ARSENIC MITIGATION IN BANGLADESH

A SUSTAINABLE SOLUTION FOR SATKHIRA DISTRICT, BANGLADESH

A PROPOSAL TO
GLOBAL CASE COMPETITION, WSU:

March 7th 2014

Team 16: Craigen Nes, Afshin Khan,
Jordan Rehwaldt, Brittany Ness,
Steven Monda, Abdul Mohamed

Plan: Identification, Filtration, & Education

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Preface and Problem Scope:

Exposure to arsenic in drinking water is a major problem worldwide posing a serious threat to human health.[1] According to Allan H. Smith a professor of epidemiology at the University of California, Berkeley, arsenic poisoning in Bangladesh is "the largest mass poisoning of a population in history".[2] Moreover, arsenic threatens the health of over twenty million people in sixty-one of the sixty-four districts of Bangladesh with specifically two million people living in the at-risk southwestern district of Satkhira.[3,4,5] Over the last few decades the availability of safe drinking water has become scarce with nearly a third of the Bangladeshi population drinking water contaminated with arsenic above acceptable levels (10 µg/L according to WHO).[6] This has caused both economic and social devastation, and without proper mitigation the problem will continue. Therefore, it is of critical importance to develop sustainable arsenic-removal technologies and community based programs to educate affected communities in order to safeguard the population's health starting in the Satkhira district. A solution to the arsenic problem in the Satkhira district will require a three-pronged approach focused on identifying current tube wells as safe or contaminated, providing filtration where necessary, and educating the population about arsenic.

Identification of Contaminated Wells:

Tube wells, used by 97% of the rural population, are the primary source of drinking water in Bangladesh, and 90% of the total Satkhira district population.[6,7] Past work to identify contaminated tube wells consisted of painting safe wells green and toxic wells red.[8] However, the reliability of the kits used in these tests is now in question with false negatives resulting in up to 68% of tests. Cheaper and more reliable testing assays are developed.[9] Optimum identification will require testing wells using better test kits and retesting wells every three years, because aging wells have an increased chance of arsenic contamination.[10] The Bangladesh government, which has performed 78.5 percent of tube well tests with international funding, should be engaged heavily in furthering this strategy.[11,12,13,14,15]

Filtration Technology as a Solution:

SONO filters are a widely used solution for small-scale arsenic removal. A SONO filter consist of three clay pitchers and uses locally available adsorbent materials such as cast iron turnings, sand, wood, and activated carbon to reduce the arsenic content of contaminated water.[16] Abul Hussam et al claim that 255 thousand SONO filters are in current use in Bangladesh, India and Nepal. Experimental data show that SONO filters can reduce arsenic, manganese, iron, and other transition metal ion content to safe potable water levels, with an average filter life of 5 years.[17]

A sustainable long-term alternative is the in-situ well treatment (called subterranean arsenic removal technology - SAR). Aerated well tube water can be released back to the well, which oxidizes arsenite to arsenate (less mobile), manganese (II) to manganese (III), and Iron (II) to Iron (III). The oxidation reaction is followed by a natural adsorption process of arsenate to Iron (III), reducing the arsenic content in water. This natural phenomenon is further enhanced by the work of microorganisms participating in the bioremediation process. Overall, in site tests show that SAR technology reduces arsenic level in wells with arsenic content above 300µg/L to a safe level below 2µg/L.[18] The advantage of using SAR technology is eliminating the use of additional chemicals in the treatment process, and solving the issue of waste disposal since the metallic impurities are adsorbed within the soil / sediment of the aquifer. SAR is a sustainable long-term technology that is capable of producing large supply of arsenic-free water with simple operation and cheap maintenance cost.[19]

Financial Viability of Filtration Options:

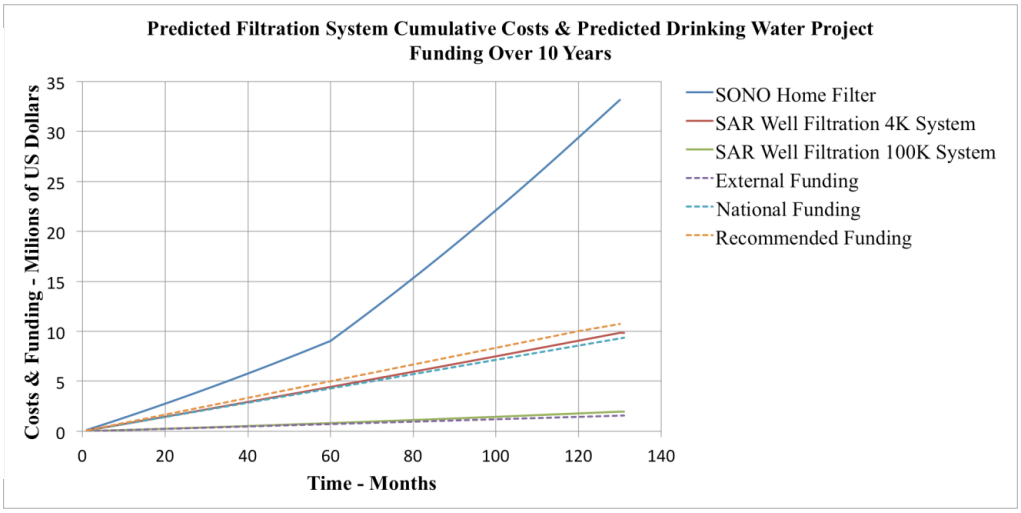
Financial projections regarding the SONO home filters, the SAR well filtration system, and potential funding were created to compare the feasibility of the two solutions. Figure 1 on the following page displays these projections. The three solid lines represent the cumulative costs of gradually installing enough of each filtration system to serve the entire district's population with drinking water, over ten years. The three dotted lines represent the projected cumulative funding options based off of recent water projects funding. The recommended funding option consists of both international and national funding for ten years, and only national funding after ten years. Assumptions for these projections are included in the graph.

The total potential funding for water projects in this district, external funding and national funding combined, is $10.02 million over ten years. In order to be truly sustainable, funding would only come from the national government after the ten year solution is implemented, roughly $71.5 thousand per month; the recommended funding option. Considering this, the commonly distributed SONO filters are not a financially viable solution. These would cost $29.39 million to supply the entire district and $376.1 thousand per month to sustain after ten years. The SAR filtration systems are much cheaper. The 4,000 L/day systems could not be sustained by the recommended funding option, however the scaled 100,000 L/day systems could be. SAR is offered in many intermediate sizings. Therefore it is recommended that a strategic combination of differently sized SAR systems, placed by population density, would create a financially sustainable solution that lowers both the district's drinking water and aquifer arsenic concentrations. It is acknowledged that in some situations SONO filtration technology could provide quick and cheap relief to a small number of people, but it is not a viable option for long-term, large-population solutions.

Figure 1. Long-Term Filter Financial Comparison with Predicted Funding

Factors considered:

- District Population & District Area [20]
- Average Household Size [21]
- Water Use perCapita [22]
- SAR Initial Costs & Operating Costs [23]
- SAR Life Expectancy and Water Output [23]
- SONO Initial Costs & Operating Cost [24]
- SONO Life Expectancy [24]
- National / District Water Project Funding [25,,26,27]
- International / NGO's Funding [28]



Education and Awareness:

Any plan to mitigate Bangladesh's arsenic calamity would be ineffectual without an emphasis on education and awareness in local communities. Despite an increase in publications regarding the health implications of arsenic, a study by van Geen et al found that "millions of people in Bangladesh continue to drink well water containing elevated levels of arsenic even though arsenic-safe water is often available from other wells located within a short walking distance."[29] A baseline survey in Bangladesh also reported nearly "70% of participants incorrectly stated boiling could remove arsenic from drinking water."[30] Although an interview with Mizanur Rahman Tanvir, a 3rd year medical student at Satkhira Medical College, suggests arsenic awareness is currently much higher in the Satkhira District, awareness of the danger of arsenic-contaminated water is still too low.[31]

The Bangladesh Constitution states "The State shall adopt effective measures for the purpose of relating education to the needs of society and producing properly trained and motivated citizens to serve those needs."[32] An arsenic education plan in Bangladesh will properly train communities in the dangers of arsenic and the steps that can be taken to reduce exposure. The government has a heavy hand in both operating and subsidizing schools, and Bangladeshi boys and girls can expect 11 years of schooling.[33,34] In the future, government educational mandates put forth by the Ministry of Education will allow arsenic awareness to be disseminated throughout Bangladesh in schools that are already in place. Additionally, the Community Medicine Department of Satkhira Medical College will be an important asset in educating the Satkhira District specifically, where community education can be implemented as either a public health elective or an extracurricular for medical students. These programs for increasing arsenic awareness through education will assist a sustainable development of water treatment and protect the health of Bangladesh residents.

Collaborations:

Effective arsenic mitigation in Bangladesh will require collaboration with both agencies to execute plans and agencies to fund plans. Executing agencies can be divided into the public sector, in the form of agencies such as the Department of Public Health Engineering and the Ministry of Education, and the private sector, in the form of filtration companies as well as local and international NGOs. Both public and private executing agencies have been important in past arsenic mitigation endeavors and will need to be engaged strategically to provide optimum future solutions. The local manufacturer and distributor of SONO filters in Bangladesh, MSUK will be a key strategic partner in providing technical and logistics expertise.

International government funding bodies such as UNICEF, the World Health Organization, and the World Bank have been active in funding arsenic mitigation programs in Bangladesh. UNICEF in particular has funded much Department of Public Health Engineering arsenic mitigation.[35] This tandem will continue to be a necessary force in further arsenic mitigation, and their link to engineering may prove valuable in implementing filtration strategies. Private donations will be another valuable source of funding in further mitigation, with international "Buy-a-Filter"/"Clean-a-Well" programs being a potential lucrative source. Although international funding will play a large role in the immediate future of arsenic mitigation in Bangladesh, costs, upkeep, and new programs should be gradually transitioned to the jurisdiction of the Bangladeshi people and government.

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