Defluoridation Using Bone char in the Ethiopian Rift Valley

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Introduction

The Ethiopian Rift Valley:

- 330,000 km² wide ~ 30%
- Four regions are partly and fully located in the Rift Valley.
- 15% of the Ethiopian population lives in the Rift Valley, which makes approximately 12 millions (3.2% growth rate)
- Issues related to water quality are the major challenges especially the occurrence of fluoride in ground water from natural geogenic sources
- Large number of deep and shallow wells are contaminated with high concentrations of fluoride
- Approximately 80% of the population in the Rift Valley, all below 40 years, is at risk to develop FLUOROSIS, ~ more than 9 million people.
- Oromia is the most affected area and occupies 45% of the Rift Valley.
Fluorosis

No Treatment:

Prevention
Sources of fluoride

Water

Food and Beverages

Other
- Fertilizer factories
- Coal burning
Prevention

Alternative low fluoride water
- Surface water
- Rain water
- Low fluoride ground water

Treatment
- Precipitation
- Adsorption
- Membrane
- Ion exchange
- Bone char
- Contact
- Precipitation

Nutritional Supplement
The idea of using animal bones as filter material is relatively simple: instead of fluoride getting incorporated into the bones and teeth of the human consumer, animal bones are used to remove the fluoride from the water before it is consumed.
Production

Lighting up: Charcoal and kerosene

Packing: 8 to 10 tons

Large scale
Charring

Regulating temperature (~ 350 °C)
Quality control test - Elaboration

* Quick test to assess the quality of a bone char production
* Controlled parameters: determined in laboratory
  * Initial fluoride concentration → 200 ppm
  * Time → 4 hs
  * pH → ~7
  * Bone char – solution ratio → 3[g] BC in 45 [ml]
* All the parameters are controlled, only the adsorption capacity varies
## Quality control test - Type

* Result: Fine > Coarse > Medium

<table>
<thead>
<tr>
<th></th>
<th>&lt; 0.5mm</th>
<th>0.5mm - 1mm</th>
<th>1mm - 2mm</th>
<th>2mm - 4mm</th>
<th>&gt; 4mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>2.25%</td>
<td>1.27%</td>
<td>14.76%</td>
<td>74.61%</td>
<td>7.04%</td>
</tr>
<tr>
<td>Medium</td>
<td>2.81%</td>
<td>2.36%</td>
<td>42.37%</td>
<td>51.28%</td>
<td>0.97%</td>
</tr>
<tr>
<td>Fine</td>
<td>11.32%</td>
<td>15.00%</td>
<td>68.38%</td>
<td>4.96%</td>
<td>0.21%</td>
</tr>
</tbody>
</table>

* **Fine**
  * Greater surface area
  * Presence of dust

* **Medium**
  * Only one production available to test → bad one
Quality control test - Type

Comparison of crushing types

Crushing types: Coarse – Medium – Fine

Ariane Schertenleib
Quality control test - Color

Comparison per color

Coarse (Sept 2012)

- White
- Light grey
- Dark Grey

Fine (Sept 2012)

- White
- Light grey
- Dark Grey

White
Dark grey
Light grey
Best removal capacity
Quality control test - Sizes

Smallest fractions $\rightarrow$ a better removal capacity than larger
Quality control test - Productions

Comparison of productions

- Coarse (March 2012)
- Coarse (Sept 2012)
- >2mm
- 1 - 2 mm
- 0.5 - 1 mm
- All (0.5 - 4 mm)

[mg/l (g/l)]

- Fine (April 2012)
- Fine (Sept 2012)
Quality control test - Scale

< 1.90 [mgF/gBC]

1.90 – 2.5 [mgF/gBC]

> 2.5 [mgF/gBC]
BC Filters: HH filter

320 filters in 6 Villages
Community filter design
Operational CF:

1. Weyo Gabriel: 3-5mg/L
2. Serity: 10mg/L
3. Bofo: 9 mg/L
4. Giraba Fila: 11mg/L
5. Gura: 12mg/L
6. Korke Adi: 10mg/L
7. Anano: 8.5mg/L
Regeneration – Pilot application

* Bone char saturated from Bofo and Serity
* Estimation of F content based on monitoring data (1.62 [mgF/gBC])
* Regeneration in washing tank, recirculation of solution from bottom to top with pump, sampling every hour (F, pH, Turb, EC)

**Steps:**
1) NaOH 0.1 [M] → 10 BV
2) H₂SO₄ 0.02 [M] → 4 BV
3) Fresh water → 1 BV

**Time required for 1 BV: (3000L)**
* Mixing and filling : 2h
* Recirculation : 2h – 3h
* Emptying : 4h
Regeneration – Result

Removal of fluoride per batch

% of total amount of fluoride

1 12.6%
2 22.4%
3 15.9%
4 10.2%
5 9.2%
6 6.5%
7 4.6%
8 4.0%
9 3.2%
10 3.9%

pH

BV
Regeneration – Conclusions

- Laboratory experiment applicable at bigger scale
- Equilibrium of fluoride liquid phase reached after 2-3hs
- pH should be at least 13
- The less fluoride, the harder to remove
- Further steps:
  - Monitoring of uptake of regenerated bone char
  - Financial viability
Way forward:

* Bone char is a promising technology to apply in Ethiopia
* The fluoride removal capacity of BC needs to be improved for better financial and operational sustainability
* Production of HAP (Fluorolith®)
* Integrated Fluorosis Mitigation Approach
Thank You