Fluorosis: a persistent problem

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Human health has probably posed some of the greatest challenges to humanity. While science has helped address many of these challenges (through the development of innumerable vaccines and antibiotics), the solution to many others is still elusive. The burden of health-related problems seems to be unjustifiably heavier on the poor, especially those in rural areas – advances in medicine take a long time to trickle down to them, new medicines may be too expensive, and the by-products of technological advancement in the form of industrial effluents and pesticide residues may be making health even more difficult to sustain. Sometimes, the natural environment of a region can affect health too – arsenic poisoning due to high levels of the element in groundwater is a familiar example. Another (probably lesser known, though widespread) example is fluorosis (Figure 1).

One of the world's oldest dental afflictions, fluorosis was described for the first time in 1901 by Frederick Sumner McKay, a young dental school graduate – he was intrigued by the 'grotesque dark stains' that he noticed on the teeth of many of the natives in Colorado. Three decades later, McKay and H. V. Churchill, a chemist, identified that ingestion of high amounts of fluoride caused the deformity (http://www.fluoride-history.de/mottledTeeth.htm and http://www.nidcr.nih.gov/oralhealth/topics/fluoride/thestoryoffluoridation.htm). Dean and others proposed a formal classification of dental fluorosis in 1934, based on the intensity of the symptoms ranging from opaque white streaks or specks on the teeth to dark brown stains and pits[1]. The 1930s also mark the beginning of studies on fluorosis in India. However, it was only in the 1980s that the Indian Government set up a system to tackle fluorosis, through the State Rural Drinking Water Supply Implementing Agencies and Health Departments[2].

Figure 1. Mildly fluorotic teeth. (Source: http://en.wikipedia.org/wiki/File:Fluorosisb%26a.jpg)

The disorder

Dental fluorosis is caused by fluoride concentrations greater than 1.5 mg/l in drinking water. Concentrations of more than 4 mg/l can cause skeletal fluorosis[3], which is much more debilitating. Singh *et al.*[4] describe the effect of severe skeletal fluorosis: 'intoxication at the rate of about 20 milligrams daily for over ten years leads to crippling deformities, including kyphosis (bending of the spine), flexion deformity of the trunk, hips and knees (that decreases the angle between bones in a joint)'.

The occurrence of high amounts of fluoride in drinking water has been reported from various parts of India, ranging from Rajasthan and Uttar Pradesh in the north to Tamil Nadu in the south, Gujarat in the west to Assam in the east. A mere perusal of the titles of recent papers on fluorosis in India, that a *Google* search would provide, is enough to show this (I found about 40 reports from various parts of India published in 2010–2011, in the first ten pages of the search). About a decade ago, people in 17 of the 32 states and union territories in India were affected by fluorosis[2]. In 1975, Handa examined the geochemistry and genesis of fluoride containing groundwater from different parts of India and observed that there is an inverse relation between fluoride and soluble calcium content in groundwater[5,6]. Evapo-transpiration, which precipitates calcite in groundwater and increases the sodium-to-calcium ion ratio, may be contributing to the increase in fluoride ion concentration[7,8]. Studies have also shown that fluoride and bicarbonate ions in groundwater are positively correlated – bicarbonate accelerates the dissolution of calcium fluorite to release fluoride into the water[9]. The contact time of water with fluoride-containing minerals, groundwater chemical composition and climate of the region may also influence fluoride concentration (M. Sudhakar Rao, Indian Institute of Science (IISc), Bangalore, pers. commun.). In addition to drinking water, food, air and crops irrigated with water having a high level of fluoride may also contribute to excess fluoride intake (K. Kesava Rao, IISc, pers. commun.)

Existing methods to overcome fluorosis

How do we as a society overcome fluorosis? Since fluoride occurs as a geogenic contaminant in certain aquifers, and many communities rely on such contaminated sources for their potable water requirements, a permanent solution to fluorosis may be impossible. But many people like J. Chandrashekar (Amrita School of Dentistry, Cochin) believe that the use of alternative sources of water and defluoridation techniques to optimize the concentration of fluoride can substantially decrease the incidence of fluorosis (pers. commun.). Over the years, there have been many attempts to develop methods to reduce the fluoride content in drinking water. A recent paper[10] compares five defluoridation techniques prevalent in India: the use of activated alumina, the use of red mud, the Nalgonda technique (that involves the use of alum, lime and bleaching powder), the use of the phyllosilicate mineral, montmorillonite, and the use of magnesium oxide. The paper concludes that of these, the magnesium oxide method, commonly called the IISc method for defluoridation, is the most effective (Figure 2) method. It is selective for fluoride removal as magnesium oxide binds well with fluoride ions. Unlike activated alumina, it does not leach out harmful chemicals into the treated water, and more importantly, magnesium oxide is easily available and the technique is economically feasible (M. Sudhakar Rao, pers. commun.). (It costs 15–30 paisa to defluoridize a litre of water using the IISc method. The Nalgonda technique, which is also a widely used method, costs about 50 paise per litre of water; http://www.globenet.org/preceup/pages/ang/chapitre/capitali/cas/indme_g.htm.) The incidence of fluorosis can also be

Figure 2. The Indian Institute of Science (IISc) method for defluoridation of water, being implemented in Pavagada Taluk, Tumkur District, Karnataka (courtesy: M. Sudhakar Rao). (Inset) The defluoridation equipment for the IISc method. The simplicity of the technique ensures its affordability.

reduced by the treatment of water by reverse osmosis and solar distillation, and using harvested rainwater for drinking. (A solar distillation unit would cost approximately Rs 1867/m^2 and the cost of operation is Rs 6/h, with the output being 3–4 l/m^2/day; http://www.tnau.ac.in/aecricbe/aetc/bio12.htm.) Novel methods such as the use of powdered corn cobs coated with aluminium or calcium chloride have also been proposed for defluoridation of water[11].

Over the years, scientists and the government have tried to take these defluoridation techniques to the most affected people in India – the villagers. However, many feel that these efforts are inadequate. Kesava Rao says, 'A reason for the persistence of fluorosis is the inability to transfer ideas from the lab to the field level. Academics have often focused on publishing papers, without worrying about the practical problems associated with implementation at the field level. Another reason is the lack of adequate monitoring. Defluoridation units that have been installed usually become defunct after some time, as there is no follow-up. For example, one family was drinking water from an activated alumina filter long after the filter was saturated with fluoride, and hence was not functional' (pers. commun.). Sudhakar Rao expresses similar concerns: 'Majority of the water-treatment plants for defluoridation, iron-removal, desalination, etc. installed under the Rural Water Supply Programme are found to be non-functional due to lack of adequate training, lack of funds and non-involvement of the community in the operation and maintenance of the treatment plants. About 85% of the water-treatment units installed in the early 90s became non-functional within two to three years of their installation. Comparatively, a number of domestic filters provided under pilot projects in parts of Rajasthan are reported to be functioning successfully because of measures taken to train the local community in the operation and maintenance of the units in advance' (pers. commun.).

A peculiar problem that is associated with fluorosis is that often people do not even consider it a disorder! Dental fluorosis is perceived by many as a question of appearance, rather than health. In fact, a 1956 paper on fluorosis says, '. . .in the milder forms of fluorosis the enamel of the tooth has a high luster which enhances the beauty of the tooth rather than disfigures it'[12]. In countries like India, even severe forms of the disorder like skeletal fluorosis, are seen as problems that have to be lived with. Kesava Rao illustrates this point: 'I met a person in Bagepalli (a small town in Karnataka) recently who used to suffer from joint pain, probably because of ingestion of water containing a high level of fluoride. It was only because of an NGO that a rainwater harvesting system was put up in his house and he became aware that fluoride may be the culprit. After drinking rainwater for a few months, his pain disappeared. Before the rainwater system was set up, he had attributed the pain to his fate.' (pers. commun.)

Defluoridation through diet?

Conventional methods for defluoridation have a few drawbacks. When chemical methods are used, ways must be devised for regeneration of the adsorbent used, and disposal of the spent chemicals. Some of the methods may be expensive, and thus unavailable to the rural population. Some others such as solar distillation may not be reliable sources of water throughout the year. For instance, Kesava Rao says that the output of a solar distillation unit installed in his department varied from 0.3 to 4.0 l/m^2/day, depending on the weather conditions (pers. commun.). In such a situation, a method to control fluorosis through diet would come as a blessing.

Many indigenous communities in India use tamarind in their daily cooking. Apart from adding to the taste of the food, this familiar condiment may also be contributing to healthy teeth by reducing the incidence of fluorosis. The effect of tamarind in enhancing fluoride excretion was first studied by Khandare *et al.*[13]. They discovered that fluoride excretion was greater in dogs fed with tamarind, and retention of fluoride in the femur bone in these dogs was lower when compared to the control group. A similar study done in 2002 showed that the effect of tamarind on fluoride excretion was similar in human subjects too – fluoride excretion was found to be 4.8 ± 0.22 mg/day during the tamarind ingestion period compared to 3.5 ± 0.22 mg/day during the control period when the subjects were fed tamarind-free diet. In addition, tamarind was also found to decrease zinc and magnesium excretion, thus contributing further to the health of the subjects[14]. The same group undertook a field study on the effect of tamarind ingestion in a fluorotic village in Andhra Pradesh, and found that daily tamarind ingestion corresponded to lesser incidence of dental and skeletal fluorosis (the prevalence of fluorosis was found to be 58.9% among daily tamarind users compared to 79.1% among occasional tamarind users)[15].

Different authors have suggested different mechanisms by which tamarind acts to reduce fluorosis. Some suggest that fluoride binds through hydrogen bonding to tartaric acid in tamarind, and thus the presence of fluoride ions in the body is decreased[16]. Others suggest that increased levels of fluoride in the body increases the level of free radicals. Crude tamarind pulp is a natural antioxidant due to the presence of high concentrations of polyphenols and flavonoids[17], which scavenge oxygen free radicals and thus exert a beneficial effect on the body[18]. Khandare *et al.*[14] speculate that the increase in alkalinity of urine due to tamarind ingestion (pH 7.6 ± 0.3 in people who consume tamarind versus pH 6.7 ± 2.5 in others) might be linked to increased renal clearance of fluoride. Tartarate present in tamarind is not metabolized by the body, and it inhibits the action of carbonic anhydrase, leading to the increased pH of urine[17]. Though the exact mechanism by which tamarind acts against fluorosis is as yet unknown, the positive effects that have been seen have led to the development of a new defluoridation technique using tamarind seeds[16].

Controlling fluorosis by exploiting the indigenous use of beneficial ingredients like tamarind in everyday food is an attractive option. But there might be other factors that act in the opposite direction, and thus make it difficult to rely on dietary control of fluorosis alone. For instance, Khandare *et al.*[15] found that even though tamarind had a beneficial effect on fluorosis, practices such as the use of aluminium utensils for cooking and storage, and smoking aggravated the problem. Studies have also shown that fluoride retention is greater in jowar and sorghum-eating populations compared to those with rice and wheat-based diets[14]. In fact, a recent community-based controlled study carried out in a village in North Karnataka showed that children who consumed jowar had 2.7 times greater risk of getting severe dental fluorosis compared to those who did not[19].

People in the villages of India have been living with fluorosis for generations. Despite many decades of work to mitigate fluorosis, the problem persists. As an Editorial in this journal says, '. . .tackling some of the problems faced by the rural poor demands as much scientific and technical creativity and know-how as needed by those working at the forefront of mainstream science. India, with its large rural and poor population has the dubious distinction of providing many such challenges'[20]. Fluorosis is an example.

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Indian media coverage of climate change

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India should be concerned about climate change since this will have adverse socio-economic impacts on its people. The three main impacts are: those on agriculture, sea-level rise leading to submergence of coastal areas, and increased frequency of extreme events. This study has analysed the media text of *The Hindu*, *The Times of India*, *The New Indian Express*, *Deccan Chronicle*, NDTV and CNN-IBN for a year and interviewed 25 journalists covering climate change.

The interview brought forth the following problems regarding climate change:

- It is abstract, not connected with day-to-day reality; it is too broad a topic and mostly a technical matter.
- Journalists ignore climate change as they do not know the technicalities involved; they hardly receive in-service training on climate change and fail to link ground realities with existing policies and politics.
- Scientists do not give climate change literature in a jargon-free language.

False sense of balance

Given that stories about climate change are steeped in scientific details, communicators should convey the scientific consensus and limitations to current knowledge according more to scientific norms of evidence rather than journalistic