WaTER Center Research – Fluoride Mitigation

Naturally occurring fluoride in the Earth's crust enters groundwater by natural processes, especially in soils at the foot of high mountains and in geological deposits created by the sea. It is not known exactly how many people are affected by excess fluoride, but fluorosis is endemic in at least 25 countries across the globe (Figure 1). People affected by fluorosis are often exposed to multiple sources of fluoride, such as in food, water, air (due to gaseous industrial waste), and excessive use of toothpaste. However, drinking water is typically the most significant source.

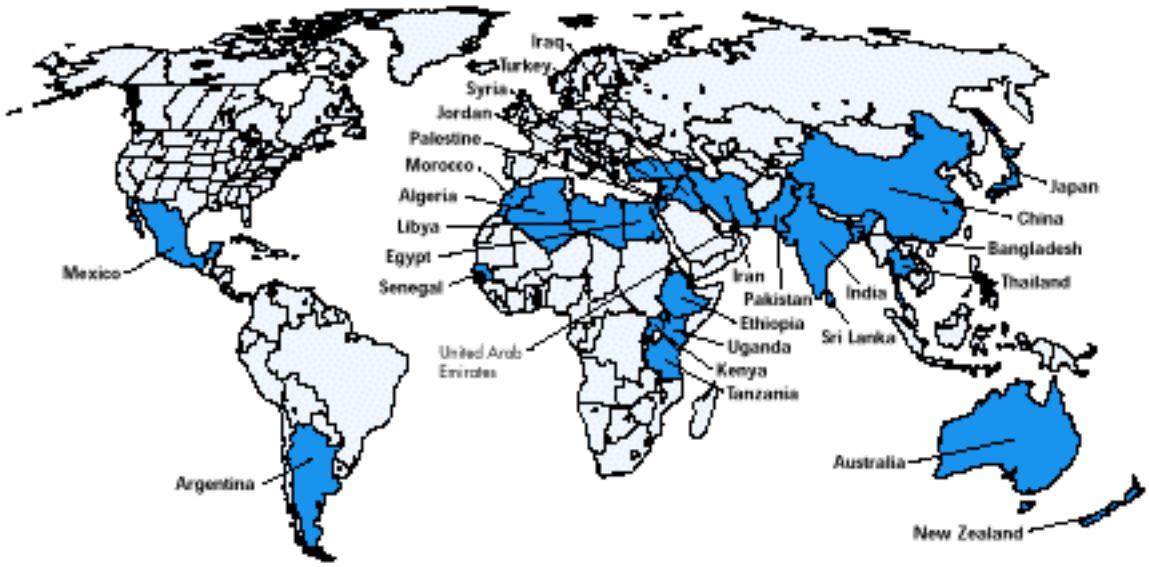

Figure 1. Countries with endemic fluorosis due to excess fluoride in drinking water. (Source: UNICEF web page, accessed 28 November, 2011).

Intermediate fluoride levels (> 1.5 mg/L) can cause dental fluorosis and higher levels can cause debilitating skeletal fluorosis and impaired intelligence / neurotoxic damage. Water treatment materials are needed that approach the efficiency of commercial materials but that are much less expensive, that ideally can be produced in country, and that are culturally acceptable and can be implemented without disrupting established village routines and structures. Materials that are currently available suffer from high cost (e.g., granular ferric oxide and activated alumina) or poor sorption capacity due to low surface area (e.g., iron coated sand).

WaTER Center researchers, with partners in Ethiopia, are exploring a low cost in-country alternative. Bone char – animal bones charred to increase surface area – has demonstrated by our team to be effective at removing fluoride. Charring bones removes organic matter and greatly increases the specific surface area and fluoride adsorption capacity on the bone hydroxyapatite. Bone char is an attractive technology because it can be locally and inexpensively produced in emerging regions.

Religious and cultural beliefs, however, may render cow or pig bone char undesirable for certain communities. Thus, we have also evaluated fish bone char as an alternative and found that it performed similar to cow bone char. Our research has reported specific surface areas of fish bone char and cow bone char of approximately 100 m^2/g, approaching the 150 m^2/g value reported for activated alumina, commonly used in the U.S. for defluoridation. Charring temperatures of 400 and 500 ^oC produced the highest surface areas (ca. 100 and 110 m^2/g, respectively) and also the highest adsorption relative to lower and higher temperatures, similar to our surface area results with wood chars.

In collaboration with Dr. Feleke Zewge at the University of Addis Ababa and Ethiopian NGOs we are continuing to test the most promising mineral-coated chars along with activated alumina in rural villages in Ethiopia.