

FLUORIDE LEVELS IN WATER AND ENDEMIC FLUOROSIS IN ETHIOPIAN RIFT VALLEY

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SUMMARY: The fluoride content of drinking water and the prevalence of endemic fluorosis were assessed and correlated in large farms, villages and towns of the Ethiopian Rift Valley. The fluoride level of drinking water collected from deep wells ranged from 1.5 mg-F/L to 36 mg-F/L (mean 10.0 mg-F/L). Dental fluorosis was found to be widespread among children, mainly in the age group of 10 to 14 years. Skeletal and crippling fluorosis were found predominantly among male workers of the sugar estates within the Rift Valley. Skeletal fluorosis invariably occurred in those that were consuming water with fluoride levels of more than 4 mg-F/L for over 10 years. The most common incapacitating neurological complication of crippling skeletal fluorosis was cervical radiculo-myelopathy.

Key Words: Fluoride, Ethiopia, Rift Valley, fluorosis, crippling skeletal fluorosis.

INTRODUCTION

More than 260 million people all over the world consume drinking water with a fluoride concentration higher than 1.0 mg-F/L. The majority of these people live in tropical countries¹. Fourteen countries in Africa, eight in Asia and the Middle East and six in the Americas face the problem of fluoride concentration above 1.5 mg-F/L in drinking water². Many of these countries are confronted with the problems of endemic dental and osteofluorosis.

Osteofluorosis and its complications, related to high-fluoride water consumption, have particularly gained attention in India³⁻⁵. Similar reports, but mainly on endemic dental fluorosis, have appeared from the African continent, the majority from African Rift Valley regions⁶⁻¹⁰.

The East African Rift Valley which cuts through Ethiopia is geomorphologically still an active volcanic region. The volcanic rocks particularly in the young basalt contain high concentrations of fluoride and fluorapatite. Large fault systems in the Valley create conditions that allow very deep percolation of infiltrating surface water. The floor of the Rift Valley which is characterized by high hydrothermal activity accelerates the solubility of fluorite. The hot climate and high fluoride water bed of the Rift Valley therefore favour the development of endemic fluorosis.

The water supplies in the Ethiopian Rift Valley come mainly from boreholes with depths from 10 to 100 meters; the majority are deep boreholes. This study was carried out to determine the fluoride content of the water supply systems in the Ethiopia part of the Rift Valley and the prevalence of the dental and skeletal fluorosis among the inhabitants of the region.

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MATERIAL AND METHODS

Samples of drinking water from representative sites in the Rift Valley were analyzed for fluoride content at the laboratory of the Wonji Sugar Estate laboratory, using ion analyzer Orion Research Specific Ion meter. Since 1985 clinical surveys have been regularly undertaken to examine the prevalence of endemic fluorosis in the Rift Valley at large and the sugar estates in particular. The prevalence of dental fluorosis was performed on randomly selected children between the ages of 7 and 20 years at schools in areas of large populations. The classification of dental fluorosis was according to Siddiqui³.

Skeletal fluorosis was detected by examining all persons with abnormal postures, deformities and other physical disabilities, including those who were bedridden. Persons so identified in the selected villages and towns were examined neurologically, using a special protocol X-rays.

TABLE 1. Fluoride Content of Water in Various Areas of the Ethiopian Rift Valley

| Samples sites: | Fluoride (mg/L) | Source of water | Years in service |
|----------------------|--------------------|--------------------|---------------------|
| Dubti (village) | 1.2 | Borehole | 9 |
| Logiya (town) | 1.0 | Borehole | 10 |
| Mille (town) | 0.4 | Borehole | 10 |
| Gewane (town) | 0.7-2.5 | Borehole | 16 |
| Amibara (farm) | 2.4-3.0 | Borehole | 5 |
| Melka Warer (farm) | 3.5 | borehole | 9 |
| Melka sedi (farm) | 1.5-4.3 | borehole | 13 |
| Awash (station) | 1.4-1.6 | treated river | 20 |
| Meterhara (estate) | 2.5-6.2 | borehole | 20 |
| Abadir (farm) | 4.0 | borehole | 12 |
| Wolenchiti (town) | 2.5 | borehole | 15 |
| Nazareth (town) | 0.8-3-3 | borehole | 20 |
| Wonji-Shoe (estate) | 2.5-14.0 | borehole | 30 |
| Koka (town) | 26.0 | borehole | 20 |
| Alem Tena (town) | 9.0 | borehole | 17 |
| Sami berta (village) | 9.0 | borehole | 23 |
| Meki (town) | 0.7-1.0 | borehole | 6 |
| Zeway (town) | 1.0-1.6 | borehole | 10 |
| Waig (village) | 3.5 | borehole | 8 |
| Koshe (village) | 3.0 | borehole | 15 |
| Adami tulu (town) | 5.1 | borehole | 10 |
| Abernosa (village) | 36.0 | borehole | 7 |
| Jido (village) | 33.6 | borehole | 12 |
| Bulbula (town) | 14.6 | borehole | 7 |
| Alaba (village) | 1.1 | borehole | 18 |
| Togo (village) | 4.9 | borehole | 4 |

RESULTS

Table 1 shows the fluoride levels of water samples in the different sites of the Rift Valley. This ranged from 1.0 mg-F/L to 36 mg-F/L. The sugar estates that had the highest population densities recorded high fluoride levels: Wonji-Shoa 2.5 to 14 mg-F/L, and Metahara 2.5 to 6.2 mg-F/L.

TABLE 2. Children with Fluorotic Mottling of Teeth in the Ethiopian Rift Valley: Age and Sex Distribution.

| Age group (years) | Males | | | Females | | | Total | | |
|-------------------|--------------|------------------|------|--------------|------------------|------|--------------|------------------|------|
| | Exa-mined No | Dental Fluorosis | | Exa-mined No | Dental Fluorosis | | Exa-mined No | Dental Fluorosis | |
| | | No. | % | | No. | % | | No. | % |
| 5 - 9 | 190 | 158 | 83.2 | 240 | 172 | 84.3 | 394 | 330 | 83.8 |
| 10-14 | 517 | 470 | 90.9 | 301 | 258 | 85.7 | 818 | 728 | 90.0 |
| 15-19 | 149 | 113 | 75.8 | 53 | 30 | 56.6 | 202 | 143 | 70.8 |
| 20+ | 25 | 10 | 40.0 | 17 | 10 | 58.8 | 42 | 20 | 47.6 |
| Total | 881 | 751 | 85.2 | 575 | 470 | 81.7 | 1456 | 1221 | 83.9 |

Dental Fluorosis. Table 2 demonstrates the extent of dental fluorosis among the children in the surveyed sites. The prevalence ranged from 70 to 100%, with 35% having the severe form of the complication. The condition was found to be statistically worse in males and the age group 10 to 14 years.

Skeletal Fluorosis. In the Rift Valley skeletal fluorosis was identified to be a serious problem in the long established sugar estates and two towns along the Ethiopian-Kenyan highway, Alem Tena and Sami Berta.

The subjective symptomatology in persons with skeletal fluorosis is variable depending on the degree of affection. It may be asymptomatic osteofluorosis where the changes are apparent only on X-rays. The majority of the more advanced cases develops progressive bone pains and stiffness of the whole body. Squatting, particularly when defecating, becomes very troublesome. Standing up from a sitting position, and sitting up in bed, become increasingly difficult. Progressive kyphosis and limitation of movements become apparent. This clinical condition progressively worsens to the more severe debilitating state of crippling fluorosis.

DISCUSSION

The Ethiopian Rift Valley groundwater have very high fluoride levels, ranging from 0.4 to 36 mg-F/L. The water sources used in areas with the highest population densities have fluoride contents of 3.5 to 13.0 mg-F/L. Studies from other countries^{11,12} and our own experience in Ethiopia¹⁰ have shown that these levels cause dental fluorosis in children and over a prolonged period skeletal and crippling fluorosis.

In the Ethiopian Rift Valley dental mottling has been recognized in areas with fluoride concentrations in water as low as 2 mg-F/L. Higher levels, above 4 mg-F/L cause severe disfiguring dental fluorosis with enamel hypoplasia.

Under the hot and dry conditions in the tropics, fluoride concentrations of 4 to 6 mg-F/L in the drinking water (or a daily fluoride absorption of more than 10 mg-F) may cause skeletal fluorosis with serious complaints in a substantial part of the population over the age of 45 years¹³. In our experience, high fluoride content in drinking water appears to play the determining role, as was observed by Reddy¹⁴. However, men doing manual labor in hot environments appear to be more susceptible to advanced osteosclerosis with neurological complications. Similar observations have been recorded by Siddiqui³. In hot climates the values for the maximum fluoride

concentration in drinking water may have to be lower than the WHO recommended 1.5 mg-F/L.

In the Ethiopian Rift Valley, with fluoride levels above 4 mg-F/L, most of our patients developed neurological complications after 15 years of exposure. In the progressive cervical radiculo-myelopathy that develops insidiously, the common predominant neurological picture usually consists of marked wasting and atrophy of the small muscles of the hands, in addition to spastic paraparesis or quadriparesis, often in flexion. In advanced stages of neurofluorosis, the clinical picture is rather uniform, with complete incapacitation and the bedridden state of severe spastic paraparesis, or quadriparesis with incontinence of urine and flexor spasms. Hyperreflexia, with absent abdominal reflexes and extensor plantar responses with or without patellar and ankle clonus confirm long tract involvement.

The World Health Organization had set guidelines limits on fluoride. The guidelines, with 1.5 mg-F/L as the upper limit of safe level are based on an average per capita daily water consumption of 2 liters. However, it is abundantly clear that the daily consumption of water in hot tropical environments is much higher than the WHO propose average and can be as high as 10 l/day.

Based on their studies in Senegal Brouwer et al. suggest that other guiding values would be more appropriate in tropical regions. They proposed that dental fluorosis will occur at fluoride levels above 0.6 mg-F/L and crippling fluorosis above 7.0 mg-F/L¹⁵. Other countries, notably Argentina¹⁶ and Tanzania¹⁷ have other types of standards operational on basis of economical, practical and technical considerations. Such controversial decisions are also confronting Ethiopia when deep bore holes are being dug in the hot dry areas of the fluoride endemic Rift Valley. When alternatives are not available the Ethiopian Water Resource Commission has chosen the better of two evils: to make water with inevitably high fluoride available to the thirsty populations.

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