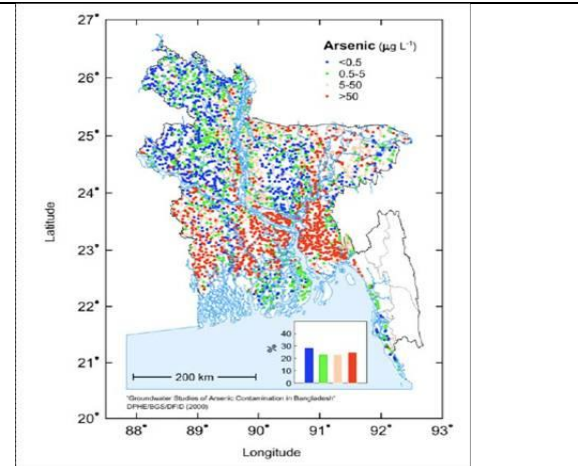


SONO Water Filter: A Sustainable Solution for Arsenic Crisis and Clean Drinking Water

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DPHE/BGS/DFID (2000): Gov. of Bangladesh. Recent maps show severe contamination throughout the Ganga-Meghna-Brahmaputra basin.

Bangladesh: Arsenic Scenario

Population: 150 million
 Area: 46,560 sq. miles
 Tube wells: 10 million (1940, UNICEF 1970)
 Origin of arsenic: Groundwater (<math>< 200 \text{ m}</math> depth)
Cause: Bio-geochemical reduction process
 Contaminated wells: 27-50%
 People affected: 75-95 million
 Arsenical skin lesions: 1.2 mil
 Children at risk: 35 million
 Cancer risk: 1-3 per 1000 people

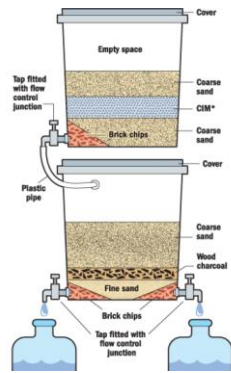
The arsenic crisis in Bangladesh is one of the worst environmental disasters and a public health crisis of unprecedented dimension. A major portions of northern India (map on left), where about 500 million people lives, may be affected by arsenic and other groundwater contaminants.

Toxic Levels of Arsenic in Water

WHO Guideline: 10 $\mu\text{g/L}$ (ppb)
 Bangladesh Limit: 50 $\mu\text{g/L}$
 USEPA : 10 $\mu\text{g/L}$

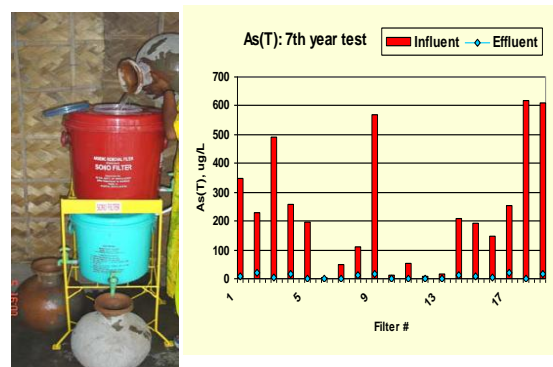
Dermatological Symptoms

Diffuse melanosis
 Spotted melanosis
 Leucomelanosis
 Mucus membrane melanosis
 Spotted keratosis
 Cancer
 Human liver degenerates at 800 ppb
 (Top: Keratosis and cancer on hand,
 Bottom: Mucus membrane melanosis)



To solve the arsenic crisis we have developed a composite iron matrix (CIM) adsorbent to remove arsenic and other toxic metals from groundwater. The CIM in combination with sand, gravel, and charcoal produced the SONO filter. The filter has been tested by three environmental technology verification projects for arsenic mitigation (ETVAM) and won

the 2007 Grainger Challenge Gold Prize for Sustainability from the US National Academy of Engineering.



Test results compiled over seven years show SONO can remove arsenic (to <math>< 10 \text{ ppb}</math>), manganese (a neurotoxin to <math>< 400 \text{ ppb}</math>), iron, and all transition metal ions to a safe potable water.



About 350,000 SONO filters are now producing clean drinking water in Bangladesh, India and Nepal. The filters are distributed by all means including boat to remote places in Bangladesh.

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SONO filter capacity and cost (\$ 35)

100 L / day
 40,000 L / year
 200,000 L / 5 years (= 200,000 Taka or \$ 2800 saved)

SONO spent material is non-toxic (TCLP test)

200 ug/L As removed / day
 USEPA limit 2 kg arsenic /hectare per year = spent media from 10 million liter water at 1000% safety margin

SONO/MSUK buy back spent CIM and recycle



Within localities inside Bangladesh, a flat-bed rickshaw-van is a very efficient means of transport for small number of filters.

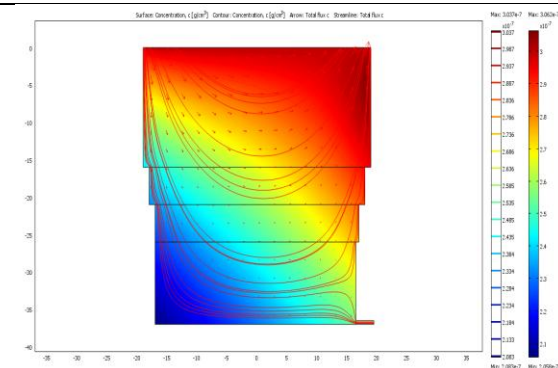
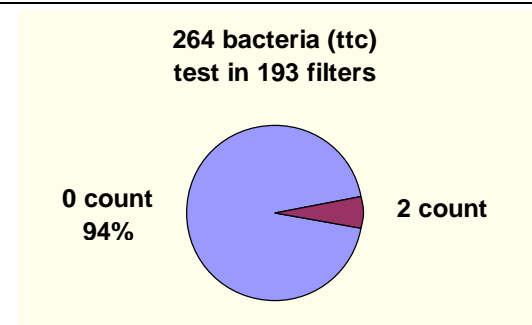


Figure shows arsenic (in red) percolating through the SONO top bucket. The active media in the middle is barely affected even at 30,000 ppb As input!

The very high arsenic breakthrough capacity of SONO filter was studied using the COMSOL Multiphysics finite element solute mass transport model. It predicts that these filters could last at least 14 years without breakthrough at the present usage rate of 100 L per day. This amount of water is sufficient for a family of five for drinking and cooking. SONO has developed larger filters to produce 100 L/hour for community and semi-commercial use. Much smaller table-top units are also under development. We also have developed a process to embed active CIM in fabrics for much lighter and efficient water filtration platform. Research on small inline filter is in progress at CCWST. Reactive transport model using COMSOL Multiphysics is now used for all filter development work.



The CIM has inherent properties to remove coliform bacteria and viruses from water at the level of drinking water quality. A patent is filed for the later: *Removing Viruses from Drinking Water, US Provisional Patent* Application No.: 61089143; Filed by George Mason Intellectual Properties Inc., August 15, 2008



Now, we have developed inline water filters using CIM technology for continuous water filtration and for future scale-up and large scale filtration for home and industry. **CIM spent material is non-toxic (TCLP test).** The used CIM can be disposed safely like soil, or can be recycled and regenerated to produce metallic iron.

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SONO Filters: 2001- April 2012

- 350,000 SONO™ filters installed in Bangladesh, Nepal, Pakistan, India, and Egypt
- 60-180 liters per day consumed for 2- 9 years
- > 1 million direct beneficiaries (1.6% of the needy)
- >1 Billion liter of clean water consumed and continues
- Cost: <0.001 Taka / Liter (1\$ = 80 Taka)



All sizes of inline filters are examined. CIM is also embedded in fabrics to make lighter and more efficient filters. A US patent is pending:
Composite Iron Matrix Embedded Fabrics - A Prototype, GMU-10-024, **US Provisional Patent** Application No.: 61/285,635, filed 12/11/2009



US patent
8,404,210,
Abul Hussam,
Iron composition based water filtration system for the removal of chemical species containing

arsenic and other metal cations and anions, March 26, 2013.

This work was possible through the tireless efforts of Professors Amir H Khan, and Abul Barkat, the workers of MSUK, and SONO Technology and Research Inc. (STRI), Kushtia, and my students at CCWST, George Mason University, USA.



Workers of MSUK, and SONO Technology and Research Inc. (STRI), Kushtia.