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Towards sustainable safe drinking water supply in low- and middle-income countries: The challenges of geogenic contaminants and mitigation measures

Foreword

by C.A. Johnson, M. Berg, and D. Sabatini

The problem of geogenic contamination of drinking water has risen rapidly in the second half of the 20th century together with the rapid growth of groundwater use, which is generally seen as a safe alternative to drinking untreated, microbially contaminated surface water. Today roughly a third of the world's population depends on groundwater for drinking and it is estimated that roughly 10% of wells are contaminated with the most widespread geogenic contaminants, arsenic and fluoride. In terms of the number of people exposed the current estimates are 140 million (Ravenscroft et al., 2009) and 200 million (Ayoob and Gupta, 2006) people, respectively. The health effects can be severe, particularly in those with poor nutrition. Ingestion of excess arsenic over prolonged periods of time can result in various internal cancers amongst other conditions, while high levels of fluoride are responsible for the development of dental and crippling skeletal fluorosis.

In the absence of alternative drinking water resources, water treatment is required. In wealthy countries with centralized water supply systems, an extra water purification step to remove arsenic or fluoride is generally used. Routinely, arsenic can be oxidized by aeration from the highly soluble and poorly sorbed arsenic(III) to arsenic(V), which sorbs to iron oxides. Fluoride removal is often achieved by the use of activated alumina or a similar sorbent. In contrast, in low- and middle-income countries there may not be an enabling environment: Policies and funds may not be in place and there may be no drinking-water treatment. The challenge for the water-supply sector is, therefore, to develop appropriate solutions for these settings.

On February 5-7, 2013, an inaugural international conference was held in Addis Ababa, Ethiopia to jointly address arsenic and fluoride contamination in drinking water. The **GeoGen2013** conference, co-hosted by Eawag, World Vision, WHO, and Addis Ababa University, drew over 90 participants from 16 countries. The objective of the conference was to bring together researchers from both the arsenic and fluoride research fields, implementing agencies and government officials to discuss and explore ways of attaining sustainable solutions for the mitigation of geogenic contaminants in drinking water. Experts discussed their experiences in mitigating the effects of contaminated drinking water in their country contexts.

There were valuable lessons to be learnt from the experience of arsenic mitigation in Bangladesh, the first country where widespread exposure was identified. Since the first survey in 2000 mitigation efforts, run largely by the government, have reduced exposure levels (>50 μg/L arsenic) by approximately one quarter despite population growth (Johnston et al., 2014 *this issue*). These authors also mention that had new water points been sited in the worst affected areas, progress would have been faster. Well switching, rather than water treatment, has been the most common mitigation option (Ahmed et al., 2006). Van Geen et al. (2014 *this issue*) found at their field site that new shallow tube wells (the origin of the problem) are being installed and used without being tested for arsenic and conclude that well testing needs to be promoted. Interviews with a spectrum of stakeholders from government officials to householders have shown that deep tube wells and piped water supply were preferred options and that, if required, community water treatment systems were preferred to household systems (Johnston et al, *this issue*; Khan & Yang, *this issue*). Using the Process Analysis Method to assess the sustainability of community and household arsenic removal systems Etmannski and Darton (2014 *this issue*) found that *trust* (in the technology and technical support) and the *distance* from their home to the safe water source were important factors, but found that willingness to pay and awareness of the health issues were low.

The water-treatment technologies presented in this special issue consider implementation as an integral part of technology design and development. Field tests allowed Gwala et al. (2014 *this issue*) to determine the best practice for their household defluoridation units and have enabled Amrose et al. (2014 *this issue*) to assess their community electrocoagulation plant for arsenic removal for robustness and reliability, cost and cultural acceptance. How an appropriate business can result in successful implementation over a decade has been demonstrated for a community plant to remove arsenic by German et al. (2014 this issue). The first step in the development of a successful business plan (Gebauer, 2014 *this issue*) is the socio-economic evaluation of a given technology, as illustrated for safe water provision options in arsenic-affected regions in Cambodia (Chamberlain and Sabatini, 2014 *this issue*) and fluoride removal options in Ethiopia (Osterwalder et al., 2014 *this issue*).

Given the complexity of the requirements to achieve consistent use of safe drinking water, the role of the research community should be to provide the best available evidence for technological options together with strategies for sustainable implementation (including social, cultural, economic and political factors).

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