Fluoride Contamination in India: Its Sources, Chemistry & Effects with a significant emergence in Chhattisgarh state

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Abstract- Fluoride is a common constituent of water samples. Its concentration in water samples differs primarily depending upon the climate, composition of the host rock, and hydrogeology of that area. Alkaline rocks and volcanic activities release large quantities of F in to the environment. Domestic sewage, run-off from agricultural land and phosphatic fertilizers are the prime sources of F contamination in water. Fluorides are mainly deposited on bones, teeth and further on skeleton and later in soft tissues. 20 out of 29 states of India have groundwater contamination from F with its concentration ranging from 0.1- 32 ppm. Groundwater studies with a perspective of F contamination in some of the cities of Chhattisgarh like Korba, Koriya, Dongargarh, Bilaspur, Mungeli, Rajnanadgaon showed its remarkable presence. In this review a comparison of the Indian situation and the regional studies has been focused for gaining a better perspective of fluorosis.
Key Words: Fluorosis, Groundwater contamination

INTRODUCTION

Geogenic sources- Among the various groundwater constituents, fluoride is one of the minor elements in natural water[1]. Fluorosis is mostly prevalent in fluoride contaminated areas in India, along with other countries in world. India alone registers more than 66 million people to be suffering from fluorosis, including 10% of children below 14 years of age[2]. Research has found that almost 20 of the Indian states have groundwater fluoride contamination to some extent, impacting 85−97% of districts in some states. In the Indian context, the fluoride is dissolved in groundwater mainly from geological sources but the process of dissolution is still not well understood[3, 4]. Higher concentrations of fluorine are present in alkaline volcanic, hydrothermal, sedimentary, and other rocks derived from evolved magmas and hydrothermal solutions[3].The amount of fluoride in water is governed by climate, composition of rocks and hydrogeology[5]. The origin of fluoride in groundwater is through weathering of alkali, igneous and sedimentary rocks[6].Fluorite (CaF_2) is the principle bearer of fluoride and is found in granite, granite gneisses and pegmatite[7,8]. The high fluorides occur in top aquifer system and have reached to endemic level in most of the states[9]. 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[10, 11]. The permissible limit for fluoride in drinking water is 1.0 mg/l[12] and 1.5 mg/l (Indian standard).

Anthropogenic sources- Apart from natural sources, anthropogenic activities like burning of coal, manufacturing process of aluminium, steel, bricks, Phosphatic fertilizers industries, often contain fluoride as an impurity and are being leached down to the ground water at a greater concentration[7, 13-15]. Though fluoride enters the body through water, food, industrial exposure, drugs, cosmetic etc., drinking water is the major source (75%) of daily intake[16]. Major health problems caused by high level of fluoride are dental fluorosis (teeth mottling), skeletal fluorosis and deformation of the bones in children as well as adults[17]. From the fluoride level found in ground water samples of the study area it can be concluded that the ground water is not safe for drinking purpose, but can be used for irrigation[18].

Fluoride Chemistry

The fluoride content in the groundwater is a function of many factors including concentration of calcium and bicarbonate ions in water[19]. The F in groundwater appears to be controlled by the distribution of Ca^{2+} and to some extent SO_4^{2-}, ionic strength, and the presence of complex ions. From correlation coefficient analysis, F was found to be inversely related to Ca^{2+} and positively related to Na^{+}. Elevated levels of F in the groundwater is generally associated with low calcium[3]. On the other hand, higher F was associated with high Na^{+} and low sulfate[20].

Indian states affected by Fluoride contamination

The problem of excessive fluoride in groundwater in India was first reported in 1937 in the State of Andhra Pradesh[21]. Twenty states in India have been identified as endemic for fluorosis and Haryana is one of them[22]. The fluoride concentration of groundwater in various villages of Gurgaon district of Haryana varied from 0.02 – 6.4 mg/l[23]. The occurrence of elevated F concentrations in groundwater (> 1.5 mg/L) in the villages of Singpur and Sagaragan in the Nayagarh district of Orissa in relation to nearby hot spring water (> 10 mg/L) has also reported[24]. One of the artesian well of the Nasipur village in Birbhum district of West Bengal has been reported to found 1.95 mg/L of fluoride[5]. In Rajasthan, 24 out of 32 districts are influenced with the problem of fluorosis and 15 million of the population are at danger[25, 26]. The fluoride concentration of groundwater of four blocks in Ajmer district of Rajasthan changed from 0.24 to 17.60 mg/l causing skeletal and dental fluorosis[27, 28]. The ground water samples of Nalgonda district of Andhra Pradesh had fluoride concentration upto 8.8 mg/l and around 30% of wells had fluoride concentration far greater than the permissible limit[29]. In Orissa, around 18 districts are contaminated with huge quantity of fluoride and are influenced by fluorosis[30].

Fluorosis in Chhattisgarh

Water quality analysis of various ponds of Bilaspur reported the fluoride concentrations in the range 0.6-1.31, which is within the WHO and BIS limit of below 1.5 ppm[31]. The pH of all the water sample are between 7.11 to 8.43 which indicates no anthropogenic contamination in the water. A greater calcium hardness ranging from 55-320 ppm reveals the limiting value F in water samples. Surface water analysis of Korba showed fluoride concentration at 0.39-1.60 ppm[32]. Extreme hardness prevalent in the water samples ranging from 498-818 mg/L related the lower F concentration in water. The geo-morphology of the area shows the presence of laterite hard soil which is rich in Fe and Al. Water samples from bore-wells of Koriya district showed F concentration varying from 0.2 to 2.2 ppm at neutral pH(7.02-7.85)[33]. Abnormal levels of F in groundwater of Dongargarh city have been identified. A much higher range of F (2.0-11.2 ppm) may be due to the mineralization of F containing bedrock in the region[34]. The groundwater of Ambagarh Chowki in Rajnanadgaon showed elevated levels of F ranging from 3.7 to 27 ppm leading to development of skin, dental and skeleton fluorosis in humans and domestic animals[35].

CONCLUSION

An understanding of water chemistry is the basis of the knowledge of the multidimensional aspect of aquatic environmental pollutant. It involves the source, mineral composition, reactions and transportation by water under suitable conditions. The weathering and leaching processes, mainly by moving and percolating water, play an important role in the incidence of F^- in groundwater. The F^- concentration in groundwater depends upon the following factors like climate, evaporation, precipitation, geology, and geomorphology of the area. It is one of the pollutants available in water supplemented by dissolution of fluoride containing rocks by their weathering and leaching or discharge by agricultural and industrial activities.

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