HOUSEHOLD-LEVEL FLUORIDE REMOVAL IN YEMEN

A pilot on the introduction of the Fluoride Nilogon Filter

ZOA
from relief to recovery

Summary

Access to safe drinking water has always been a challenge in Yemen, increasingly so during the war. Elevated fluoride levels in groundwater sources is an endemic problem in several governorates, causing dental and skeletal fluorosis. The long-term effect of fluoride is known worldwide and is detrimental for infants, especially when malnourished. In 2021, ZOA and Tezpur University conducted a pilot to introduce and test the Fluoride Nilogon filter among 300 households in three villages in Lahj governorate. Fluoride levels reduced from 3.1 mg/l to less than 1.0 mg/l. Uptake of the low-cost technology among the people has been high.

Fluoride in Yemen

Access to safe drinking water has always been a challenge in Yemen, known for its rapidly decreasing groundwater table. On top of this many groundwater sources in Yemen contain fluoride concentrations above WHO guideline. Elevated fluoride intakes can damage on dental and skeletal tissues. Dental and skeletal fluorosis (with adverse changes in bone structure) may be observed when drinking water contains 3–6 mg of fluoride per litre, particularly with high water consumption. The long-term effect of fluoride is known worldwide and is especially detrimental for infants (and likely even worse if they are malnourished). In Yemen, bone disease and dental fluorosis are observed in many areas as a result of the excessive intake of fluoride. Reports from government indicate high fluoride content in groundwater in districts of governorates such as Sana'a, Ibb, Dhamar, Taiz, Al-Dhale'e and Raimah with concentrations up to 50 mg/l.

While both government and the Yemen WASH sector acknowledge the presence and risk of fluoride in drinking water, no cost-effective interventions to reduce fluoride levels have taken place thus far. This is mainly due to the lack of low-cost treatment options and the nature of short-term humanitarian interventions that focus on access and quantity of water supply rather than on quality.

Fluoride Nilogon filter

Technologies to remove fluoride from drinking water exist. High tech options, including reverse osmosis or distillation, are often used in centralized water supply systems. Low tech options include the use of bone char, activated alumina or household gravity filters. Yet no such technologies have been found in Yemen.

Given the remote nature of the locations,
where ZOA encountered the sources with high fluoride, low-tech and low-cost options have been preferred to assess.
Literature research linked ZOA Yemen to Tezpur University, which successfully developed and implemented a technology called a Fluoride Nilogon filter for many years in India.

The Fluoride Nilogon filter is a simple, low-cost, safe and environment-friendly method for removal of excess fluoride from drinking water. It consists of 2 buckets – the top one filled with crushed limestone (5-10 mm) for the removal of fluoride. The outflow subsequently passes through a sand-gravel filter or any other filter. A small quantity of phosphoric acid is mixed with the fluoride-containing water and then the water is put into the container filled with crushed limestone. Within 3 hours, fluoride is removed, through precipitation and adsorption, from any initial concentration to about 0.6 ppm. The recurring cost of Fluoride Nilogon is very low, as it mainly depends on the daily addition of phosphoric acid. The household filters can be constructed in-country at a cost of USD 15. This includes the material costs, thus providing a cheap, sustainable and low cost solution to address the fluoride issue.

[1] "Study about the Fluorosis in Selected Villages of Ta'aiz Governorate," Republic of Yemen Ministry of Water & Environment National Water Resources, June 2009. http://nwrayemen.org/uplaod/pdf/fluoride_inTaiz%5B1%5D.pdf

[2] "Nilogon" means removal in Assamese. For more information on the Nilogon Filter, see: Gogoi et al, "Fluoride removal from groundwater by limestone treatment in presence of phosphoric acid," Journal of Environmental Management 152, 2015, pp. 152, 132-19; Mohan et al, "Field experience of Fluoride Nilogon: a method of fluoride removal from groundwater," Current Science 118 (2), 2020, pp.118, 255-263.

[3] Phosphoric acid is an edible weak acid added in some soft drinks and used as preservative in packaged food.

Methodology

ZOA received funding from a Dutch foundation to set up a small pilot to introduce and test the Fluoride Nilogon filters in Yemen. Over a period of 8 months the following has been done:

Selection and testing of suitable limestone for filters
Setup and distribution of 300 household filters
Testing of 40 filters on fluoride levels of inflow and outflow
Community meetings on awareness raising
Household survey and barrier analysis for feedback

Results

Technical / chemical

Samples of inflow and outflow have been taken at different weeks after installation of the filters to test the fluoride concentration in the drinking water. The water source has a fluoride concentration of about 3.2 mg/l. All the sampled filters are now within WHO standards for safe drinking water.

	Fluoride concentration
WHO threshold	< 1.50 mgl/l
Week 1 (N=10)	1.09 – 1.36 mg/l
Week 2 (N=10)	1.34 – 1.48 mg/l
Week 3 (N=10)	0.89 – 1.45 mg/l
Week 4 (N=10)	1.12 – 1.40 mg/l
Lab testing (N=4)	0.70 – 1.20 mg/l

Social

A household survey (N=110) and Barrier Analysis (N=27) 2 months after the distribution of the filters showed:

- All households, except one, that had received the filter, were still using the filter daily and felt it was easy to use.
- The main barrier encountered was acid running out/waiting for a representative to distribute new acid (32%).
- 54% of the households were using the treated water for drinking only and not for cooking. Using untreated high fluoride water for cooking increases the fluoride intake.
- Awareness of the impact of high fluoride levels in domestic water is high.

Challenges encountered

- Due to the restrictive operating environment in Yemen, it was not possible to have an experienced staff member/ student from Tezpur University present during the project implementation. A major internet shutdown, due to airstrikes at the start of 2022, challenged the remote monitoring even more.
- After the first activation of the limestone, the fluoride levels increased, rather than decreased, and adaptations had to be made. In-depth testing showed there was leaching of fluoride from the sand in the sand-gravel filter, aggravating the situation. The sand was then replaced.
- The fluoride measuring device available in Yemen had a range limited to 2.0 mg/l, making accurate high reading less reliable.
- Access to project sites in Yemen are limited by approvals. When the project stops, additional access for follow-up monitoring is limited.

Conclusions

The pilot has shown that the Fluoride Nilogon filter is an appropriate technology that successfully reduces fluoride levels in domestic water to within WHO-standards. Acceptance and uptake of the technology by the population has been very high as well. It is worth continuing the introduction of the Fluoride Nilogon filter in Yemen to other actors in the water sector to assure safe drinking water for all.

Recommendations

Future projects with the Fluoride Nilogon filters should consider the following:

- Raise awareness among the users to use the filtered water for both drinking, cooking and mouth-washing purposes.
- Use an ion meter with an ion-selective electrode with a measurement range up to 20.0 mg/l and detection limit of at least 0.1 mg/l to improve quality of measurements.
- Monitor selected filters for a longer time to show long-term functioning and adoption of the filter.

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