Fluoride Contamination and Treatment in the Ethiopian Rift Valley

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Background of Ethiopia

- Area of Ethiopia ~ 1.13M Km².
- Rift Valley constitutes ca. 30%
- 2005 population ~ 73 million. Rift Valley population ~10 million (15%)
- Elevation varies from 120 m b.s.l. at the Danakil depression to 4,620 m a.s.l. at Mt. Ras Dashen in the NW highlands.
- Mean annual rainfall varies from less than 100 mm in the lowlands to over 2,000 mm in the highlands
THE ETHIOPIAN RIFT VALLEY

Geography of the Ethiopian Rift Valley

- The Great African Rift Valley ~ 6,400 Km ~ starts from the Middle east (Jordan) & terminates near the town of Beira on the cost of Mozambique
Extent of Fluoride Problem

- From 10 million people living in Ethiopia Rift Valley, about 8.5 million people are exposed for high fluoride contamination.
- In Ethiopian Rift Valley waters, fluoride varies from 0.5 to 264 mg/l (up to 26mg/l in drinking water sources).
- Over 40% of deep and shallow wells and springs in the rift valley have fluoride levels above the optimal (WHO) level of 1.5 mg/l.
- Over 80% of the children in the rift valley have developed varying degrees of dental fluorosis.
- Crippling skeletal fluorosis cases increasing (old people).
Progressive disabilities caused by skeletal Fluorosis
Study Objectives

- Obtain accurate info on past/present situation of Fluoride & Fluorosis
- Examine status of defluoridation programs in Ethiopia
- Draw recommendations on the most appropriate and usable defluoridation techniques (HH and communal) for Ethiopia.
Fluoride Levels in Deep and Shallow Wells of Ethiopia

Fluoride in Ethiopian Waters

Deep Wells
N=415

Shallow Wells
N=221

0 200 400 km

mg/l
264
7.1
3.5
1.3
0.43
0.21
0.11
0.001

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Source of Fluoride in Ethiopian Rift Valley

The source of high fluoride concentration in the Ethiopian Rift valley is related with three causes:

1. Addition by active volcanic & fumarolic activities in the area.

2. High water - rock interaction in the area, particularly interaction of water with volcanic ash and volcano - sedimentary rocks.

3. Low calcium concentration in the area, which restricts the precipitation of F- as fluorite (CaF$^2$).
Key Issues/Challenges of Fluoride Mitigation in Ethiopia

- Less knowledge on the vertical variation of fluoride with different aquifer systems
- **Limited fresh surface water resources** in the affected areas and high treatment costs
- **Low rainfall** and high evapo-transpiration in the affected areas
- High cost and less effectiveness of Deflouridation methods
- Challenges of meeting **globally acceptable limit (WHO)** of fluoride (1.5 mg/l)
Current Interventions/Actions

- Identification of the sources and mapping of affected areas.
- Provision of surface water from rivers and lakes – for towns and semi urban areas
- Rainwater harvesting – for households and schools
- Multi village gravity schemes – rural villages and semi urban areas
- Defluoridation – community and household
Defluoridation in Ethiopia

Small scale Community Defluoridation Plants

- 3 pilot sites – Use Nalgonda method (aluminum sulphate and lime)
- Reduce F⁻ from 7.5 – 9 mg/l to < 3 mg/l.
- Average beneficiaries/unit - 1000 people
- Capital cost ~2,300 USD
- Maintenance and operation cost ~ 1,040 USD/month ≈ 1 USD / month/capita
- Estimated income based on minimum water requirement ~ 1,330 USD/month.
Household Defluoridation

- Piloted in one district
- Defluoridation kits - a 40 lt plastic bucket fitted with tap
- Use aluminum sulphate
- 1gm aluminum sulphate for 1 liter water
- Costs 0.033 USD/20 liters (daily HH consumption) ≈ 1 USD/month/HH(5 people) ≈ 0.2 USD/month/capita

Aluminum Sulphate being added and stirred with raw water
Large-scale Defluoridation Schemes

- Installed and operated by a state farm
- Uses activated alumina with 2 treatment units and caustic soda for regeneration.
- Both activated alumina and caustic soda are imported.
- Treatment reduced $F^-$ from 5 mg/l to 2 mg/l.
- Costs about 0.031 USD/20 liter treated water.

Defluoridation Tank
Limitations of Defluoridation Projects in Ethiopia

- Expensive
- Limited level of fluoride reduction
- Need well trained technicians to run the system - Communal systems
- Need intensive community promotion and monitoring to create awareness within the whole community – especially HH methods
- Environmental impact – poor sludge disposal
Partnership/Stakeholders

- **UNICEF** – Financial support and technical assistance at all levels
- **Addis Ababa University** – research on the sources of fluoride and ground water flow
- **Ministry of Water Resources** – Technical support for the Regional Water Bureaus
- **Catholic Relief Service** – Piloting of community and household water treatment systems
- **Regional Water Resources Bureaus of Oromia and SNNPR regional States** – sampling of sites, fluoride mapping and piloting of HH treatment
- **Private Consultants** – studying on the effect of fluoride &
- **Affected Community** – involving in the piloting & assessment
Lessons Learned / Best Practices

- A combined effort of stakeholders helped to understand the extent of the problem and piloting of mitigation activities.
- Identifying the source and mapping of affected areas is very important to design for solutions & alternative sources.
- Household treatment is more cheaper than community treatment ~ treating only the water that is required for drinking and cooking and no cost of technicians.
- Multi village gravity water supply schemes for large number of interconnected villages are possible alternative sources for fluoride affected areas and found economically feasible.
- The rural population can afford to pay for treatment units if there is an intensive education and awareness creation on the effect of fluoride.
The Way Forward

- Expanding the implementation of multi village large scale gravity schemes
- Implement low cost treatment systems like slow sand filtration to provide water from surface water sources.
- Detailed study on the vertical variation of the fluoride concentration and identify aquifers with less fluoride concentration – sealing aquifers with high fluoride concentrations
- Artificial and enhanced recharge of shallow ground waters from runoff – facilitate dilution
- Rainwater harvesting – underground dams
- Linking of fluoride issues with the hygiene and sanitation promotion
- Expansion of low cost deflouridation methods
- Revising the existing F- local guideline (3 mg/l) to the globally acceptable limit.
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Thank You For Your Attention