International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.03, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

An Emphasis of Fluoride Effect on Human health and Treatment- Review

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ABSTRACT

Water is the major medium of fluoride intake by humans. Fluoride in drinking water can be either beneficial or detrimental to health, depending on its concentration. The presence of fluoride in drinking water within permissible limits is beneficial in the calcification of dental enamel. According to the World Health Organization (WHO), the maximum acceptable concentration of fluoride is 1.5 mg/l, South Africa's acceptable limit is 0.75 mg/l, while India's permissible limit of fluoride in drinking water is 1 mg/l. Concentrations beyond these standards have shown dental and skeletal fluorosis and lesions of the endocrine glands, thyroid and liver. Fluoride stimulates bone formation and small concentrations have beneficial effects on the teeth by hardening the enamel and reducing the incidence of caries. Fluoride is a ubiquitous element present in earth's crust and is also being added to the environment anthropogenically. It is the most electronegative of all elements. Fluorine is found in the soil and the content of Fluorine in the lithosphere varies between 100 and 1500 g/ton. Fluoride has gained importance due to its dual influences on human beings. In lower concentrations, Fluoride is an essential nutrient which aids in the formation of bones, prevents tooth decay, whereas in higher concentrations it causes fluorosis, brittling of bones, curvature of bones, dwarfishness, mental derangements, cancer and in extreme cases even death. According to WHO standards, the Fluoride in drinking water should be within a range that slightly varies above and below 1 mg/L. In temperate regions, where water intake is low, Fluoride level up to 1.5 mg/L is acceptable. The Bureau of Indian Standards, BIS (IS-10500) has prescribed a desirable limit and permissible limit of Fluoride in drinking water as 1.0 and 1.5 mg/l respectively.

Keywords: Fluorosis, WHO, Concentration, human body, lithosphere and permissible limits.

I.INTRODUCTION

Water is one of the major elements essential for sustenance of all forms of life and is available in abundance in nature covering approximately three fourths of the surface of the earth. The chemical nature of water is one of the most important criteria that determines its usefulness for a specific need and as such not all the waters are fit for drinking; hence the problems of scarcity of drinking water. Over the year's groundwater has generally been

considered to be a protected and safe source of water, fit for drinking without treatment, as the main focus has been on the bacteriological quality of potable water. Little consideration used to be given to the risks of chemical pollution, particularly to the presence of elevated levels of fluoride, arsenic and nitrate in groundwater. Consumption of water having excess fluoride over a prolonged period leads to a chronic ailment known as fluorosis. Incidence of high-fluoride groundwater has been reported from 23 nations around the globe. It has led to endemic fluorosis, which has become a major environmental health issue in many developing countries. According to a recent estimate, 62 million people are affected by various degrees of fluorosis in India alone[1].

Fluoride being a highly electronegative element has extraordinary tendency to get attracted by positively charged ions like calcium. Hence, the effect of fluoride on mineralized tissues like bone and teeth leading to developmental alternations is of clinical significance as they have highest amount of calcium, hence they attract the maximum amount of fluoride that gets deposited as calcium-fluorapatite crystals. About 95% of fluoride in the body is deposited in hard tissues and it continues to be deposited in calcified structure even after other bone constituents have reached the steady state. Fluorine is the thirteenth most abundant element in the Earth's crust. It rarely occurs as the element but normally is found as the fluoride ion or as a number of inorganic and organic fluorides. It occurs in varying concentrations in rocks, soil, water, air, plants and animals both naturally and as a consequence of human activity such as agricultural or industrial processes. Human exposure may be through any or all of these sources. Dissolution of fluoride-containing rock minerals is the source of naturally occurring fluorides in groundwater whereas application of phosphate fertilizers or sewage sludges or pesticides are the artificial source of fluoride in groundwater and surface water[2-22].

The presence of fluoride in quantities in excess of limits is a serious matter of concern from a public health point of view. Like any other pollutant the fluoride pollution can also occur due to both natural and manmade reasons. Fluoride in drinking water is known for both beneficial and detrimental effects on health. The fact that the problems associated with the excess fluoride in drinking water is highly endemic and widespread in countries like India prompted many researchers to explore quite a good number of both organic and inorganic materials adopting various processes from coagulation, precipitation through adsorption, Ion exchange. Leaching of Fluoride from the earth crust is the chief source of fluoride content in ground water; however, the other sources like food items also add to increase the overall ingestion of fluoride into the human body. Presents a review, which focuses on the sources of fluoride in drinking water, its impacts on health and different control measures. Nalgonda is the worst effected districts with a presence of excess fluoride in ground water in the state of Telangana. There are 59 mandals with 1175 Gram panchayats and about 3100 habitations in the district. District is totally agrarian with rain fed agriculture with only about 10% irrigation under canals. Fluoride beyond desirable amounts (0.6 to1.5 mg/l) in ground water is a major problem in many parts of the world.

II.SOURCES OF FLUORIDE

Fluoride is a ubiquitous element present in earth's crust and is also being added to the environment anthropogenically. It is the most electronegative of all elements. Fluorine is found in the soil and the content of

Fluorine in the lithosphere varies between 100 and 1500 g/ton. Fluoride has gained importance due to its dual influences on human beings. In lower concentrations, Fluoride is an essential nutrient which aids in the formation of bones, prevents tooth decay. whereas in higher concentrations it causes fluorosis, brattling of bones, curvature of bones, dwarfishness, mental derangements, cancer and in extreme cases even death. It is estimated that around 260 million people worldwide (in 30 countries) are drinking water with Fluoride content more than 1.0 mg/l. In India alone, endemic Fluorosis is thought to affect around one million people and is a major problem in many states, especially Rajasthan, Telangana, Andhra Pradesh, Tamil Nadu, Gujarat and Uttar Pradesh. According to WHO standards, the Fluoride in drinking water should be within a range that slightly varies above and below 1 mg/L[23]. In temperate regions, where water intake is low, Fluoride level up to 1.5 mg/L is acceptable. The Bureau of Indian Standards, BIS (IS-10500)[24] has prescribed a desirable limit and permissible limit of Fluoride in drinking water as 1.0 and 1.5 mg/l respectively.

III.HEALTH EFFECTS

According to WHO standards, the Fluoride in drinking water should be within a range that slightly varies above and below 1 mg/L[23]. In temperate regions, where water intake is low, Fluoride level up to 1.5 mg/L is acceptable. The Bureau of Indian Standards, BIS (IS-10500)[24], has prescribed a desirable limit and permissible limit of Fluoride in drinking water as 1.0 and 1.5 mg/l respectively. There is a minor aberration from this standard as U.S. standard recommends that the fluoride content in drinking water should be between 0.6 and 0.9 ppm. Fluoride concentrations beyond the standards cause dental and skeletal fluorosis. Fluoride toxicity can also cause non-skeletal diseases like aches and pain in the joints, non-ulcer dyspepsia, Polyurea (tendency to urinate more frequently) and polydipsia (excessive thrust), muscle weakness, fatigue, anemia with very low hemoglobin levels, etc. besides other reasons.

High fluoride levels in drinking water has become a critical health hazard of this century as it induces intense impact on human health. Fluoride in minute quantity is an essential component of normal mineralization of bones and formation of dental enamel. However, its excessive intake may result in slow, progressive crippling scourge known as fluorosis. The beneficial and harmful effects of fluoride ingestion are separated by a very narrow margin. Fluoride ingestion through potable water with concentrations about 1.0 mg/l is known to strengthen teeth and the skeleton; however, water concentrations beyond 1.0 mg/l are undesirable because prolonged consumption of such water causes fluorosis. Dental fluorosis is caused by prolonged consumption of water with fluoride concentrations between 1.5 and 4.0 mg/l. This is characterized by browning and mottling of teeth. Prolonged drinking of water with concentrations of fluoride between 4.0 and 10 mg/l causes' skeletal fluorosis and when water of concentrations beyond 10.0 mg/l is taken for a long time crippling fluorosis may ensue. Skeletal fluorosis is characterized by weakening of bones and malformation of the skeleton. Symptoms of crippling fluorosis are the growing together of bone junctions causing immobility. The other problems associated with health impact of fluoride are generally overlooked because of the notion prevailing that fluoride only affects bones and teeth. Other problems arise due to the excessive intake of fluoride are fibre degeneration, low hemoglobin levels, deformities in RBCS, excessive thirst, headache, skin rashes, nervousness, neurological manifestation, depression, gastro intestinal problems, urinary tract malfunctioning, nausea, tingling sensation in

fingers and toes, repeated abortions, male sterility etc. It is also responsible for destruction of about 60 enzymes. Therefore, the fact that an adult may show no signs of dental fluorosis does not necessarily mean that his or her fluoride intake is within the safety limit. When the tea is heavily consumed as sweet and strong and is consumed from a very young age when it is put in nursing bottles cause dental fluorosis. Chronic intake of excessive fluoride can lead to the severe and permanent bone and joint deformations termed as skeletal fluorosis. Early symptoms include sporadic pain and stiffness of joints: headache, stomach-ache and muscle weakness can also be warning signs. The next stage is osteosclerosis (hardening and calcifying of the bones) and finally the spine, major joints, muscles and nervous system are damaged. Whether dental or skeletal, fluorosis is irreversible and no treatment exists. The only remedy is prevention, by keeping fluoride intake within safe limits[25-26]. The various forms of fluorosis that may arise from excessive intake of fluoride through drinking water. If fluoride is consumed in more than 10.0 ppm, it can promote dental fluorosis, skeletal fluorosis and crippling skeletal fluorosis, possibly cancer.

Research of several investigators during the last many years has proven that life-long impact and accumulation of fluorides causes not only human skeletal and teeth damage, but also changes in the DNA-structure, paralysis of volition, cancer. In India, about 62 million people including 6 million children suffer from fluorosis because of fluoride contaminated water. Teotia stated that chronic fluoride toxicity depends upon the actual amount of fluoride ingested per day and the duration of exposure to high fluoride intake through drinking water since the amount of fluoride taken through food appears to be relatively small. The daily intake of fluoride depends upon concentration of fluoride in drinking water and total amount of water ingested per day. The amount of water ingested is itself dependent upon a number of variables such as body size, food habits, environmental temperature and extent of physical activity. During the hot summer season, agricultural laborers may drink up to 8 liters of water a day. In addition, Indian diets contain large amounts of water and practically all staples are cooked in water[27].

3.1 Dental fluorosis

Dental fluorosis, also called “mottled enamel”, occurs when the fluoride level in drinking water is marginally above 1.0 mg/l. A relationship between fluoride concentration in potable water and mottled enamel was first established in 1931. Typical manifestations of dental fluorosis are loss of shining and development of horizontal yellow streaks on teeth. Since this is caused by high fluoride in or adjacent to developing enamel, dental fluorosis develops in children born and brought up in endemic areas of fluorosis. Once formed, the changes in the enamel are permanent. When the above manifestations are seen in an adult, they clearly indicate that the person has been exposed to high fluoride levels during her or his childhood. Fluorosis is a preventable disease of teeth and bones that afflicts millions of people worldwide. It is caused primarily by the prolonged ingestion of fluoride-rich drinking water, which is most often groundwater that has percolated through and leached volcanic and sedimentary deposits. Dental fluorosis is an accumulation of fluoride in teeth and is caused by ingestion of fluoride during the period of tooth development, i.e. prior to tooth eruption[28-29]**.** The fluoride becomes

incorporated into the crystal lattice structure of the enamel and causes hypo mineralization which increases the porosity of the enamel[30-34].

3.2 Skeletal fluorosis

Skeletal fluorosis affects both adults and children and is generally manifested after consumption of water with fluoride levels exceeding 3 mg/l and typical symptoms of skeletal fluorosis are pain in the joints and backbone. In severe cases this can result in crippling the patient. Recent studies have shown that excess intake of fluoride can also have certain non-skeletal health impacts such as gastro-intestinal problems, allergies, anemia and urinary tract problems. Nutritional deficiencies can enhance the undesirable effects of fluoride. Skeletal fluorosis is characterized by increased bone mass and density, accompanied by a range in skeletal and joint symptoms. In early stages, the Symptoms include pain and stiffness in the backbone, hip region, and joints, accompanied by increased bone density. The stiffness increases steadily until the entire spine becomes one continuous column of bone, a condition known as ‘‘poker back’’. As this condition progresses, various ligaments of the spine can also become calcified and ossified. In its most advanced stages, fluorosis produces neurological defects, muscle wasting, paralysis, crippling deformities of the spine and major joints, and compression of the spinal cord. The threshold level of fluoride ingestion needed to cause skeletal fluorosis varies depending on water Intake, water quality and other dietary factors skeletal fluorosis affects both children and adults[35]. It does not easily manifest itself until the disease attains an advanced stage. Fluoride is mainly deposited in the joints of the neck, knee, pelvic, and shoulder bones, and once it takes place, it makes movement or walking difficult. The symptoms of skeletal fluorosis are similar to those of spondylitis or arthritis. Early symptoms include sporadic pain, back stiffness, burning-like sensation, pricking and tingling in the limbs, muscle weakness, chronic fatigue and abnormal calcium deposits in bones and ligaments. Atan advanced stage, osteoporosis in long bones and bony outgrowths may occur. A rare bone cancer, osteosarcoma, may result and finally, the spine, major joints, muscles, and the nervous system may sustain damage. Crippling skeletal fluorosis is the advanced and severe form of skeletal fluorosis. The prevalence of high levels of fluoride intake over the long term, accompanied by malnutrition, strenuous manual labor and impaired renal function, leads to severe skeletal fluorosis. Some cases of skeletal fluorosis have been documented in the Unites States[36].

IV.TREATMENT

Defluorination of water is feasible or if the only solution would take a long time for planning and implementation, defluorination of drinking water has to be practiced. Two options are then available, the central treatment of water at the source and the treatment of water at the point of use at the household level. In developed countries treatment at the source is the method adopted. Defluorination is carried out on a large scale under the supervision of skilled personnel, usually at a treatment works alongside other treatment processes. Cost is not then a limiting factor. The same approach may not be feasible in less developed countries, especially in rural areas, where settlements are scattered. Treatment may only be possible at a decentralized level at the community, village or household level. Treatment at the point of use has several advantages over treatment at community level. Costs are lower, as defluorination can be restricted to the demand for cooking and drinking.

Chemical treatment of the entire water demand would lead to production of large volumes of sludge, which requires a safe disposal. Limitations of point of use treatment are that reliability of the treatment units has to be assured, and that all users should be motivated to use only the treated water for drinking and cooking when untreated water is also available in the house.

Defluorination methods can be broadly divided into three categories according to the main removal mechanism, Chemical additive methods, Contact precipitation, Adsorption/ion exchange methods. Chemical additive methods these methods involve the addition of soluble chemicals to the water. Fluoride is removed either by precipitation, co-precipitation or adsorption onto the formed precipitate. Chemicals include lime used alone or with magnesium or aluminum salts along with coagulant aids. Treatment with lime and magnesium makes the water unsuitable for drinking because of the high pH after treatment**.** Treatment of water and wastewater containing fluoride ions requires a suitable and effective method. Membrane filtration[37], precipitation[38], nanofiltration[39], ion-exchange[40], electro coagulation flotation[41] and adsorption[42] have been used for fluoride removal. Among these methods, adsorption is the effective and widely used method because it is universal, has a low maintenance cost and is applicable for the removal of fluoride even at low concentrations. In recent years, considerable attention has been focused on the study of fluoride removal using natural, synthetic and biomass materials such as activated alumina[42], fly ash[43], alum sludge[44], chitosan beads[45-46], red mud [47], zeolite[48], calcite[49], hydrated cement[50], attapulgite[51] and acid-treated spent bleaching earth[52].

As the many regions in Telangana and Andhra Pradesh are affected by fluoride. Several different materials have been used for defluorination such as activated carbon (AC), tricalcium phosphate, synthetic ion exchangers, lime activated alumina and alum. There have also been many methods developed to remove excessive fluoride from water including adsorption, ion exchange, precipitation, electrolysis, donnan dialysis and electro dialysis[53]. Among these methods, adsorption is still one of the most extensively used and cheapest methods for defluorination of water[44]. However, in recent years, a considerable amount of attention from scientists has been devoted to the study of different types of low-cost materials for fluoride uptake such as spent bleaching earth, Wollaston and chine clay, bentonite and activated bentonite, kaolinitic clay, agricultural by-products, fly ash, carbon slurry, biogas residual slurry, zeolite, bone char and flax shive [54].

High concentrations of fluoride in drinking water had caused widespread fluorosis. A simple, precise, rapid and reliable technique has been developed for removal of fluoride in drinking water. The innovative technique employs activated alumina for defluorination of drinking water. Alumina is inert in nature; hence it is safe to use and handle. The innovation in regeneration of alumina makes the technique cost effective. The reliability of the newly developed technique has been established by analyzing spiked water samples of high concentrations of fluoride and levels of fluoride has been brought down to less than 1 ppm. The synthesis of a zirconia/multi-walled carbon nanotube hybrid is also a novel sorbent for water defluorination. The ZrO_2/MWCNTs were significantly more effective in fluoride removal than all other sorbents tested before, including ZrO2

impregnated carbons. The kinetics of fluoride adsorption on the mixed oxide is driven by boundary layer diffusion [55].

Defluoridation of drinking waters is usually accomplished by either precipitation or by adsorption processes. One of the well-known methods called 'Nalgonda Technique' was developed by National Environmental Engineering Research Institute, Nagpur, India is a precipitation processes employing alum followed by sedimentation and/or filtration. It involves the addition in proportions and in sequence of lime/sodium carbonate, alum or aluminum chloride and bleaching powder.

VI.CONCLUSION

Rock minerals and waste disposal contributes fluoride contamination in groundwater. The presence of fluoride in quantities in excess of limits is a serious matter of concern from a public health and researchers have observed different concentrations of fluoride for the different diseases. High fluoride levels in drinking water has become a critical health hazard of this century as it induces intense impact on human health. Fluoride in minute quantity is an essential component of normal mineralization of bones and formation of dental enamel. To mitigate fluoride contamination for an affected area, the provision of safe, low fluoride water from alternative sources should be investigated as the first option otherwise various methods, which have been developed for the defluoridation of water can be used to prevent fluoride contamination. Groundwater of a particular area should be thoroughly studied before its use for domestic purposes and accordingly a suitable method can be chosen for its treatment.

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