deformation
7.0	Foods and water	Acute ostio Fluorosis stiffness in Joints, Skeleton deformation thyroid changes, kidney damage
8	Foods and water	10% Osteosclerosis
50	Foods and water	Thyroid changes, stiffness in joints
100	Foods and water	Growth retardation and kidney damage

also been observed due to calcification of blood vessels in endemic areas. While abortions, stillbirths and children born deformed are common, the adolescent age group is most vulnerable. However, fluoride toxicity, and the biological response leading to ill effects depend on several other factors apart

Control strategy:

There is a need for development of a broad concept to tackle excess fluoride problem and its implementation of strategy. The strategy may consist the following major steps.

Survey for delineation of fluoride affected areas :

The water quality analysis may be carried out in 10% of the source in the possible affected areas to delineate the area broadly. The areas identified so, could be health surveyed by observing teeth of the school children preferably above 8 years old. For this purpose, the specially trained school teachers/ health workers may be used to assess the impact on the teeth, *i.e.* dental fluorosis. If both data are conclusively indicating the effect of fluoride through drinking water, the area should be scanned through analysis of 100% water samples of existing sources, following the health survey to develop the strategies to tackle the problem.

Preventive measures :

Using Information, Education and Communication (IEC) activities/techniques to sensitize the public to drink only fluoride free water and routinely monitor the drinking water quality in affected area and its surroundings may be taken up. Simultaneously, the people in such areas may be advised to switchover to the diet, which can encounter the physiological effects of fluoride intake. Importance of a nutritive diet rich in calcium and vitamin- C supplements and consumption of de-fluoridated water need to be stressed to the people specially pregnant and lactating mothers in affected areas to avoid abortions, stillbirths and infant health problems. In the country, serious efforts to tackle fluorosis due to intake of excess of fluoride through drinking water had been made only after the launching of Rajiv Gandhi National Drinking Water Mission (Presently, Department of Drinking Water Supply) in 1986. Obviously, there is a need to develop a strategy to tackle fluorosis in the country.

Conclusion:

Fluoride intake in excess to 1.5 mg/I through water, food and air can cause several ailments, *viz*., neurological,

muscular, allergic, gastro-intestinal, urinary tract and headache, fluorosis including crippling and other skeletal abnormalities and damages of the fetus. Since fluorosis being an incurable disease, the preventive and control measures are the only solutions.

The field researches on fluorosis conducted so far in India has influenced the policy planning both in the Water Supply and Health Sectors to focus on prevention and control of fluorosis.

The control measures for fluorosis include reconnaissance survey of villages, collection of specific data on medical health, water quality of sources and social-economic aspects of people in areas where the manifestation of fluoride toxicity is identified.

The fluoride problem may be tackled by adopting a well-planned systematic approach to identify and use safe alternative sources or treat fluoride-containing waters using proven treatment technologies, if safe water is not routinely available at economical distance. The domestic de-fluoridation should be resorted to as stop gap or interim measure until permanent alternate distant safe source based water supply or community based de-fluoridation system installations are commissioned. The Consumption of a nutritive diet, calcium and vitamin-C supplement and consumption of de-fluoridated water should be recommended to pregnant and lactating mothers, if abortions, still births and infant health problems are to be avoided. A strong and appropriately informed education and communication (IEC) to achieve full success should support the total programme.

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