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Fluoride and its different aspect on environmental and human health

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Though the earth contains most of water but certainly now-a-days it is not free everywhere. Anions are generally present in water rapid urbanization and industrialization is giving birth to some undesirable anions that are causing serious environmental and health issues. WHO recommended fluoride as such an abundant anion (thirteenth most abundant) in worldwide ground water. Elevated level of fluoride concentration is associated with arid climatic condition. In tropical countries like India and different parts of this country the problem of excess fluoride is most severe. The fundamental purpose of this particular review is to discuss the general aspects associated with fluoride and fluorosis.

Keywords: Anions, urbanization, industrialization, climatic conditions, fluorosis.

Introduction

Water is the fundamental need for survival to all the living beings. Ground water is the main source available for drinking and household purposes to more than half population of the world[1, 2]. In this era of fast civilization numbers of industries are growing day by day. A huge number of toxics are released from them regularly which ultimately come to the water bodies and pollute them[3]. Therefore, even after crossing four years of the 'Decade of Water Life' (2005-2015) till today the supply of quality water is still an unconvinced promise to a huge section of world's population[4]. World Health Organization (WHO) indicated fluoride as one of the inorganic pollutant responsible for ground water besides arsenic, selenium and nitrate[1, 5]. Worldwide a huge amount of people from 25 nations including the popular countries India and China are under the alarming fate of fluorosis[4]. Fluoride is the thirteenth most abundant (0.054%) naturally occurring element on the Earth's crust[6,7]. Along with the natural sources human beings are also responsible for the elevated concentration of fluoride. Before 1990's the toxicological effects of fluorides were being neglected for its "good reputation" in preventing dental caries[8]. However, in recent decades due to growing awareness of people serious investigation on its undesirable effects have done. This element works as "double edged sword". Below its permissible level (according to WHO 1.5 mg/L) it is very much beneficial for healthy bones and calcification of enamels. But on exceeding the permissible level it causes teeth peeling, wound in thyroid, endocrine glands and liver. As per the studies fluoride could induce oxidative stress, lipid peroxidation, gene modulation and intercellular redox homeostasis modulation[8]. Along with dental fluorosis skeletal fluorosis is another symptom of chronic fluoride exposure, which leads to permanent bone and joint deformation. Removal of fluoride is therefore a necessary need for the wellbeing of human health as well as environment.

A brief study was made by Ayoob *et al.*[4] on the status of the presence of fluoride in consumed water and its dreadful effects above its permissible level. On the other hand, a complete demonstration of how fluoride affects cells was made by Barbier *et al.*[8]. Activated sand with 10% Fe_2O_3 was used by Togarepi *et al.*[9] for fluoride removal purpose. They reported fluoride removal up to 90% at pH 6 and a contact time of 3 h for a preliminary fluoride concentration 10 mg/L.Al_2O_3 supported carbon nanotube was used by Li *et al.*[10] to remove fluoride in the pH range 5–9 with adsorption capacity

28.7 mg/g. Briao *et al.*[11] used RO technique for desalination of water from Guarani Aquifer system for drinking purpose in Southern Brazil, which gave data of 100% fluoride removal and 93% recovery of drinking water by blended water. A suggestion of using brick powder for fluoride removal purpose was obtained by Rani *et al.*[12]. It showed an increased removal up to 54.4% from 29.6% within the specified pH range of 6 to 8 with of 0.6 to 1.0 g/100 mL adsorbent dose in various contact times. Defluoridation technique by anion exchange resin and also modified anion exchange resin with lanthanum complex of Alizarin fluorine blue was also studied[13].

Geographical lookout on fluoride contamination:

Fluoride contamination is no more a small regional problem; it is a universal problem now. If we go through the world map systematically it could be noticed that a large part of Africa, north and northeast China, México, India[14–16] are severely fluoride affected, here the fluoride concentration is higher than 30 mg/L. Countries like Kenya, Senegal[17], Srilanka[18,19], Tanzania and Argentina[1] are also rigorously affected by fluoride. In East Africa, the high fluoride level in drinking water resulted awful skeletal and dental fluorosis in local people[4,20,21]. In Tanzania not only in ground as well as surface water is also fluoride polluted. Because of this horrible fluoride contamination in Tanzania (in 2008), the drinking water guideline for the local people has been reduced and set to 4 mg/L from 8 mg/L[21,22]. The fluoride concentration were exceeded the WHO permissible limits in the rural areas of the Northern regions of Arusha, Kilimanjaro, Mwanza, Shinyanga, Singida[20,23]. Instead of the safe guidelines given by WHO there are a massive number of people, around greater than 200 million worldwide who drink water with fluoride concentration greater than the permissible level[24]. India is the most brutally fluoride affected country[7]. Here 12 million fluorides are deposited on the Earth crust among 85 million tons[7,25] and fluoride concentration in ground can be ranged between 0.3 to 6.9 mg/L[26,27]. In India, almost 66 million people are affected by fluoride pollution[26] and 15 to 19 states are also suffering[26,27]. In 2002, seventeen states of India were documented to be fluorosis affected[7]. Some parts of our state West Bengal like Purulia are also rigorously fluoride contaminated.

Sources of fluoride:

There are two main sources of fluoride:

(a) Natural sources (mainly geochemical deposits):

The foremost foundation of fluoride in nature is the fluoride bearing rocks and their weathering. In the earth crust there are various fluoride containing minerals e.g. topaz, fluorotite, biotites and rocks namely granite, sellatite (MgF_2), basalt, shale, cryolite (Na_3AlF_6), fluorspar (CaF_2), fluorapatite [$Ca_3(PO_4)_2Ca(F,Cl_2)$] etc.[28]. During the water flow fluoride from these rocks is being leached into the ground water.

(b) Artificial/ manmade sources:

Waste water discharged from the glass and ceramic industries, pharmaceutical, brick and iron works, electroplating and metal smelters, mines, semiconductor manufacturing industries have increased the fluoride levels in the surface as well as ground water[28,29]. Along with these high temperature plastic[30], coal combustion, steel manufacturing, Al, Cu and Ni production, phosphate ore processing, fertilizer production[1,7] etc. are the anthropogenic sources of fluoride. Some of the mouthwashes, tooth pastes and also fluoride of drinking water supplies made slight contribution in fluoride pollution[1].

Effects of fluoride contamination on human body:

Fluoride is the elemental form of fluorine, the most electronegative element[7]. Therefore, it generally gets attracted by the calcium which is the key ingredient of both bone and teeth and which is also positively charged. In this way it forms calcium-fluorapatite and takes part in the mineralization process[16]. But the process is beneficial up to a certain fluoride concentration. When it is present at low concentration in drinking water it is beneficial for the body tissues, it improves the bone health and takes part in dental enamel formation[7,31]. On the other hand on its high concentration (exceeding the WHO safe limits) it can be dangerous[7]. Not only the people in the rural areas are affected due to their lack of awareness but also in the developing countries it has become severe problem with a report of exposure of over 300 million people[32]. At its alarming levels fluoride can cause two main damages such as dental fluorosis and skeletal fluorosis. If the teeth are completely grown before being fluoride affected then dental fluorosis might not attack. This kind of fluorosis is mostly found in children. Initially dental fluorosis is characterized by chalky white teeth and its final severe form is rigorous pitting of teeth. Teeth disintegration is also found[16].

In case of severe skeletal fluorosis victims suffer from knee pain, back pain, joint pain etc. Their legs become deformed and can't function properly. Even it is not easy for them to be seated in a squatting position. Bharati *et al.*[33] has also found these types of bone disorder in the people of Bagalkot and Gadag, the two districts of Karnataka during their survey. Skeletal fluorosis can cause paralysis not only of body parts but also one's mind. Along with these two main symptoms serious neurological damage[34], anxiety, Alzheimer's syndrome[30,35], infertility in women, cognitive impairment problem, depression[36,37], disruption of various metabolic functions such as oxidative phosphorylation, glycolysis, coagulation, brain functioning, pineal gland functioning, neurotransmission[1,38] are also associated with fluoride contamination. Therefore, not only a single body part but fluoride contamination can affect most of the organs of human body.

Fluoride metabolism:

Absorption, distribution and excretion these are the three pH dependent steps of fluoride metabolism.

Absorption:

Gastrointestinal track is the chief source of fluoride adsorption after ingestion. The absorption of fluoride from this track occurs without the help of any particular transporters by passive diffusion[39]. This is the most affected organ system[38]. Small amount of total ingested fluoride (20–25%) is absorbed in stomach by a pH dependent process[40]. The remaining percentage of fluoride was then follows a pH independent mechanism to be absorbed by the proximal small intestine[39]. Fluoride absorption is moreover exaggerated by foods which communicate with fluoride[39].

Distribution:

From the stomach and intestine fluoride gets absorbed into the plasma and showed a rapid increase in the plasma fluoride levels. Blood plasma acts as the main centre from which the circulation of fluoride occurs in the body fluids, mineralized and soft tissues[40]. Therefore, fluoride gets deposited into bones, growing teeth and in pineal gland. Accumulation of fluoride occurs in major concentration in pineal gland than in bones and teeth[41].

Excretion:

Fluoride toxicity also hampers the kidney function though

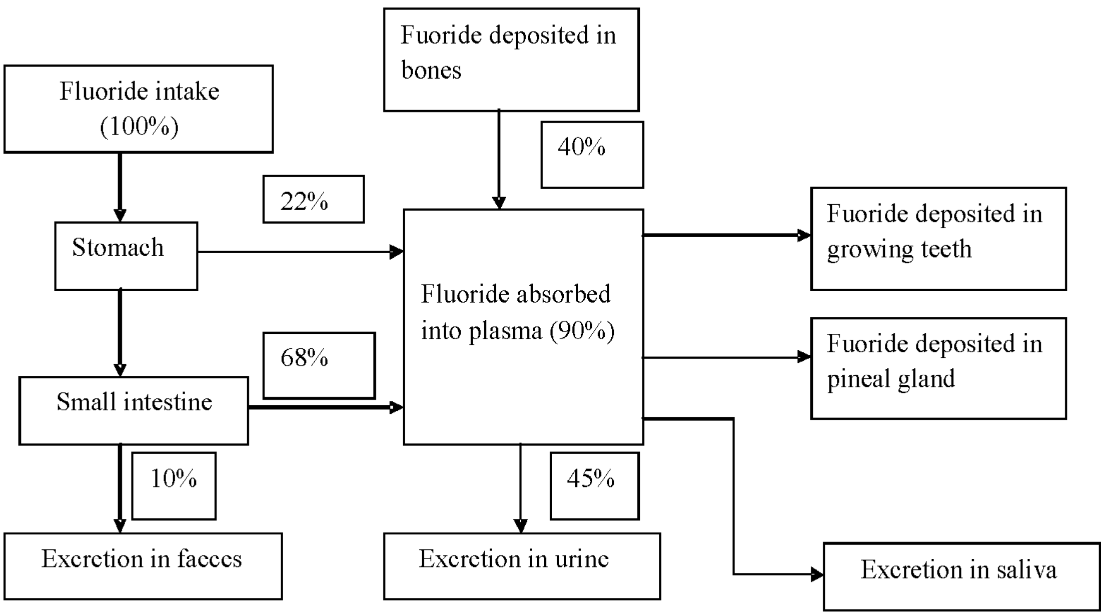

Fig. 2 Mechanism of fluoride metabolism.

renal excretion plays a significant part in regulating the fluoride levels in human body[37,39]. In case of adults 60% and children nearly 45% ingested fluoride is excreted through urine[39] daily. The rest fluoride excretion occurs through saliva and breast milk. The detailed mechanism is shown in Fig. 1 diagrammatically.

Conclusion

There was a time when the mineralizing and calcification effects of fluoride had covered its bad effect on human health and environmental issues. But, day by day its bad effects are coming into light. Not only teeth and bones but the chief organs of human body like the gastrointestinal track, kidney etc. is badly affected by fluoride toxicity. Not only small towns and rural areas but in big, developed countries are also suffering from the terrible affects of fluoride. In contrast to developed areas the rural areas where the people sometimes fail to diagnose fluorosis and suffer lifetime. As fluoride have no such sharp identifiable characteristics. Therefore fluorosis is an endemic burden which the innocent people carry for their whole life. Basically it's a very big problem in the interior arid areas where there are many people who are dealing with extreme poverty, lack of education. Therefore for the sake of community there is a great need of a detailed survey to identify fluorosis as well as building awareness among the people.

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