Arsenic Removal Technology Field Testing & Performance Verification

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Outline

- ✓ The goal of performance verification
- ✓ Definition of performance claim and the model followed to verify performance claim
- ✓ Roles and responsibilities
- ✓ The National Policy for Arsenic Mitigation and the performance verification
- ✓ Describe in detail the field testing and performance verification activities
- ✓ Technologies screened, field tested and verified
- ✓ QA/QC in data collection
- ✓ Common features of arsenic removal technologies
- ✓ Key findings and their implications
- ✓ Concluding remarks

The goals of Performance Verification

- ✓ Test arsenic removal technologies in the field and Confirm or deny proponents' performance claim
- ✓ Protect the health and wellbeing of arsenic affected population
- ✓ Keep non-performing technologies out of the market
- ✓ Establish deployment conditions for verified technologies.

Defining Some Terms

- **<u>Performance Claim</u>:** The effect foreseen by the vendor on the technology in the arsenic contaminated water
- **<u>Performance Parameters</u>:** Parameters that can be documented quantitatively in tests and that provide relevant information on ART.
- **<u>Verification</u>:** Evaluation of product performance parameters for a specific application under defined conditions and adequate quality assurance
- **<u>Example</u>:** Technology **AsPureW** can generate 10,000 L of arsenic-safe water from groundwater **at natural pH and contaminated with *As, PO_4^{3-}, SiO_4^{2-}, and SO_4^{2-} at concentrations of up to 1500 µg/L, 5 mg/L, 80 mg/L, and 300 mg/L, respectively***.
- **<u>Technical Expert Committee (TEC)</u>**: A committee composed of eminent Bangladeshi scientists: Professors Feroz Ahmed, Amir H. Khan and Abu M. S. Alam

The BETV-SAM Performance Verification Model - 1

Technology Screening

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Technology Specific
Test Plan (TSTP) for candidate technology

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Well Selection
5 Wells in 5 regions for field testing

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Field Testing

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Data Collection

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Data Collection/Analysis

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The BETV-SAM Performance Verification Model - 2

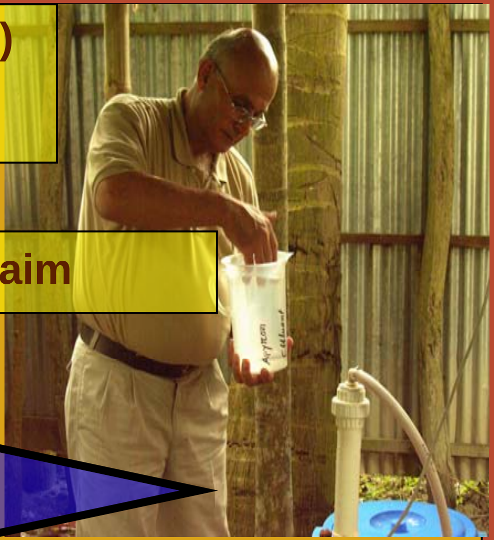
1) Assessment of Performance (Arsenic)
2) Bacteriological Findings
3) Waste Issues

Verification/Rejection of Performance Claim

UNICEF/DPHE/BETV-SAM

1) Social Issues
2) Economic Issues

Verification Report (Technical)



Deployment recommendations to Technical Expert Committee and BCSIR

Certificate issued by BCSIR with Deployment Conditions

Roles and Responsibilities

- OCETA provides technical support and builds capacity to complete the tasks at all stages of the project
- BCSIR reviews applications, selects technology for field testing, prepares Technology Specific Test Plan (TSTP) and the verification procedure, with help from TEC
- BCSIR hires and trains a Field Testing Agency (TA) and hires Analytical Laboratories
- BCSIR collects data from TA and Analytical Laboratories, compiles and analyses the data, and prepares a verification report.
- BCSIR officially signs off the verification report and, if the technology is successful, issues the verification.
- The TEC reviews the report to and ensure that data are analyzed and interpreted correctly and that the report is satisfactory

National Policy For Arsenic Mitigation

- ✓ Establish "a network of well equipped laboratories with arsenic measurement capacity at appropriate level"
- ✓ "Tap international expertise in areas where necessary local expertise is yet to be developed"

1. This project tapped into the Canadian expertise to build capacity in local analytical laboratories as well as at BCSIR Analytical Research Division Laboratory
2. Create a Verification Unit at BCSIR

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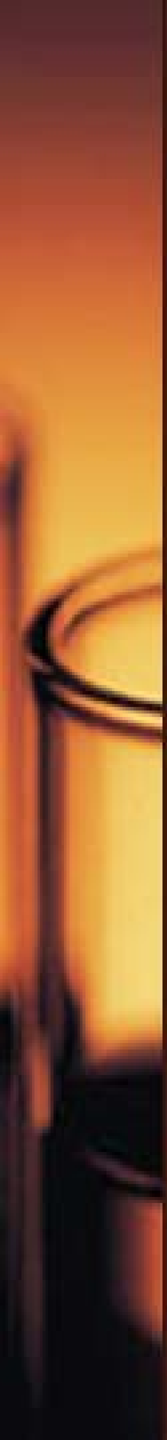


Why Test Arsenic Removal Technologies?

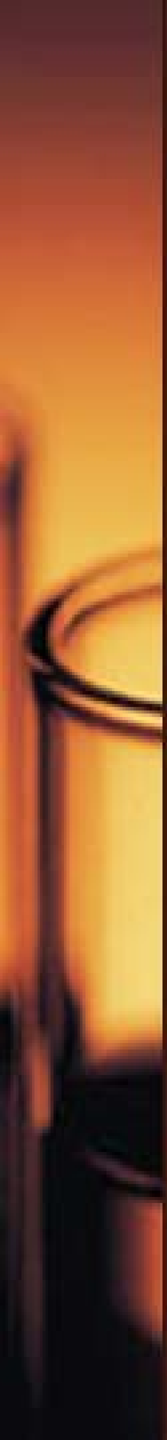
- ✓ Proponents either do not have test data from Bangladesh or do not have verifiable data that is necessary for the performance verification
- ✓ Their test data are not collected by an independent agency and are not impartial
- ✓ Water matrices in Bangladesh are often different from the one the technologies were tested on
- ✓ Tests must identify what other chemicals the technology can remove from, or add to, treated water
- ✓ Also need to know if the technologies capable of harbouring and growing Bacteria

The BETV-SAM Performance Verification - 1

- ✓ Screen application and select promising technologies for the field testing and performance verification
- ✓ Prepare field testing protocol for each technology
- ✓ Hire and train field testing agencies (TA) to carry-out the field work
- ✓ Train BCSIR and DPH engineers and scientists to supervise TA’s field work
- ✓ Finally BCSIR scientists and the BETV-SAM engineers and scientists supervise and oversee the field work, answer questions, solve unforeseen problems, and provide technical guidance

The BETV-SAM Performance Verification - 2

1. The field testing is carried out on five wells in five different hydrogeological areas under the following conditions:
   - The water quality parameters of the test well is compatible with the performance claim
   - The technology processes a reasonable volume of water in a day, and
   - The field test is continued until:
     - A. Arsenic breakthrough (Effluent [As] > 50 ppb), or
     - B. The volume of treated water meets proponent's claim
2. Analyze and interpret data and prepare technology verification report;
3. Establish deployment conditions, etc.



The BETV-SAM Performance Verification - 3

- ✓ **Data collected for a technology include**
  - At least five sets of water quality parameters for raw and treated water samples
  - Three samples of raw and treated water analyzed by metal scan (ICP-MS)
  - At least 12 – 15 arsenic data from treated water
  - Ion chromatography analysis of at least five raw and treated water
  - Bacteriological analysis of raw and treated water
  - pH, turbidity, etc.
  - Constant monitoring in the field

The BETV-SAM Performance Verification - 3

- ✓ Analyze and interpret data and prepare technology verification report;
- ✓ Establish deployment conditions, specify O&M, precautionary measures to prevent bacterial contamination of water, etc.
- ✓ The project sought and received advice from eminent Bangladeshi Academics at all stages of the performance verification processes

The BETV-SAM Performance Verification - 5

- ✓ Not surprisingly, all technologies faced challenges
- ✓ These technologies had not been not tested as rigorously or as extensively before
- ✓ The BETV-SAM team provided as much assistance as possible and modified proponent's O&M instructions in most cases in order to make the technologies perform satisfactorily
- ✓ The field testing was a good educational experience for us all and taught us a thing or two about ARTs including:
  - How should these technologies be operated?
  - What water quality parameters affect performance most?
  - How to diagnose technology failure in the field?

The Outcome the BETV-SAM Project

- ✓ The project screened **45** applications and selected **17** technologies for field testing:

A - Household Technologies:

1 – Adsorption Technologies: Alcan, Nelima (2), Kanchan, Read F, Shapla, Sono,

and Wholly Water

B – Coagulation Technologies:

CIWPL, Star, and Shawdesh

C – Community ARTs:

Adsorption ARTs: Alcan, Apyron,

MAC-C, Read F, Sidko,

D - Ion Exchange ART

Technologies that Passed the Verification Process

- **A –Household ARTs:**
  - Alcan,
  - Nelima,
  - Read F,
  - Shawdesh,
  - Sono
  - Two other ARTs could have been certified had their proponents made minor modifications to their technologies
- B - **Community ARTs:**
  - Sidko

Photos of Verified ARTs

Data Quality & Performance Verification

- ✓ The performance of a technology cannot be verified in the absence of credible and verifiable data
- ✓ The BETV-SAM spared no efforts to ensure that data collected in this program are reliable, credible, and verifiable
- ✓ Analytical laboratories selected for sample analysis have all demonstrated their ability to generate accurate, precise, and reproducible results by participating in a number of round robin tests
- ✓ The program continuously scrutinized analytical data submitted by all laboratories to ensure accuracy and reliability of the data

The QA/QC Procedures

- ✓ The procedures followed to ensure data accuracy, precision, and reliability are:
  1. Raw and treated water samples, field blanks, and field standards were analyzed by qualified (commercial and governmental) analytical laboratories in Dhaka
  2. Duplicates were collected with 20% of all samples
  3. Duplicate samples for chemical analysis along with field blanks and field standards were analyzed by the designed, BCSIR, and an ISO 17025 Accredited laboratories
  4. In addition, all laboratories performed analysis of their own duplicates, blanks, and standards
  5. In addition, all samples were also analyzed in the field using field test kits and following strict SOPs

Why so Much "Complexity"?

- ✓ The health and wellbeing of millions of people is at stake
- ✓ Decisions are made based on verification data
- ✓ Therefore, these technologies need to be tested properly, to obtain accurate results. There are no short cuts.

Common Features of ARTs

- ✓ ARTs employed metal oxides (cerium, iron or aluminum oxides) and iron

- ✓ 1 kg of iron oxide adsorbs 16 g–40 g of As $(1.6\text{-}4)\times10^{7}$ µg/L of As
  - 1 kg of iron oxide should treat **<u>(4 -10) ×10⁴</u>** L of GW with 400 µg/L of As
  - 1 kg of iron should treat **<u>(7.6 – 19) ×10⁴</u>** L of GW with 400 µg/L of As
- ✓ Aluminum oxide absorbs less, ~4 g/kg
  - ➢ 1 kg Alumina should treat **<u>10,000</u>** L of GW with 400 µg/L of As

Key Findings

- ✓ Field tests revealed the actual versus the claimed performances of the technologies
- ✓ Volumes of water produced were below proponent claims, because:
  - -Dissolved organic matter reduces ART capacity
  - -Iron dissolved in well water is not allowed to oxidize and precipitate out
  - -Inadequate contact time between well water and arsenic removal media
  - -Filtration procedures/materials

Nevertheless, some technologies performed satisfactorily and were certified for use in Bangladesh.

Common Features of ARTs

- Oxidizes to iron-oxyhydroxide
- The precipitate is slimy, does not adsorb on filter media, fills the cracks and crevices.

- Iron oxide accumulation slows flow rate, creates flow channels, and reduces contact time
- Leaks into the effluent and brings As with it

Example – SONO ART

- The technology is designed to produce ~60 L of arsenic-safe water in a days

1. Add well water to the top bucket
2. Open the tap and then let it pass through to the second bucket
3. Ensure that media is under the water at all times
4. From here on; add well water to the top bucket, let it pass through the buckets and collect treated water in a clean Kolshi

Example –Alcan ART

- ✓ Arsenic removal media are placed on two separate plates
- ✓ The technology works best this way:

1. Fill the unit with well water
2. Allow 30 min. to 1 h for iron to oxidize and coagulate
3. Withdraw only enough water at a time to drain the top layer of media. Then add more water to keep top media covered with water.
4. Add fresh well water, allow it to stand for about 20 – 30 min, collect an amount of water equal to that added to the filter
5. Wash filter media once every two weeks
6. Sanitize media after washing

Example – Read-F Technology

- ✓ The Read-F contains arsenic removal media and sand layers
- ✓ On our instructions, they have added a reservoir to store well water

1. Add well water into the reservoir, allow it to stand for a few minutes.
2. Open the tap afterwards and allow water to pass through the unit and collect treated water in a clean Kolshi
3. Backwash the media and sand filter once or twice per week, depending on the well iron level

Example: SIDKO ART

- ✓ The technology is designed to operate continuously

1. Pump well water into the overhead tank
2. Allow it to stand for 1 to 2 hours, depending on well iron level
3. Open the valve and let it pass through sand and iron removal media
4. Backwash sand filter daily
5. The technology should not be used to generate more than 1000 L of treated water
6. The technology should be able to produce 360,000 – 450,000 L of arsenic-safe water by following this procedures

Costs for Safe Potable water/ Household Options

Technology	Capital-O&M Cost/ Tk	Cost (Tk/L of Water)
Alcan-HH	3,500	0.18
Read-F	5,500	0.19
Sidko	350,000	0.18
Sono	2,700	0.12
Rain WH	2380	0.15 (WB)
DTW/PSF	8160	0.01 (WB)
Dug/Ring W	7960/6340	0.02 (WB)
PWD	---	0.03 (WB)

Costs for Safe Potable water/ Community Options

Tech	Capital-O&M Cost/ Tk	Cost (Tk/L of Water)
Sidko	350,000	0.18
Coagulation/ Flocculating	20,300	0.08
RO	83,000	0.25
IARP	2,720,000	0.004
Piped Water	----	0.03 (WB)

Concluding Remarks (1)

- ✓ The technologies that have been certified are suitable for use in Bangladesh.
- ✓ The work performed in this project was consistent with the National policy on arsenic mitigation
- ✓ The project collected independent, credible, and verifiable performance data.

Concluding Remarks (2)

- ✓ It takes time, effort and money to undertake a reliable test of a technology's performance.

- ✓ The field test work also helped improve the performance of the certified technologies

- ✓ These technologies have a role to play in many arsenic-affected areas.

Thank You for Listening