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The Untold Story of Fluoridation: Revisiting the Changing Perspectives

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Abstract

The discovery of fluoride in dentistry has revolutionized treatment modalities with a new aspect of prevention and conservation of tooth structure coming into foreplay. Since then, there has been a lot of research on both topical and systemic fluoridation in an overzealous attempt to control the most debilitating dental problem of caries. Although topical fluoride is still being widely used as a preventive measure for dental caries, systemic administration of the same has gained major criticism worldwide due to the low margin of safety of fluoride and no control over the amount of individual intake when administered on a community level. This problem is more prevalent in countries with presence of natural fluoride belts that extend from Turkey to China and Japan through Iraq, Iran, and Afghanistan increasing the chances of both dental and skeletal fluorosis and hence increasing the focus toward defluoridation. This historical review highlights the distribution of fluoride worldwide and in India and also discusses about the various claims of the antifluoride lobby.

Keywords: Antifluoride lobby, defluoridation, fluoride, fluorosis

Introduction

Fluoridation of drinking water supply is an established top 10 public health achievements of the 20th century.[1] Fluoridation can be defined as the upward or downward adjustment of the level of fluoride content in drinking water to an optimal level just enough to prevent caries but not to cause fluorosis.[2] An optimum level of fluoride according to the climate varies and is universally calculated by applying the equation of Galagan and Vermillion.[3] Fluoride levels of 0.5 ppm are recommended in warm climates because more water is consumed and levels as high as 1.5 ppm are regarded as optimum in cold climate where less water is consumed. However, on an average, the optimum fluoride level in drinking

water is calibrated at 1.0 ppm worldwide (0.7–1.2 ppm).[2] Fluoride is a mineral that occurs naturally in most water supplies and is of geological origin. Known fluoride belts on land include one that stretches from Syria through Jordan, Egypt, Libya, Algeria, Sudan, and Kenya and another that stretches from Turkey through Iraq, Iran, Afghanistan, India, northern Thailand, and China. There are similar belts in the Americas and Japan.[4] According to the US Center of Disease Control and Prevention, fluoridation of community drinking water is a safe, cost-effective, and efficient strategy of reducing dental decay among Americans of all ages and from all social strata.[5] It forms the foundation for sound community caries-prevention programs.

The water fluoridation controversy arises from political, moral, ethical, economic, and safety concerns regarding the fluoridation of public water supplies. Public health authorities throughout the world find a medical consensus that water fluoridation at appropriate levels is a safe and effective means to prevent dental caries.[6] Authorities' views on the most effective fluoride therapy for community prevention of tooth decay are mixed; some state water fluoridation is most effective, whereas others see no special advantage and prefer topical application strategies.[7,8] Those opposed argue that water fluoridation has no or little cariostatic benefits, may cause serious health problems, is not effective enough to justify the costs, and is pharmacologically obsolete.[9]

History of Fluoridation

It started as an observation and soon took the shape of an idea. It ended, five decades later, as a scientific revolution that shot dentistry into the forefront of preventive medicine. This is the story of how dental science discovered – and ultimately proved to the world – that fluoride, a mineral found in rocks and soil, prevents tooth decay. Although dental caries remains a public health worry, it is no longer the unbridled problem it once was, thanks to fluoride.

Fluoride research had its beginnings in 1901, when Frederick McKay was astounded to find scores of Colorado Springs natives with grotesque brown stains on their teeth known as Colorado Brown Stain. McKay in 1909 along with Dr. G. V. Black conducted a study showing that almost 90% of the city's locally born children had signs of the brown stains. Black investigated fluorosis for 6 years, until his death in 1915. During that period, he and McKay made two crucial discoveries. First, they showed that mottled enamel (as Black referred to the condition) resulted from developmental imperfections in children's teeth. This finding meant that city residents whose permanent teeth had calcified without developing the stains did not risk having their teeth turn brown; young children waiting for their secondary set of teeth to erupt, however, were at high risk. Second, they found that teeth afflicted by Colorado Brown Stain were surprisingly and inexplicably resistant to decay.[2]

McKay and Kempf published a report on their findings that reached the desk of the chief chemist, H. V. Churchill, at company headquarters in Pennsylvania who decided to conduct his own test of the water in Bauxite – but this time using photospectrographic analysis, a more sophisticated technology than that used by McKay. H. V. Churchill concluded that high levels of water-borne fluoride caused discoloration of tooth enamel.

Later, Dr. Treadley H. Dean began investigating the epidemiology of fluorosis in 1931. One of his primary research concerns was determining how high fluoride levels could be in drinking water before fluorosis occurred. For this purpose, a state-of-the-art method to measure fluoride levels in water with an accuracy of 0.1 parts per million (ppm) was developed. Dean and his staff set out across the country

to compare fluoride levels in drinking water. By the late 1930s, he and his staff had made a critical discovery. Namely, fluoride levels of up to 1.0 ppm in drinking water did not cause enamel fluorosis in most people and only mild enamel fluorosis in a small percentage of people.

Dean wondered whether adding fluoride to drinking water at physically and cosmetically safe levels would help fight tooth decay. The City Commission of Grand Rapids, Michigan – after numerous discussions with researchers from the PHS, the Michigan Department of Health, and other public health organizations – voted to add fluoride to its public water supply the following year. In 1945, Grand Rapids became the first city in the world to fluoridate its drinking water. During the 15-year project, researchers monitored the rate of tooth decay among Grand Rapids almost 30,000 schoolchildren. After just 11 years, Dean concluded that the caries rate among Grand Rapids children born after fluoride was added to the water supply dropped more than 60%. This finding, considering the thousands of participants in the study, amounted to a giant scientific breakthrough that promised to revolutionize dental care, making tooth decay for the first time in history a preventable disease for most people.[2]

As of 2012, 25 countries have artificial water fluoridation to varying degrees, 11 of them have more than 50% of their population drinking fluoridated water. A further 28 countries have water that is naturally fluoridated, though in many of them the fluoride is above the recommended safe level. As of 2012, about 435 million people worldwide (around 5.4% of the global population) received water fluoridated at the recommended level, nearly half of them living in the United States.

Various Fluoride Conspiracy Theories

Organized political opposition has come from libertarians, the John Birch Society,[10] and from groups like the Green parties in the United Kingdom and New Zealand. Water fluoridation has frequently been the subject of conspiracy theories. During the "Red Scare" in the United States during the late 1940s and 1950s, and to a lesser extent in the 1960s, activists on the far right of American politics routinely asserted that fluoridation was part of a far-reaching plot to impose a socialist or communist regime.[10] Dr. Charles Bett, a prominent antifluoridationist, charged that fluoridation was "better than using the atom bomb" because the atom bomb has to be made and transported to the place it is to be set off while poisonous fluorine has been placed right beside the water supplies which we consume as a daily necessity. In 1987, Ian E. Stephens claimed that he was told by "Charles Elliot Perkins" that "repeated doses of infinitesimal amounts of fluoride will in time reduce an individual's power to resist domination by slowly poisoning and narcotizing a certain area of the brain and will thus make him submissive to the will of those who wish to govern him". All these claims back then had a political and ethical basis and rarely any scientific basis was found.

The Fluoride Controversy and the Antifluoride Claims

The controversy over fluoridation of drinking water supply began as early as the 1960s, approximately a decade after the American Public Health Service officially launched the National Fluoridation Program. The controversy has gained momentum over the years as more research is released to support the stance of the antifluoride lobby. Several factors have spurred the present-day controversy. The irreversible, debilitating effects of fluoride toxicity, the transient effects, and hence the continuous need of exposure to fluoride to maintain caries resistance and the fact that benefits of topical use of fluoride are as good as ingested fluoride are some of the leading contributing factors.

Antifluoride Claims

Antifluoride lobbyists start with the fact that fluoride is not an essential nutrient and no disease has ever been linked to a fluoride deficiency.[11] In fact, fluoride is claimed to be a cumulative poison and biologically very active even at low concentrations because it interferes with hydrogen bonding and inhibits numerous enzymes.[12] Only 50% of the daily ingested fluoride is excreted through the kidneys. The remainder accumulates in bones, the pineal gland, and other tissues. Initial studies on animals showed that fluoride accumulation in the pineal gland led to reduced melatonin production and an earlier onset of puberty. The same researcher then showed in later studies that fluoride can also accumulate to very high levels in the human pineal gland.[13] Fluoride toxicity can lead to renal damage in children. Researchers studied 210 children living in areas of China with varying levels of fluoride in water (0.61–5.69 ppm). Among this group, the children drinking water with more than 2 ppm fluoride – particularly those with dental fluorosis – were found to have increased levels of NAG and y-GT in their urine, both of which are markers of kidney damage. The children's urine also contains increased levels of lactic dehydrogenase – a possible indicator of liver damage. A diseased kidney is unable to effectively excrete fluoride, so individuals with compromised kidneys are at risk of developing fluorosis even at normal recommended limit of 0.7–1.2 ppm.

Fluoride has been shown to be mutagenic by causing chromosome damage and interference with the enzymes involved with DNA repair in a variety of cell and tissue studies carried out in animals.[14] Recent studies have also found a correlation between fluoride exposure and chromosome damage in humans.[15,16] The only government-sanctioned animal study to investigate whether fluoride causes cancer, in 1990, found a dose-dependent increase in cancer in the target organ (bone) of fluoride-treated, male rats.[17] This led to a 14-year research carried out by Harvard University that showed a significant link between fluoridation and a rare form of bone cancer called osteosarcoma in young boys, consistent with the results of the 1990 animal study.[18]

Fluoride as a neurotoxin has been proven in several animal studies. A 2006 National Research Council report stated that it is apparent that fluorides have the ability to interfere with the functions of the brain and the body by direct and indirect means.[19,20] This finding was confirmed by a study where groups of children exposed to 8 ppm fluoride in water were found to have lower average IQs, less children attaining high IQ, and more children affected by low IQ.[21] While 8 ppm is much higher than the fluoride level added to water in fluoridation programs (0.7–1.2 ppm), these results are in congruence with previous studies[22] from China that indicate that fluoride may affect IQ at lower levels.[23]

If fluoride is added to water which contains aluminum, then aluminum fluoride complexes will form. Aluminum fluoride complexes have the potential to interfere with many hormonal and some neurochemical signals.[24] Aluminum fluoride was recently nominated by the Environmental Protection Agency (EPA) and National Institute of Environmental Health Sciences as a “high health research priority” due to its “known neurotoxicity.”

Dental fluorosis is not only a cosmetic defect. Its psychological impact on the child has been established by the US National Institute of Mental Health. A study found that children with severe dental fluorosis are more likely to be perceived by their peers as less intelligent, less attractive, less social, less happy, less careful, less hygienic, and less reliable – characteristics which could have major effects on a child's self-esteem.[25]

The US Center of Disease Control and Prevention declared that in the second half of the 20th century, the steep decline dental decay in the United States can be attributed to fluoridation. However, antifluoride lobbyists show that a similar decline in dental decay has been observed worldwide in countries that do not fluoridate their drinking water supplies. To overcome selection bias, the criteria of the countries selected for this comparison study were tri-pronged, countries with a mean annual per capita income of US$10,000 or more in the year 2000, a population in the year 2000 of greater than 3 million, and finally those countries that had WHO caries data available. The most common explanation for the worldwide declining trend was the wide distribution of fluoridate toothpastes but serious research later attributed, at best, 40%–50% of the caries reduction to fluoride products.[26]

Once fluoride is put in the water, it is impossible to control the dose each individual receives. This is because some people, for example, manual laborers, athletes, diabetics, and peoples with kidney disease, drink more water than others. In addition, the average person receives fluoride from sources other than the water supply such as fluoridated oral hygiene products, food, and beverages processed with fluoridated water, mechanically deboned meat, and teas.[27]

Some individuals appear to be highly sensitive to fluoride as shown by case studies and double-blind studies. In one study, which lasted 13 years, the results showed that about 1% of patients given 1.0 mg of fluoride each day developed negative reactions. According to the Agency for Toxic Substances and Disease Registry (1993), certain subsets of the population may be particularly vulnerable to fluoride's toxic effects. These include the elderly, the diabetics, and people with poor kidney function. Also vulnerable are those who suffer from malnutrition, for example, calcium, magnesium, vitamin C, vitamin D, iodine deficiencies, and protein-poor diets. Those most likely to suffer from poor nutrition are the poor, who are precisely the people being targeted by new fluoridation programs. While being at a heightened risk, poor families are less able to afford avoidance measures, for example, bottled water or fluoride removal equipment.

Fluoridation of community drinking water is considered unethical because individuals are not being asked for their informed consent prior to medication. It is standard practice to obtain consent for all medication, and this is one of the key reasons why most of Western Europe has ruled against fluoridation. It is a violation of human rights, a direct violation of the Nuremberg code that states that research or even routine medical procedures must be done with the voluntary cooperation of the subjects who must be fully informed of the risks or benefits of the procedure in which they are involved.[9]

Studies have shown an association between the use of fluorosilicic acid and its sodium salt to fluoridate water and increased uptake of lead into children's blood. Lead is acknowledged as a neurotoxin that damages the child's developing brain, and lead toxicity is unaddressed especially in developing countries. Sodium fluoride is an extremely toxic substance, just 200 mg of fluoride ion is enough to kill a young child, and just 3–5 g (e.g., a teaspoon) is enough to kill an adult.[28]

The US Food and Drug Administration (FDA) has never approved of any fluoride product designed for ingestion as safe or effective is a popular claim by the antifluoride lobby but according to the EPA-FDA Memorandum of Agreement, the FDA's regulatory purview is limited to the safety and efficacy of food, drugs, or cosmetic-related products, as well as bottled water which is marketed as a consumer beverage. Thus, if bottled water has fluoride additives and is approved by FDA, then this comes under the category of fluoride product meant for ingestion.

The American Dental Association (ADA) recommends that water with added fluoride, bottled or otherwise, should not be used to mix concentrated formula or foods intended for babies age 1 year and younger to prevent tooth damage. Fluoridated bottled water comes with special instruction for infant consumption. The ADA stance is in congruence with the antifluoride lobby who report that the level of fluoride put into water (1 ppm) is up to nearly 50 times higher than normally found in mothers' milk (0.019 ± 0.004 ppm).[29] Therefore, there are no benefits, only risks, for infants ingesting this heightened level of fluoride at such an early age.

Fluoride Situation in India

Fluoride is an acute toxin, with a rating slightly higher than lead. It is, in fact, one of the most bone-seeking elements known to human beings. Excess fluoride causes several diseases, such as osteoporosis, arthritis, brittle bones, cancer, infertility in women, brain damage, Alzheimer's disease, and thyroid disorders. A worrying scenario is daily ingestion of just 2 mg of fluoride could result in crippling skeletal fluorosis after 40 years. Most of the people affected by high fluoride concentration in groundwater live in tropical countries where the per capita consumption of water is more because of the prevailing climate.

Fluorosis is an important public health problem in 24 countries, including India, which lies in the geographical fluoride belt that extends from Turkey to China and Japan through Iraq, Iran, and Afghanistan.[30] Of the 85 million tons of fluoride deposits on the earth's crust, 12 million are found in India.[31] Endemic fluorosis is prevalent in India since 1937.[32] It has been estimated that the total population consuming drinking water containing elevated levels of fluoride is more than 66 million. Endemic fluorosis resulting from high fluoride concentration in groundwater is a public health problem in India.[33] The available data suggest that 15 states in India are endemic for fluorosis (fluoride level in drinking water >1.5 mg/L), and about 62 million people in India suffer from dental, skeletal, and nonskeletal fluorosis. Of these, 6 million are children below the age of 14 years. Groundwater is considered as the major source of drinking water in most places on earth.[34,35]

Almost half of each day's fluoride intake is retained and is absorbed by the bones and teeth. It was Gerald Cox, of the Mellon Institute in the United States, who first found in 1938 that while 1.0 mg/L of fluorine in water prevents dental caries, over 1.5 mg/L causes mottled teeth. The Bureau of Indian Standards (bis) standard for fluoride content is 1–1.5 mg/L. It is believed that levels above or below this could cause dental decay. Ironically, there is an increased incidence of dental caries, yellow teeth, and twisted limbs among people of all age groups in India.[35]

A recent publication of the Geological Survey of India names areas that should go on fluoride red alert as follows: Fazilka and Jalalabad in the border district of Ferozepur in Punjab; parts of Gurgaon, Rewari, Mahendergarh, Hisar, Fatehabad, and Faridabad in Haryana; Unnao, Rae Bareilly, and Sonbhadra in Uttar Pradesh; Sidhi district in Madhya Pradesh; Beed district in Maharashtra; Nalgonda district in Andhra Pradesh; and Dindigul district in Tamil Nadu. Recent studies have shown that fluoride content in tubewell water in Fazilka is 6–12 mg/L. Almost 70% of Fazilka's population suffers from dental decay. Jalalabad is not much better off. Although surface water is less contaminated, tubewells pump out water that contains high fluoride content. The affluent farmers, of course, drink “mineral water.” However there is no quality check on the purity and composition of mineral water and there have been instances where bottled canal water has been sold with the pretext of being mineral water.

Fluoride toxicity is taking its toll. There is a sharp rise in the number of people with “yellow teeth.” Cases of arthritis are on the rise in Haryana. The fluoride content in the state's groundwater is often as high as 7–8 mg/L. Unnao and Rae Bareilly districts of Uttar Pradesh show fluoride content between 2.9 and 15 mg/L. Dental and skeletal fluorosis, known as “lunj punj” in Unnao, is rampant in these districts. Toothless villagers with twisted limbs are not an uncommon sight. Village Siraha Khera in Unnao faces a social boycott today. The two tap water samples from north and south locations in Agra had fluoride levels of 1.6 and 1.7 mg/L. Nalgonda, Andhra Pradesh, contains much higher fluoride than the world average fluoride concentration of 810 mg/kg.[36,37] The situation in Sonbhadra and Sidhi is completely different. Here, the groundwater fluoride content is below 1 mg/L. This causes rapid dental caries in children and adults alike.

In the vast geographical expanse and varied geological setup of India, the causes for fluoridation of groundwater are many. We have no control over the natural release of fluoride into groundwater. The contamination of groundwater by industries – -brick kilns, aluminium, and steel – is, however, preventable. In Faridabad, these industries bore holes in the ground, into which they inject waste. Certain phosphatic fertilizers also cause fluoride to leach into the groundwater. In Unnao, for example, the use of such fertilizers has risen by 5 lakh metric tonnes in the past decade.[37] Table 1 shows the prevalence of dental fluorosis and Table 2 shows the prevalence of skeletal fluorosis in India.[37]

Groundwater contamination is an enormous problem and drastic steps need to be taken soon to solve this crisis. The first step is to identify and seal off contaminated tubewells. Simultaneously, people must be provided with safe drinking water from state-drilled tubewells. In the affected areas, a massive campaign effort is needed. There should also be promotion of higher calcium and vitamin C intake. Since most Indians cannot afford these, the state must arrange for free distribution. The next step is reduction in fluoride concentration through artificial recharge techniques such as flooding of groundwater with surface water.[38] The most efficient technique would be defluoridation by the Nalgonda technique. The fluoride content of up to 5 mg/L has been found in the groundwater in laterite, basalt, and the Precambrian basement (gneiss) aquifers in the region of Gad basin (Konkan area of Maharashtra). In Pune, it was 0.01–1.38 mg/L during pre-monsoon season and 0.01–1.21 mg/L during post-monsoon season.[39] In Nagpur, the level of fluoride in groundwater was 1.8–1.9 mg/L.[40]

Conclusion

Despite the profusion of rhetoric to the contrary, dental caries is a critical concern even today and continues to plague majority of the world's population with giant unmet treatment needs.[41] Fluoride is the pivot of caries prevention and a major breakthrough in the history of dentistry. A dogma had existed for many decades that fluoride has to be ingested and acts pre-eruptive. Current evidence clearly suggests that the mechanism of action of fluoride is mainly topical and post-eruptive.[42,43,44,45,46] Fluoride, as it is rightly said, is a double-edged sword. Since topical benefits of fluoride are as good as systemic but the risks are maximal on ingestion, the ideal recommendation would be to limit fluoride to dentifrices and mouthwashes. Adopting the precautionary principle categorizes fluoridation of community drinking water supply as an unreasonable risk. On the international front, most of the west European countries have rejected water fluoridation including Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Italy, Luxembourg, Netherlands, Norway, Sweden, and Switzerland. The only three western European countries which still practice water fluoridation are Ireland (100%), Spain (10%), and the United Kingdom (11%). In countries like India, the need of the hour is *DE-fluoridation*

of community water supplies and should be considered by the government as an effective means to reduce fluoride toxicity in our country. Thus, even for the usage of preventive topical and systemic fluoride, the benefits and the risks must be thoroughly weighed.

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Conflicts of interest

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Figures and Tables

Table 1

Prevalence of dental fluorosis in India

State/Area	Age-group (years)	Prevalence (%)	Authors
Cuddalore, TN	5-12	31.4	Sarvanam *et al.* Indian J Community Med 2008;33 (3):141-50
Alapuzzha, Kerala	10-17	35.6	Gopalakrishnan *et al.* Natl Med J India 1999;12 (3):99-103
Vadodara, Gujarat	Adults	39-59	Kotecha *et al.* Indian J Med Res 2012 June; 135 (6):873-877
Davangere, Karnataka	12-15	13-100	Chandrasekhar and Anuradha. Int Dent J 2004;54 (5):235-9
Jhajjar, Haryana	7-15	30-94	Yadav *et al.* Environ Geochem Health 2009;31 (4):431-8
Birbhum, W Bengal	Adults	61-66	Majumdhar. Indian J Public Health 2011; 55:303-8
Punjab	5-60	91.1	Shashi & Bhardwaj Biosci. Biotech. Res. Comm 2011;2:155-163
Nalgonda, A.P	12-15	71.5	Shekar *et al.* Indian J Public Health 2012; 56 (2):122-8
Durg, Chattisgarh	Adults	8.2	Pandey. Trop Doct 2010;40 (4):217-9
Dungarpur, Udaipur (Rajasthan)	All ages	39-72	Choubisa *et al.* J Environ Sci Eng 2010;52 (3):199-204
Palamau, Jharkhand	Children	83.2	Srikanth *et al.* Research repot Fluoride 2008;41 (3) 206-211
Assam	All ages	31.3	Chakraborti *et al.* Current Science 2000;78 (12):1421-1423.
Uttar Pradesh	All ages	28.6	Srivastava *et al.* Int J Oral & Maxillofacial Pathology 2011:2 (2):7-12
Kareka, Shivpuri MP	13-50	86.8	Saksena & Narwaria Int J Environ Sci 2012;3 (3)
Raigad, Maharashtra	0-23	91.7	Bawaskar & Bawaskar.Trop Doct 2006;36:221
Nalgonda, AP	Adults	30.6	Nugude *et al.* Indian J Public Health 2010;54 (4):194-6

Table 2

Prevalence of skeletal fluorosis in India

State/Area	Age group	Prevalence (%)	Authors
Nalgonda, AP	All ages	24.9	Nirgude *et al.* Indian J Public & Health 2010 Oct-Dec; 54 (4):194-6
Durg, Chttisgarh	Adults	6-38	Pandey. Trop Doct 2010;40 (4):217-9
Dungarpur & Udaipur, Rajasthan	All ages	12-27	Choubisa *et al.* J Environ Sci Eng 2010;52 (3):199-204
Bihar	1-5	20	Khandare *et al.* Calcif Tissue Int 2005;76 (6):412-8
Palamau, Jharkhand	Adults	47.4	Srikanth *et al.* Research report Fluoride 2008;41 (3) 206-211
Assam	Adults	1.74	Chakraborti *et al.* Current Science 2000;78 (12):1421-1423
Uttar Pradesh	All ages	14.2	Srivastava *et al.* International Journal of Oral & Maxillofacial Pathology 2011: 2 (2):7-12
Kareka, Shivpuri, MP	13-50	39.2	Saksena & Narwaria. Int J Environ Sci. 2012;3 (3)