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FLUORIDE IN GROUND WATER OF RAJASTHAN, INDIA A CHALLENGING TOXICOLOGICAL AND GEO-ENVIRONMENTAL ISSUE: A REVIEW

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ABSTRACT:

Fluoride is often called a two-edged sword, inadequate intake of fluoride causes dental caries whereas excess intake causes dental and skeletal fluorosis and other ill effects on human health. Its excess ingestion into human body slowly converts the working, productive and healthy population into nonfunctional, unproductive and burden on society. The seriously affected people become a live dead body which does not able to perform their daily life function. It becomes an evil for socioeconomic, mental, physical and healthy development of affected population in world wide. The major sources of fluoride in water are geogenic and anthropogenic. Excess ingestion of fluoride affects not only calciferous tissues but other tissues and physiology of human body also. The health problems linked to fluoride are depend on socioeconomic status, literacy level, nutrition level, geography of habitation and availability of facilities to population. This paper presents a review, which focuses on the sources of fluoride in drinking water, status and its ill effects on habitants in Rajasthan, which becomes a big challenging toxicological and geo-environmental issue.

Keywords: Fluoride, dental fluorosis, skeletal fluorosis, geogenic and anthropogenic

[1] INTRODUCTION

The word fluoride is derived from the Latin term ‘Fluore’ meaning ‘to flow‘. It is the most electronegative and reactive of all elements and thus in nature rarely found in its elemental state. Fluoride is ubiquitous in nature and is present in rocks, soil, water, plant food and even in air. The natural concentration of fluoride in groundwater mainly depends on the geological, chemical and physical characteristics of the aquifer, the porosity and

acidity of the soil and rocks, the temperature, the action of other chemical elements, and the depth of wells. In the Indian context, the fluoride is dissolved in groundwater mainly from geological sources. Higher concentration of fluoride in ground water of Indian continent is associated with igneous and metamorphic rocks and fluoride epidemic is reported mostly in granite and gneissic geological formation of different states in India (Deshmukh *et al*., 1995; Agrawal, 1997; Tripathy *et al*., 2005; Raju *et al*., 2009).

Fluoride in drinking water can be either beneficial or detrimental to health, depending on its concentration (Murutu et al., 2012), within permissible limits it is beneficial for calciferous tissues but excess intake resulting in hard tissue and soft tissue irreversible damage in form of dental fluorosis, increased chances of caries and periodontal diseases, skeletal and non-skeletal fluorosis and acute toxicity which is lethal. According to the World Health Organization (WHO), the maximum acceptable concentration of fluoride is 1.5 mg/l (WHO, 2006). Naturally occurring fluorides in groundwater are a result of the dissolution of fluoride-containing rock minerals by water (Kabata and Pendias, 1984) while artificially high soil F levels can occur through contamination by application of phosphate fertilizers or sewage sludges, or from pesticides (EPA, 1997).

The problem of Fluorosis is worldwide affecting many countries, Sporadic incidence of high fluoride content in groundwater has been reported from India, China, Sri Lanka, West Indies, Spain, Holland, Italy, Mexico, and North and South American countries. India and China, the two most populous countries of the world, are the worst affected and in India especially Rajasthan which is the largest state of India.

[2] STATUS OF FLUORIDE IN INDIA

In 21th century, India more than 35 million populations of 19 states is consuming fluoride above permissible limit through drinking water. In 1991, 13 of India's 32 states and territories were reported to have naturally high concentrations of fluoride in water (Mangla, 1991), but this had risen to 17 by 1999 (UNICEF, 1999). At present 62 million people, including 6 million children suffer from fluorosis because of consuming fluoride contaminated water (Raju *et al*., 2009). This is indicating that endemic fluorosis is the most alarming public health problem of the country. The most seriously affected areas are Andhra Pradesh, Punjab, Bihar, Madhya Pardesh, Haryana, Rajasthan, Gujarat, Tamil Nadu and Utter Pradesh (Kumaran *et al*., 1971; Teotia *et al*., 1984; Ayoob & Gupta, 2006; Hussain *et al*., 2012).

Endemic skeletal fluorosis was reported from India in the 1930. It was observed first in Andhra Pradesh bullocks used for ploughing, when farmers noticed the bullock's inability to walk, apparently due to painful and stiff joints. Several years later the same disease was observed in humans (Short *et al*., 1937). The prevalence of dental fluorosis has been investigated in Rajasthan by Choubisa *et al*. (1997). (Yadav and Lata, 2003) examined the prevalence of dental fluorosis at lower drinking-water fluoride concentrations in the Jhajjar district, Haryana. Concentration of fluoride in ground water varies state to state in India, fluoride concentrations recorded in different state by different are Angul-Talcher, Orissa 0.2-2.4 mg/L (Reza & Singh, 2013), Guwahati, Assam 0.18-6.88 mg/L (Dass *et al*.,

2003), Balasore, Odissa 0.6 -5.83 mg/L (Das *et al*., 2012), Rohtas, Bihar 0.1-2.5 mg/L (Ray *et al*., (2000), Delhi 0.11-32.5 mg/L (Susheela *et al*., 2003), Dindigul (TN) 2.47-5.26 mg/L (Hanipha & Hussain, 2013), Erode, (TN) 0.5-8.2 mg/L (Karthikeyan *et al*., 2010), Faridabad, Hariyana 1.0-40 mg/L (Garg & Singh, 2013), Mehsana, Gujarat 0.1– 40 mg/L (Chinoy *et al*., 1992), Jind, Haryana 0.2-2.0 mg/L (Singh *et al*., 2013), Kachchh, Gujarat 0.62-3.42 mg/L (Trivedi *et al*., 2012).

Karnataka 1.0-7.4 mg/L (Sumalatha *et al*., 1999), Palghat, Kerala 1.5-5.75 mg/L (Shaji *et al*., 2007), Shivpuri (MP) 0.2-6.4 mg/L (Nawlakhe *et al*., 1995), Mathura (UP) 3.4-4.6 mg/L (Rawat *et al*., 2012), Nalagonda (AP) 0.1-8.8mg/L (Brinda *et al*., 2010), Rajasthan 0.5-5.8 mg/L (Hussain *et al*., 2013), Rameswaram (TN) 1.5-2.5 mg/L (Sivasankar & Ramachandramoorthy, 2011), Sonitpur, Assam 0.17-5.602 mg/L (Datta *et al*., 2010), Talupula (AP) 0.78-6.10 mg/L (Nagarajun *et al*., 2011), Agra (UP) 0.1-12.8 mg/L (Gupta *et al*., 1999), Warangal (AP) 1.1-5.8 mg/L (Radhika & Praveen, 2012), Birbhum (WB) 0.006-1.95 mg/L (Gupta *et al*., 2006) and Yavatmal (MH) 1.4- 2.4 mg/L (Chavhan, 2012).

[3] STATUS OF FLUORIDE IN RAJASTHAN

In Rajasthan the first case of skeletal fluorosis was reported from Jobner near Jaipur city by Kalsiwal and Soloman in (1959). Later during 1964 in the villages of Nagaur and Bhilwara district high fluoride contents in drinking water were observed. All the 33 districts are endemic to fluoride problem but the district of Barmer, Nagaur, Rajsamand, Jalore, Tonk, Churu, Pali and Ajmer are worst affected (Fig. 1). On the other hand, the eastern part of the state is bordered by Haryana state where fluoride content is relatively higher (Kaushik *et al*., 2002; Singh *et al*., 2007; Khaiwal & Garg 2007), which to some extents influences the groundwater quality of northern Rajasthan due to its physiographical structure (Suthar *et al*., 2008). In Rajasthan, fluoride concentrations have been found between 0.6 mg/L to 69.7 mg/L (Choubisa, 1998; Susheela, 1999).

In state many fluoride affected pockets were identified different researcher such as Jahazpur, Bhilwara (Meena *et al*., 2015; 2016a; 2016b), Nagaur (Arif *et al* , 2014), Newai, Tonk (Yadav *et al*., 2014), Sanganer, Jaipur (Arif *et al*., 2013), Bassi, Jaipur (Saxena & Saxena, 2013), Ladnu, Nagaur (Arif *et al* , 2013), Rajasthan (Hussain *et al*., 2013), Central Rajasthan (Husssain *et al*., 2012), Dungarpur (Choubisa, 2012), Dausa (Yadav *et al*., 2012), Dholpur (Singh *et al*., 2012), Nagaur Tehsil, Nagaur (Arif *et al*., 2012), Uniara,Tonk (Arif *et al* , 2012), Deoli, Tonk (Meena *et al*., 2011), Nawa, Nagaur (Gautam *et al*., 2011), Malpura, Tonk (Tailar & Chandel, 2010), Sikar city (RadheyShyam & Kalwania, 2010), Jodhpur & Barmer (Mathur *et al*., 2010), Ajmer (Vikas *et al*., 2009), Northan Rajasthan (Suthar *et al*., 2008), Alwar (Yadav *et al*., 2008), Ajmer (Sharma, 2007), Bhilwara city (Sharama *et al*., 2007), Banera, Bhilwara (Hussain *et al*., 2005), Hurda, Bhilwara (Hussain *et al*., 2005), Raipur, Bhilwara (Hussain *et al*., 2003), Dungarpur (Choubisa *et al*., 2001), Bhilwara town (Hussain *et al*., 2001), Sirohi (Hussain *et al*., 2000), Banswara (Choubisa *et al*., 1997), Southern Rajasthan (Gupta *et al*., 1983) and Ajmer (Mathur, *et al*., 1976).

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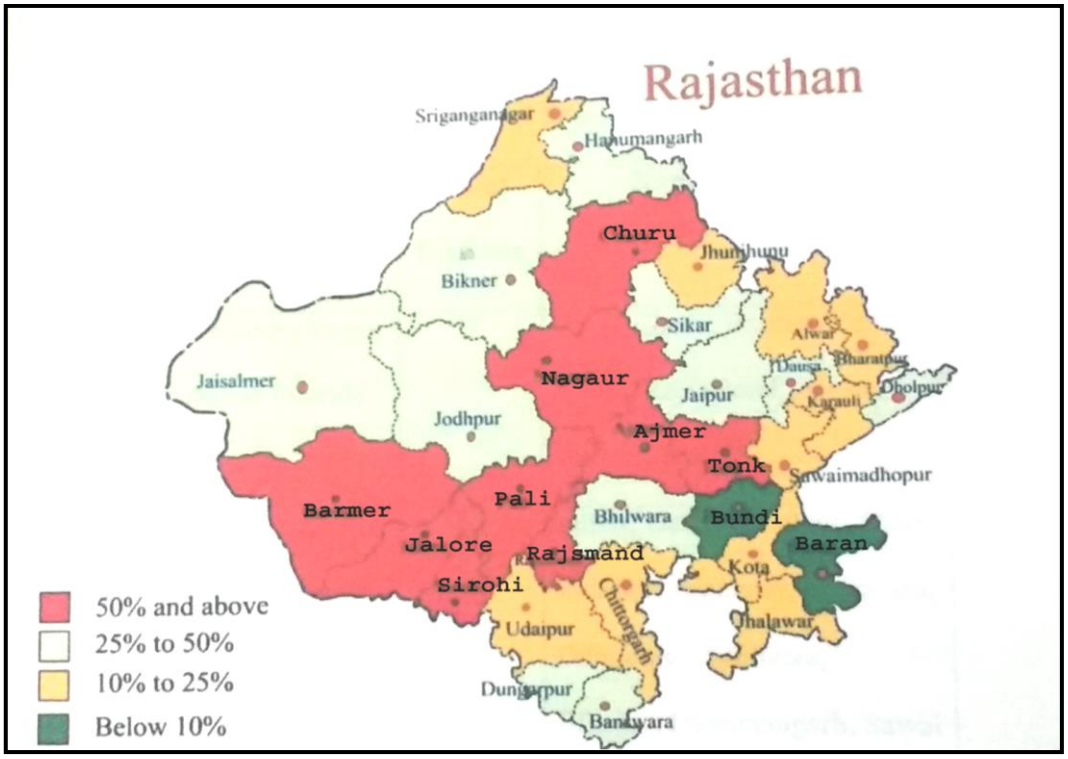

Fig. 2: Status of fluoride contamination in ground water of Rajasthan

[4] EFFECTS OF EXCESS FLUORIDE CONSUMPTION

Fluoride has extraordinary tendency to get attracted by positively charged ions like calcium. The calcified tissues likes bone and teeth have maximum amount of calcium hence they attract the maximum amount of fluoride that gets deposited as calcium-fluorapatite crystals. Most of the ingested fluoride ions get incorporated into the apatite crystal lattice of calciferous tissue teeth enamel that is principally composed of crystalline hydroxyl apatite. The hydroxyl ion gets substituted by fluoride ion from hydroxylapatite since fluorapatite is more stable than hydroxyl apatite. Thus, a large amount of fluoride gets incorporated in calcified tissues and only a small amount is excreted through sweat, urine and stool (Murray, 1973; Chaturvedi, *et al*., 1990). Acute excess intake of fluoride for prolonged time creates health hazards such dental fluorosis, skeletal fluorosis, non skeletal fluorosis, gastric and kidney problems, interference in calcium metabolism and many enzyme activities. Fluorosis is a disease which is caused by excess intake of Fluoride.

[5] DENTAL FLUOROSIS

Dental fluorosis is hypo-mineralization of tooth enamel caused by intake of excess fluoride during enamel formation in which loss of luster and shine of the dental enamel (Wong *et al*., 2010). It appears as a range of visual changes in enamel resulting degrees of intrinsic tooth discoloration. The severity of the condition is dependent on the dose, duration and age of the individual (Bergc & Slayton, 2015). In the mildest form there are faint white

lines or specks. Slightly more severe cases appear as white mottled patches, while severe fluorosis is characterized by brown discoloration and brittle, pitted and rough enamel. Normally, the degree of dental fluorosis depends on the amount of fluoride exposure up to the age of 8-10, as fluoride stains only the developing teeth while they are being formed in the jawbones and are still under the gums. The effect of dental fluorosis may not be apparent if the teeth are already fully grown prior to the fluoride over exposure. Therefore, the fact that an adult shows no signs of dental fluorosis does not necessarily mean that his or her fluoride intake is within the safety limit. DF is an irreversible condition, the teeth once affected by dental fluorosis cannot be reversed to normal but the discolored teeth can be masked by beaching or other methods. The incidence and severity of DF depends fluoride concentration in drinking water.

[6] SKELETAL FLUOROSIS

Skeletal fluorosis is a bone disease caused by excessive consumption of fluoride. Excessive quantity of Fluoride deposited on the skeleton, which is more in calcellous bone compared to cortical bone is called skeletal fluorosis. The disease is generally diagnosed at a developed stage. A fluoride poisoning lead to severe pains associated with rigidity and restricts the movement of cervical and lumbar spine, knee and pelvic joints as well as shoulder joints. Crippling deformity is associated with the rigidity of joints and includes kyposis (abnormally increased convexity in the curvature of the thoraces viewed from side), scoliosis (lateral curvature of vertebral column), flexion deformity (the act of vending or the action of being bend) of knee joint, paraplegia (paralysis of lower part of the body, including the legs) and quadriplegia (paralysis of all four limbs). Skeletal fluorosis affects the young children as well as the older individuals. In the early clinical stages of skeletal fluorosis, symptoms includes Pain in the bone and joint, Sensation of burning, Pricking and tingling in the limb, Muscles weakness, Chronic fatigue, Gastrointestinal disorder and reduce appetite. In the second clinical stage pain in bones become constant and some of the ligaments begin of calcify. In the advanced skeletal fluorosis the extremities become weak and moving of joints is difficult. The main structural changes in fluorosed bones are exostosis, mottling of the osteons, increase in bone mass and density, osteoid seam and resorption surface and trabecular bone volume and increased osteon diameter and in biochemical changes the collagen content, hydroxylation of praline and lysine in bone collagen and collagen cross link precursors get reduced.

[7] NON SKELTAL FLUOROSIS

The conventional belief that fluoride affects only bone and tooth has been negated in recent years as the evidences on the involvement of the soft tissues/ organ of the body are convincing. Besides skeletal and dental fluorosis, excessive consumption of fluoride may lead to muscle fibre degeneration, low haemoglobin levels, deformities in RBCs, excessive thirst, headache, skin rashes, nervousness, neurological manifestations (it affects

brain tissue similar to the pathological changes found in humans with Alzheimer's disease), depression, gastrointestinal problems, urinary tract malfunctioning, nausea, abdominal pain, tingling sensation in fingers and toes, reduced immunity, repeated abortions or still births, male sterility, etc. It is also responsible for alterations in the functional mechanisms of liver, kidney, digestive system, respiratory system, excretory system, central nervous system and reproductive system, destruction of about 60 enzymes. Fluoride in excess is known to interfere in thyroid functioning and causes TSH elevation and decreases T3/T4 hormones (McLaren, 1976). In recent research showed that excess exposure of F^- does have adverse effect on the mental ability of children and a strong correlation between exposure to fluoride and low IQ was found (Neville *et al*., 2015).

[8] CONCLUSION

In a ground water of Rajasthan in many blocks fluoride concentration is exceeding the prescribed limits of WHO and BIS. Excess intake of fluoride through drinking water is causing ill effects on human health as well as other habitants. The seriously affected people become a live dead body which does not able to perform their daily life function. It becomes an evil for socioeconomic, mental, physical and healthy development of affected population in world wide. The major source of fluoride in ground water of Rajasthan is geogenic. The health problems linked to fluoride are depend on socioeconomic status, literacy level, nutrition level, geography of habitation and availability of facilities to population. The excess concentration of fluoride becomes a big challenging toxicological and geo-environmental issue in Rajasthan.

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