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A Review on Fluoride in Ground Water: Causes, Effects and Solutions

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ABSTRACT:
Water, the most vital resource for all kinds of life on this planet, is also the resource, adversely affected both quantitatively and qualitatively by all kind of human activities on land, in air or in water or naturally. Fluoride contamination of ground water is one of them and it is a major concern in present context. The main source of fluoride in ground water is the leaching of fluoride from the rock minerals of the earth's crust and anthropogenic activities. Defluoridation of water is a practical option to overcome the problem of excessive fluoride in ground water. This review paper describes the information on fluoride contamination, sources of its occurrence, effects on human & animal health and removal techniques.
Key Words: fluoride, fluorosis, ground water, human health, skeletal fluorosis, defluoridation

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I. INTRODUCTION:

Water is one the most fundamental and essential elements amongst the natural resources and is imperative for the survival of all living organisms. It serves as an extremely important requisite for sustainable development as well as economic growth & development. With extensive growth of population there has been massive urbanization and industrialization leading to pollution as a result of chemical discharge in water bodies, causing water pollution. Fluoride contamination in drinking water is a burning environmental issue of the World today. Occurrence of fluorine in ground water has drawn worldwide attention due to its considerable impact on human physiology [1]. Some ions dissolved in water and present in appropriate concentration are essential for human beings while higher concentration results in toxicity, fluorine is one of them. It is distributed ubiquitously as fluorides. It has been classified as essential parameters in ascertaining the suitability of potable water [2] [3] [4]. Fluoride content in ground water is mainly due to natural contamination, but the process of dissolution is still not well understood [5] [6]. About 203 districts in 20 states of the India are affected with fluoride contamination. Groundwater with high fluoride concentration (>1.5 mg/L), according to WHO, 2011 [7], is affecting more than 260 million people around the world [8]. India is one among the 23 nations in the world, where the fluoride contaminated groundwater is creating the health problems [9].

II. PROPERTIES OF FLUORINE:

Fluorine is the lightest halogen with molecular weight 19 and atomic number 9, and one of the most electronegative of all elements. This fluorine exists as a diatomic molecule with remarkably low dissociation energy (38 K cal/mole), and is physiologically more active than any other ion. Fluorine is never found in elemental state in nature. Fluorine in drinking water is totally in an ionic form and hence it rapidly, totally and passively passes through the intestinal mucosa and interferes with major metabolic activities of the living system. The occurrence of fluoride in ground water has attracted attention globally, since it has considerable impact on human health. The fluoride content in the groundwater is a function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, temperature, pH, concentration of calcium and bicarbonate ions in water, etc. [10]. Excess fluoride affects plants and animals also. Standards prescribed by various regulatory bodies for fluoride concentration in drinking water are different according to their climatic conditions. According to the World Health Organization (WHO), the standard prescribed for fluoride ion concentration in drinking water is 1.0 mg/l [11], whereas by Bureau of Indian Standards (BIS) it is 1.0mg/l [12]. Fluoride in smaller dose (0.8-1.0mg/l) helps to prevent dental caries particularly in the children below 8 years of age. Fluoride in higher concentration causes dental fluorosis (1.5 -2.0mg/l) and skeletal fluorosis (>3.0mg/l) [13].

III. CAUSES OF FLUORIDE IN GROUND WATER:

The world's fluoride stores in the ground are assessed to 85 million tons. Out of which 12 million tons are situated in India. Usually the surface water is not contaminated with high fluoride, whereas ground water may be contaminated with high fluoride because the usual source of fluoride is fluoride rich rocks. When water percolates through rocks it leaches out the fluoride from these rocks. The rocks rich in fluoride are: Sellaite (MgF2), fluorspar (CaF2), cryolite (Na3AlF6), fluorapatite 3Ca3(PO4)2Ca(FCl2)), rock phosphate, voracity, topaz and hydroxylapatite [14] [15]. It exists in the form of fluorides in a number of minerals. Intensive and prolonged semi-arid climate, long term withdrawal of groundwater for irrigation, alkaline nature of sub-surface circulating water, long residence time of water in fractured aquifers and geological structure are the favorable conditions for fluoride enrichment in the ground water. Teotia et al. (1981) [16] stated that low calcium and magnesium hardness and high alkalinity are characteristic in the majority of the drinking water samples. Besides these minerals, alkali rocks, hydrothermal solutions, phosphate fertilizers, burning of coal, manufacturing process of Aluminum, steel and bricks may also contribute to higher concentration of fluoride in groundwater.

IV. EFFECTS OF FLUORIDE CONTAMINATION:

Fluoride ingestion in low levels mixes is helpful to the body, but consumption of fluoride above the WHO's concentration guidelines has more drastic effects, such as sever tooth and skeletal fluorosis, which can cause brittle bones/teeth mottling, skeletal fluorosis, joint impairment and possible damage to the thyroid gland [17]. In India, about 62 million people including 6 million children suffer from fluorosis because of fluoride contaminated water [18]. Fluoride ions in aqueous solutions converted into HF in acidic environments such as those of the exists in stomach, and up to about 40% of ingested fluoride is absorbed in the stomach as HF. Prolonged and excessive intake of fluoride may result in a serious public health problems [19]. Hundreds of research articles published over the past several decades have demonstrated potential harm to humans from fluoride at various levels of exposure, including levels currently deemed as safe. Fluoride is also known to impact the cardiovascular, central nervous, digestive, endocrine, immune, integumentary, renal, and respiratory systems, and exposure to fluoride has been linked to Alzheimer's disease, cancer, diabetes, heart disease, infertility, and many other adverse health outcomes. Increased sources of fluoride exposure are accompanied by increased human health risks. In severe cases, the bone structure may change and ligaments may calcify, with resulting impairment of muscles and pain. Acute high level exposure to fluoride causes immediate effects of abdominal pain, excessive saliva, nausea and vomiting. Therefore, it has become a necessity to reduce and work toward eliminating avoidable sources of fluoride exposure, including water fluoridation, fluoride-containing dental materials, and other fluoridated products. Excess fluoride affects plants and animals also. Exposure to fluoride accumulates in the foliage of plants and mainly occurs through the atmosphere or through root absorption of soil. This results in a number of problems in the environment, including decreased plant growth and yield. In addition to harming wildlife, this implicates fluoride pollution as a danger for crop yields and other agricultural activities.

Fluoride toxicity depends on the following factors:

1. Excess concentration of fluoride in drinking water
2. Low Calcium and high alkalinity in water
3. Daily intake of fluoride
4. Exposure duration to the fluoride
5. Age of the individual
6. Derangement in hormonal profile

V. REMOVAL OF FLUORIDE FROM WATER:

Removal of fluoride ion from water is known as defluoridation, There are various method available for fluoride removal like Chemical precipitation, Adsorption, Ion-Exchange, RO, Electro-dialysis etc. [9]. Most of these methods have high operational and maintenance cost, low fluoride removal capacities, lack of selectivity for fluoride, undesirable effects on water quality, generation of large volumes of sludge and complicated procedures involved in the treatment or less efficient [20] [21]. Nalgonda technique developed by NEERI is commonly preferred at all levels because of its high efficiency, low price and ease of operation [22]. Adsorption techniques have been quite popular due to their simplicity and availability of wide range of adsorbent materials. Many researchers reported successfully fluoride remediation using different, conventional and non-conventional methods. An adsorption process considered better as compared to other methods because, a wide variety of adsorbents and their modifications have been tested for the removal of fluoride from water with 80-99 % removal efficiency. These investigations concluding that

suitability of adsorption process for the removal of fluoride. The adsorbents tested for removal of fluoride include activated carbons prepared from biological sources, conventional adsorbents i.e. resins, activated alumina, bauxite, hematite, polymeric resins etc. have been employed for the treatment of drinking water [23]. Researchers worked on various locally and abundantly available materials like aloevera and CaCl2 [24], fish bone charcoal [25] [26], red mud [27] [28], Clays [29], fly ash [30] [31], synthetic zeolites [32] [33], neem bark powder [34], activated alumina [35] etc. Different low-cost adsorbent materials are also available for effective removal of fluoride from water. The naturally available adsorbents are horse gram powder, ragi powder, multani mitti, red mud, calcined clay, concrete, pineapple peel powder, chalk powder, orange peel powder, rice husk, Moringa oleifera extract (MOE), gooseberry, activated alumina-coated silica gel, activated sawdust, activated coconut shell carbon, coffee husk, bone charcoal, activated soil sorbent, etc., are some of the different materials investigated for adsorptive removal of fluoride from water [36].

VI. CONCLUSION:

Supply of drinking water with less fluoride should be emphasized. Rainwater harvesting techniques should be promoted since they have a dilution effect on the fluoride concentration of the ground water of the affected area. Sometimes we focus on attractive packaging or advertisements rather than necessity and buy fluoride contained products without knowing whether it suits or not. Hence we should take care the fluoride content, while buying the products. Risk to the health of people living in the high fluoride area needs to be checked by conducting regular health check up and necessary remedial measures have to be provided to them. Awareness generation program and emphasis on importance of consuming calcium, vitamin C, E and antioxidant-rich diet can be made for minimizing the adverse effects of fluoride.

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