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Fluoride – A Double Edged Sword

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Abstract: Fluoride is the major inorganic pollutant of natural origin found in ground water. The ground water contributes only 0.6% of the total water resources on Earth. Even though, it is the preferred and major source of drinking water in rural as well as in urban areas particularly in developing countries like India as treatment of this water is often not required. The 90% of the total drinking water requirement and 50% of the agricultural requirement is fulfilled by the ground water in India. The major sources of fluoride in ground water are fluoride bearing rocks and pollution caused due to urbanization and industrialization. Drinking water is the chief source of fluoride. Indian standards (2012) for drinking water prescribe the desirable limit 0.6-1.2mg/L. According to WHO (1997) Permissible limit for fluorides in drinking water is 1.5mg/L. Fluoride is often termed as a double edged weapon, as the fluoride ions have dual significance in water supplies. High concentration of fluoride (> 1.5 mg/L) may lead to chronic fluoride toxicity, which manifest as dental and skeletal fluorosis, at the same time a concentration less than 0.8mg/L results in dental caries and in the concentration of 0.8-1.0 mg/L, beneficial for calcification of dental enamel. Thus the optimal and judicious use of fluoride offers maximum caries protection; whereas injudicious and excessive systemic consumption can lead to chronic fluoride toxicity. Excessive fluoride in drinking water is not a regional issue, it prevails worldwide. In Telangana, Nalgonda district is often categorized as endemic fluoride belt, where fluoride exists more than 20 times of permissible limits. Fluoride is above the normal values in many states like U.P, M.P, AP, Bihar, Delhi, Gujarat, Rajasthan, Jammu Kashmir, Punjab, Haryana, Karnataka, Kerala and Tamil Nadu etc. There are several developed and developing countries like Argentina, USA, Algeria, Libya, Egypt, Jordan, Turkey, Iran, Iraq, Kenya, China, Japan, New Zealand, Australia, Thailand, Canada, Srilanka, Syria etc, which are endemic for fluorosis. It has been revealed by many studies that, fluoride concentration is high in tube well waters than hand pump water and Reservoir water. There is a remarkable negative correlation between fluorosis and balanced diet. Children especially below 8 years of age are susceptible to fluorosis and poor men are the chief victims as they consume unsafe and imbalanced diet.

Key Words: Fluoride, Fluorosis, Fluoride toxicity, Fluoride belt

Introduction

Water is the essential component of the living system. It is being used by man for various purposes like drinking, cooking, bathing, washing, agriculture and industrial production. Water is the important natural resource which man has exploited than any other resource for the sustenance of his life. Developmental activities caused degradation and drastic changes in the physical and chemical properties of water through pollution.

At present the water born diseases become a menace particularly in developing countries like India. The ground water contributes only 0.6% of the total water resources on the Earth. But it is the preferred and major source of drinking water in rural as well as in urban areas. The reasons behind this include non-availability of surface water due to drought and a false belief that ground water is pure and safer than surface water due to the Earth covering. In India, ground water fulfils about 90% of the total drinking water requirements and 50% of the agricultural requirements.

Environment and development are the two sides of a coin. Now the ground water is getting polluted severely due to urbanization and industrialization processes. The ground water generally colourless but contains salts such as carbonates, bicarbonates, chlorides, sulphates etc. But recent studies have been reported the presence of various hazardous contaminants like fluorides, nitrates, sulphates, toxic heavy metals in many parts of India. (Sahu et.al. 2006 &Oberoi and Gupta, 2010).

Excessive fluoride in drinking water is not a regional issue, it prevails worldwide. In Telangana, Nalgonda district is often categorized as endemic fluoride belt, where fluoride exists more than 20 times of permissible limits. In Andhra Pradesh, Prakasam and Anantapur districts are severely affected. Among the dual Telugu states, about 3072 villages are facing the fluoride issue. Fluoride is above the normal values in many states like U.P, M.P, AP, Bihar, Delhi, Gujarat, Rajasthan, Jammu Kashmir, Punjab, Haryana, Karnataka, Kerala and Tamil Nadu etc. There are several developed and developing countries like Argentina, USA, Algeria, Libya, Egypt, Jordan, Turkey, Iran, Iraq, Kenya, China, Japan, New Zealand, Australia, Thailand, Canada, Srilanka, Syria etc, which are endemic for fluorosis.

In India, the fluorosis was first identified in Tamil Nadu in 1937 (Short et al., 1937). Later this disease was also identified in different states. At present about 62 million people in 15 states has been suffering from dental, skeletal and non-skeletal fluorosis. (Arlappa et al., 2013). The disease is making its appearance in newer non- - fluoride areas due to geo - environmental conditions. According to WHO (1970), one hospital bed out of four in the world is occupied by a patient who is sick because of polluted water.

Methodology

Research methodology is followed in presenting the paper. It is emphasized that the primary and secondary data is collected from various Text books, Journals, Articles etc.

Sources of fluoride in ground water

Fluoride is the major inorganic pollutant of natural origin found in ground water. The major sources of fluoride in ground water are fluoride bearing rocks such as fluorspar, cryolites, fluoropatite and hydroxyl apatite (Agarwal et al.1997).

Fluoride – A double edged sword

Fluoride is often termed as a double edged weapon, as the fluoride ions have dual significance in water supplies. High concentration of fluoride (> 1.5 mg/L) may lead to chronic fluoride toxicity, which manifest as dental and skeletal fluorosis, at the same time a concentration less than 0.8mg/L results in dental caries and in the concentration of 0.8-1.0 mg/L, beneficial for calcification of dental enamel (Fig1). Thus the optimal and judicious use of fluoride offers maximum caries protection; whereas injudicious and excessive systemic consumption can lead to chronic fluoride toxicity.

Healthy Teeth and Bones (0.8-1.0mg/

Fig1: The dual significance of Fluoride in Drinking Water.

Fluoride ion concentration in drinking water is playing a vital role in human health. Systematic fluorosis (Basin, 2003 & Kumar et al., 2003) is an endemic problem in several developing countries like India, Pakistan and Africa etc

Beneficial and Biological effects of Fluoride

Fluoride is mainly present in bones and teeth. The beneficial effects of fluoride in traces are overshadowed by its harmful effects caused due to its overconsumption. The Biochemical functions of the Fluoride are as follows.

1. Fluoride prevents the development of dental caries by forming a protective layer of acid resistant fluoroapatite with hydroxylapatite of the dental enamel and prevents the dental decay by bacterial acids.
2. Fluoride inhibits the bacterial enzymes thus reduces the production of acids.
3. Fluoride is necessary for the proper development of bones.
4. Sodium Fluoride (NaF) inhibits the enzyme enolase of glycolysis.
5. Fluoroacetate inhibits aconitase of citric acid cycle.
6. Fluoride prevents osteoporosis in adults particularly in post – menopausal women.

Harmful effects of fluoride

1. Fluoride in less concentration (<0.8mg/L) in drinking water is associated with the development of dental caries in children.
2. Excessive intake of the fluoride above 1.5 mg/L in children causes mottling and discolouration of enamel, corroding of teeth. The teeth are weak and become rough with characteristic brown or yellow patches on their surface. These manifestations are collectively referred to as dental fluorosis.
3. An intake of fluoride above 20 mg/L is toxic and causes pathological changes in the bones. Hypercalcification, increased bone density and sclerosis of the bones of limbs, pelvis and spine. Even the ligaments of the spine and collagen of bones and tendinous insertions get calcified. Neurological disturbances are also commonly observed. These manifestations are collectively constitute skeletal fluorosis.
4. In the advanced stages, the individuals are crippled and cannot perform their daily routine work due to stiff joints. The knees angle in and touch one another. This condition is referred to as genu valgum or knock knee. This is due to the outward bending of distal portion of knee joint and inward bending of its proximal portion.
5. In some cases, outward bowing of lower leg may occur. This condition is called as genu varum or tibia vara.
6. Some times knee joint bends backwards. This condition is referred to as genu recurvatum or back knee. This deformity is more common in women.
7. Fluoride also affects the R.B.C. cell wall. It is now known that when fluoride is ingested, it will also accumulate on the erythrocyte membrane, besides other cells, tissues and organs. The erythrocyte membrane in turn looses calcium content and becomes amoeboid. This is referred to as non – skeletal fluorosis.
8. Fluoride may magnify in food items like wheat, spinach, butter, tea etc.

Dean's Fluorosis Index

Tooth enamel is principally made up of hydroxyapetite (87%) which is crystalline calcium phosphate. Fluoride, which is more stable than

hydroxyapetite displaces the hydroxide ions from hydroxyapetite to form fluoropatite. Fluorosis of dental enamel occurs when excess of fluoride is ingested during the first 8 years of life. It is characterized by mottling of dental enamel .On prolonged exposure teeth become hard and brittle. This is called dental fluorosis. Dental

Table1: Criteria for Dean's Fluorosis Index

Score	Criteria
Normal	The enamel represents the usual translucent semivitriform type of structure. The surface is smooth, glossy and usually of a pale creamy white colour.
Questionable	The enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few white flecks to occasional white spots. This classification is used in those instances where a definite diagnosis of the mildest form of fluorosis is not warranted and a classification of "normal" is not justified.
Very mild	Small opaque, paper white areas scattered irregularly over the tooth but not involving as much as 25% of the tooth surface. Frequently included in this classification are teeth showing more than about 1-2 mm of white opacity at the tip of the summit of the cusps of the bicuspids or second molars.
Mild	The white opaque areas in the enamel of the teeth are more extensive but do not involve as much as 50%of the tooth.
Moderate	All enamel surfaces of the tooth area affected, and the surfaces subject to attrition show wear. Brown stain is frequently a disfiguring feature.
Severe	All enamel surfaces are affected and hypoplasia is so marked that the general form of the teeth may be affected. The major diagnostic sign of this classification is discrete or confluent pitting. Brown stains are wide spread and teeth often present a corroded – like appearance.

fluorosis manifests in the form of different signs. Dean's classification of dental fluorosis enerally used for classifying the dental fluorosis. (Table1).

Prevention and Control

The people of affected areas are advised not to use water from tube wells. Instead they are advised to use water from reservoirs or harvested rain water which contains comparatively less fluoride content or free of it. Another alternative is to defluoridate the drinking water supplied to the villagers by standard techniques such as Nalgonda technique (Technical digest, 1978). Tube well of low concentration (<0.5mg/L) of fluoride can be mixed with water having higher concentration of fluorides (>1.5mg/L). The short term solution to minimize the fluoride concentration in drinking water could be the use of domestic defluoridation filters. It is recommended that alternative arrangements for supply of potable water from other safe sources to the affected village may be taken up on top priority.

Alum treatment, Reverse osmosis, Ion exchange are promising methods in minimising the fluoride level in drinking water. There is a remarkable negative correlation between fluorosis and balanced diet. Intake of Ca, Mg, Vit-C, Tamrind and prawns etc is recommended.

Conclusion

As per 21 article of the Indian constitution, providing safe drinking water is the prime responsibility of the governments. They must put this on top priority. The villagers have to be educated through awareness camps on health, sanitation, and nutrition and water quality.

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