

Fluoride Problem in the Groundwater of Sri Lanka

Fluorine - the Needy and Greedy Element

Fluorine, the most reactive and electro-negative halogen on the earth, is an element that virtually never occurs naturally in its free, gaseous form. In the form of fluorides, however, it is one of the most plentiful and wide spread of elements, standing seventeenth in order of abundance in the earth's crust. Fluorides occur in water, soil, rocks, dusts and the atmosphere. It is also present in most foods, many plants and virtually in all animal tissues. Fluoride is considered as an essential element for the human body for promoting growth of healthy bone and teeth. Although every food stuff contains at least a trace of fluoride, the total intake of fluoride from food is relatively small, and most of it is ingested through drinking water.

Fluoride in Drinking Water and Health

The deficiency as well as excessive fluoride in drinking water creates a number of health problems. Prolonged exposure to low fluoride concentrations in drinking water causes dental caries, whereas continued exposure to higher (than optimum) levels in drinking water causes dental fluorosis (mottled teeth surface) (Figure 1) and skeletal fluorosis (stiffness of joints, crooked and or/brittleness of bones).

The world health organisation (WHO) has recommended a fluoride concentration of between 1.0 to 1.5mg/L in drinking water as the optimum level that promotes dental as well as skeletal health. Fluoride in drinking water is therefore, has become one of the most important geo-environmental and toxicological issues in the

world. During the last four decades, high fluoride concentrations in drinking water sources and the resultant disease "fluorosis" is being highlighted throughout the world. African countries, such as Morocco, Tunisia, Algeria, Sudan, Egypt, Somalia, Uganda, Tanzania, Kenya, Senegal, Nigeria and South Africa have high fluoride groundwater. Further, out side Africa, India, China, Japan, Canada and the united State of America (USA) also have high fluoride-bearing groundwater. In these countries, fluoride levels in the range of 10-60 mg/l in groundwater have been reported. In developing countries, especially in the tropical regions, rural communities, who mostly depend on groundwater sources for their domestic water supplies, face this problem seriously. In India alone, about 25 million people in 8700 villages are consuming water with high fluoride concentrations. Fluoride concentrations as much as 20.0 mg/l have been recorded in groundwater from these areas. Pampered et al. (1997)

Fluoride Problem in Sri Lanka

In Sri Lanka, endemic dental fluorosis was first described by Seneviratna et al.

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(1974) based on a survey conducted on the dental health of schoolchildren from three districts as shown in Table 1.

They also reported average concentrations of fluoride in groundwater in the 9 provinces of Sri Lanka (Table 2).

It is clearly seen that the areas of high fluoride-bearing groundwater show higher dental fluorosis, whereas those in the low fluoride regions suffer from dental caries.

Sources and Causes

In Sri Lanka, when comparing the fluoride-rich and fluoride-poor areas with the climatic, geomorphological, and geological factors prevailing in the country, low fluoride concentrations in groundwater are common in the wet

Table 1: Fluoride concentration in groundwater and related dental health in three districts of Sri Lanka

	Anuradhapura District (Dry Zone)	Polonnaruwa District (Dry Zone)	Kandy District (Wet zone)
Dental fluorosis(%)	77.50	56.20	13.00
Dental caries(%)	26.20	26.50	95.90
Fluoride levels in Groundwater (mg/l)	0.10-4.70	0.50-13.10	0.02-3.70

Source : Seneviratna et al. (1974)

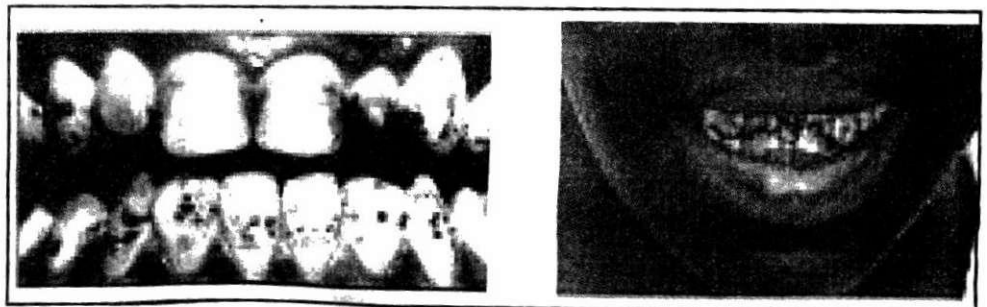


Figure 1: Dental Fluorosis

Table 2: The average fluoride concentrations in the well water of different provinces of Sri Lanka

Province	Average Fluoride Concentration (mg/l)	Zone
Northern Province	0.65	Dry zone
Eastern Province	0.76	do
North Central province	1.40	do
North western province	0.78	do
Sabaragamuwa province	0.20	Wet zone
Western Province	0.20	do
Southern Province	0.30	do
Central province	0.50	do
Uva Province	0.40	Intermediate zone

Source: Seneviratna et al. (1974).

zone where annual average rainfall even some times exceeds 5000mm. High fluoride is common in the dry zone



Figure 2: Distribution of fluoride ions in the groundwater

where annual average rainfall is less than 2000mm (Figure 2)

Physiographically, the high fluoride zones lie within the low plains of the island, whereas the low fluoride areas are mostly confined to the central highlands. This situation can be explained by the fact that leaching of fluoride from soil in the wet zone and transporting it with groundwater towards low lying dry zone areas take place in wet zone, whereas concentration

due to high evapo-transpiration and slow rate of ground water movement is taking place in the dry zone areas. Dissanayake, (1996). In wet zone, the saturated zone is replenished by the downward infiltration through the capillary zone during a large part of the year than in the dry zone, thus diluting the saturated-zone groundwater. Figure 3 compares the fluoride content in groundwater from the water supply bore holes (tube wells with hand pumps) located in six different rock types under dry and wet zone conditions. Irrespective of the rock type, groundwater remains low in fluoride in the Wet Zone while in the Dry Zone fluoride reaches as high as 10.0 mg/l. The slow rate of groundwater movement in the low plains also tends to increase the fluoride concentration because the contact time of groundwater with a particular geological formation is comparatively long. Dharmagunawardhane and Dissanayake, (1993)

As stated before, fluoride is important, because it is essential for the growth of human, and in the same time, creates serious health problems due to either deficiency or to excessive intakes by the body. Since main ingestion path is through drinking water, it is important to know how it enters the water. A vast majority of the Sri Lankan population uses groundwater for their domestic water supply, and the groundwater which is always in contact with rocks and soils that contain fluoride-bearing minerals, upon weathering, release fluoride into groundwater. In Sri Lanka, a large number of county rocks contain fluoride-bearing minerals such as Biotite, hornblende, pyroxene, sphene, and apatite. Biotite is present in almost all rock types, and recent studies have revealed that average fluoride concentration in biotite is around 3400 parts per million (milligrams per Kilogram) Dharmagunawardhane, (2004). In addition to its high fluoride concentration and wide distribution, this mineral is also less resistant to weathering. Therefore, mineral biotite can probably be considered as the principal source of fluoride for groundwater. It should also be noted that rice-growing districts such as Kurunegala, Anuradhapura, Ampara, Polonnaruwa, Hambantota, etc. also receive a considerable amount of fluoride through application of rock phosphate as a fertiliser in the paddy fields. Although the solubility of rock phosphate is low, the continues application of rock phosphate in rice fields, residual accumulation in soil and subsequent leaching could release large fluxes of fluoride into groundwater of these areas.

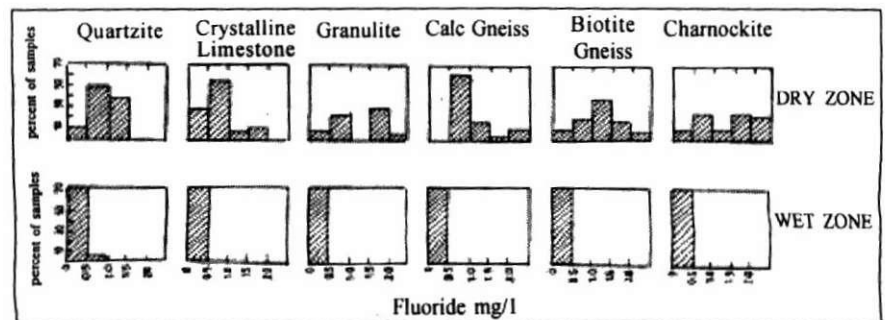


Figure 3: Variations of fluoride concentration in groundwater of water supply Bore holes located six different rock types under dry and wet zone conditions (Dharmagunawardhane Dissanayake, (1993))

Indirect Health Problems

Another serious health problem with growing concern in the recent past is the Chronic Kidney Disease (CKD) among many people in the dry zone districts of Sri Lanka. Statistically, it has been highlighted that this problem too, is common in the areas of high fluoride-bearing groundwater. Although it is a known fact that exposure to very high fluoride doses causes kidney failure, fluoride levels in groundwater of these areas are much lower than such toxic concentrations.

However, prolonged exposure to elevated fluoride levels in drinking water and possibility of its detrimental effects cannot be ruled out. Recent research conducted in Sri Lanka has revealed that dissolution of low-grade aluminium cooking utensils is enhanced when cooking with fluoride rich water. (Ileperuma, Dharmagunawardhane and Herath, (2004).

This situation is rather accelerated when acidic ingredients such as tomato, tamarind, vinegar and lime, etc. are used in cooking. Low-grade aluminium utensils release, not only aluminium ions, but also many other toxic metals, lead, and chromium.

All these released ions can form complex ions with fluoride and can damage the kidneys when enter the blood stream. Thus, fluoride in water can cause health problems directly as well as indirectly.

Remedies

Presence of excessive fluoride in water cannot be detected or directly felt by the users, because it does not affect the taste, colour or the smell of water. It can only be detected by laboratory analysis.

Therefore, exposure is inevitable, especially in high-fluoride areas.

In general, it tends to occur in higher concentrations in groundwater (well water, tube well water) than in the surface water (stream, river, lake water). Also in low lying dry zone areas than in wet zone areas.

However, it should also be noted that surface water is often polluted and cannot be directly consumed. Therefore, removal of fluoride from water, using different techniques, is practised in the world. However, most of those, especially large-scale ones, are expensive and complex.

In the simplest (and more practicable at rural level) methods, the affinity of fluoride ion to hydroxyl (OH), Ferrous, or Aluminium ions is used. Fluoride ion tends to replace the OH ions in minerals and occupy its place in the mineral lattice. It also binds with Aluminium and Ferrous ions by surface adsorption, and tends to stay together under some favourable conditions.

If fluoride-rich water is percolated through a filter, material with above-mentioned ions concentration of fluoride can be reduced to a grate extent (and to safe limits). Locally available brick chips, tile chips, Laterite (Kabuk) chips contain these ions and have shown promising results in Sri Lanka Dharmagunawardhane, and Dissanayake (1996).

Time to time, The National Water Supply and Drainage Board and some Non-Governmental Organizations distribute such filters among the communities in the high fluoride areas of the country.

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