Evaluation of Arsenic Mitigation Technologies for Use in Bangladesh

Roy K. Boerschke and **Donna K. Stewart**
Ontario Centre for Environmental Technology Advancement (OCETA),
63 Polson St., 2nd Floor, Toronto, Ontario, Canada. M5A 1A4.

Abstract

Arsenic contamination of groundwater sources for the rural population of Bangladesh has become a major health issue. Central to any arsenic mitigation effort will be the availability of viable and cost effective technologies for treating arsenic contaminated water. The Environmental Technology Verification – Arsenic Mitigation (ETV-AM) Program is multi year, CIDA funded initiative designed to work in association with the Government of Bangladesh (GoB) and other international and national development partners working in the arsenic mitigation sector. The initiative is an intensive program designed to assess technologies based upon a rigorous performance criterion, followed by verification under conditions of actual use. Only those technologies meeting the specific requirements of Bangladesh will be implemented. The primary objective of ETV-AM is to complete a thorough assessment and verification of arsenic mitigation technologies that are currently being utilized or proposed for use in Bangladesh, based upon standards established in association with the GoB. In addition, ETV-AM will institutionalize a mechanism by which all proposed future technologies can be evaluated. All technology options are screened based upon a weighted decision matrix that integrates technical, social and fiscal parameters. A limited number of technologies that best meet the requirements of Bangladesh, based upon the screening protocol, are advanced through a funded assessment and verification program. Assessment and verification is based upon technical standards established in association with the GoB. In addition, social and fiscal criteria specific to Bangladesh are evaluated. Technologies wishing to bypass the ETV-AM process must still meet all requirements of technology assessment and verification based upon the technical standards established by the ETV-AM Program.

INTRODUCTION

Contamination of groundwater with arsenic has become a public health crisis in Bangladesh. Groundwater is the primary source of drinking water for the inhabitants of rural Bangladesh, with approximately 95 percent of the population consuming water obtained from bore hole wells (tube wells). Conservative estimates indicate that in excess of 21 million people are consuming water containing arsenic concentrations above 50µg/L, the recommended limit in Bangladesh(1).

The effects associated with the chronic ingestion of arsenic contaminated water are unclear. Epidemiological studies have indicated a correlation between the ingestion of inorganic arsenic and health effects(2,3). Studies indicate the incidences of skin cancer and cancer of specific internal organs increases with increased exposure to inorganic arsenic(4). In addition, non-cancerous effects have been reported for skin, vascular and gastrointestinal systems(4). To date, approximately 150,000 patients have been diagnosed with symptoms of arsenic poisoning in Bangladesh(1), with numerous deaths being associated with complications resulting from arsenicosis.

The issues surrounding the arsenic crisis cannot be understated. In addition to the potential enormous cost with respect to human lives, issues associated with quality of life, social interactions, and potential losses of revenue from both lost productivity and income generated from exports of crops must be emphasized(5). Inaccurate information has also help feed the crisis attitude and in many instances has significantly impacted the ability of donors to assist in addressing the situation.

Many efforts have been undertaken in an attempt to provide relief to individuals consuming arsenic contaminated water. The Government of Bangladesh (GoB), as well as national and international development partners, in an attempt to determine possible options for arsenic mitigation has been inundated with technology options by vendors and institutions. Some technology options have been adopted without rigorous testing and have failed when applied in the field. The application and subsequent failure of technologies have severe social consequences. Failure of technologies has led many communities to lose faith, and has severely damaged the hard-earned credibility and goodwill of implementing agencies. In addition, the failure of technologies has resulted in unwillingness by many development partners to commit funds to arsenic mitigation, specifically the implementation of remedial technology options without appropriate control procedures.

The application and subsequent failure of technologies that have not undergone rigorous technical reviews clearly indicate the urgent need to introduce a technology assessment and verification program in Bangladesh.

Through an intensive program designed to assess technologies based upon a rigorous performance criterion, followed by verification under conditions of actual use, only those technologies meeting the specific requirements of Bangladesh will be implemented.

The Environmental Technology Verification – Arsenic Mitigation Program (ETV-AM) is an initiative focused upon the development and implementation of a mechanism through which a formal assessment and verification of arsenic mitigation technologies can be undertaken in a recognized, systematic manner.

ETV-AM PROGRAM OVERVIEW

The GoB, working with national and international development partners, has undertaking arsenic mitigation projects in Bangladesh to address the public health crisis resulting from contamination of the groundwater. A key element of the mitigation strategy is to identify viable arsenic removal technologies for application at the household and extended household level in Bangladesh. The purpose of the ETV-AM Program is to complement the current GoB initiatives by evaluating the appropriateness and applicability to Bangladesh of technologies for removing arsenic from groundwater using a rigorous technology assessment and verification process.

Through ETV-AM, OCETA in collaboration with the GoB, international agencies, academic institutions and NGOs, has begun to establish a comprehensive technology verification process for reviewing proposed groundwater arsenic mitigation technologies. Following development of the technology verification process, ETV-AM will work with the GoB and national and international development partners in performing detailed screening to identify the best candidate arsenic mitigation technologies, with subsequent formal assessment and verification.

The ETV-AM Program encompasses two phases (Figure 1). Phase I consists of three stages:

i. Stage 1 – Screening
ii. Stage 2 – Laboratory Performance Evaluation and Review
iii. Stage 3 – Field Testing and Verification

Evaluation of proposed arsenic mitigation technologies is based upon internationally recognized technical protocols. In addition, technologies are evaluated on social and economic parameters specific to Bangladesh.

The goal of Phase I is to identify suitable technologies for arsenic mitigation of drinking water using a rigid assessment and verification program. To meet the Program goal for Phase I, the following objectives were established:

1. Develop detailed criteria for screening, assessing and verifying arsenic mitigation water treatment technologies in association with the GoB and stakeholders;
2. Screen candidate technologies based upon the criteria;
3. Conduct laboratory tests to validate the efficacy of the technologies based upon the established technical protocols, and identify possible changes that may enhance a given technology, as required;
4. Organize independent third party verification of vendor performance claims against an established protocol(s); and
5. Perform field verification of technologies under actual operational conditions and identify strengths and weaknesses of candidate technologies under field conditions.

Working in association with the GoB, the ETV-AM Program has developed a mechanism through which the following tasks can be undertaken in a systematic manner (Figure 1).

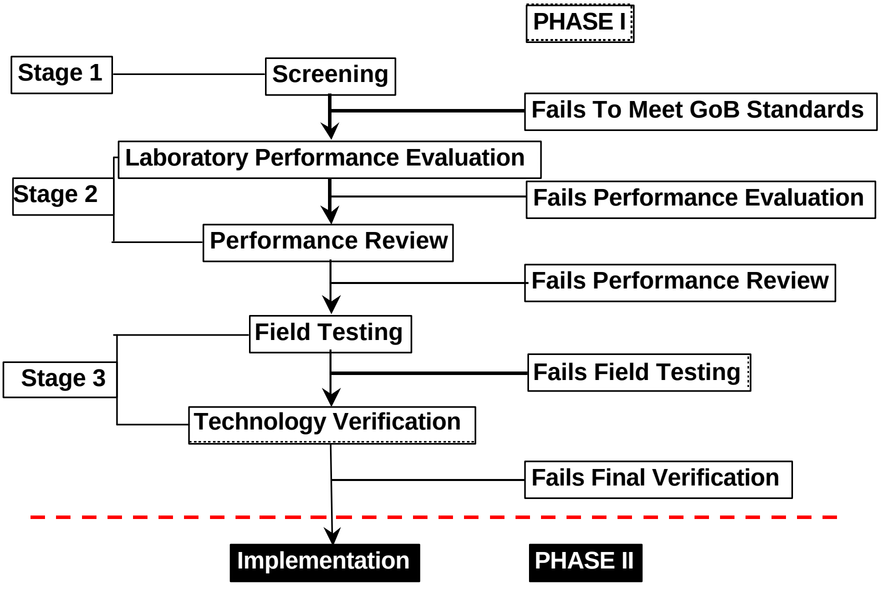

Figure 1 : Stages in Phase I of the ETV-AM program

ETV-AM PROGRAM COMPONENTS

Registration

The initial stage that must be undertaken by all proponents is registration of their proposed technologies with the GoB. The registration mechanism will be the first stage of a controlled pathway through which arsenic mitigation technology applications will be processed. ETV-AM is working with the GoB through the Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) implementing the mechanism through which technology registration will be undertaken.

Technology proponents will be required to provide specific technical, social and fiscal information. Technologies brought forward without the necessary documentation (i.e. 'Black box' technologies) will not be accepted. A detailed application for all potential applicants is required because it provides the GoB and implementing agencies an information source upon which to base their evaluations and provides a common reference upon which all parties can fallback. ETV-AM, in association with the GoB and development partners has produced an electronic application, which will be used as the basis for a formal application.

Technology proponents are offered two possible courses for verification:

i. Proponents are invited to participate in the ETV-AM process. The ETV-AM process is designed to screen all technology applicants based upon a series of technical, social and fiscal parameters specific to Bangladesh, through which a limited number of technologies shall emerge. The technologies that emerge from the screening process will be those that best demonstrate themselves with respect to the parameters identified, thus having the greatest potential for long-term viability. The ETV-AM Program absorbs costs associated with assessment and field verification of the technologies emerging from the screening process. It must be noted that technologies will be screened based upon criteria established by OCETA, in association with BAMWSP and national and international development partners, and reflect parameters that are viewed to most significantly impact the viability of technology options.

ii. Proponents may proceed directly to the technology assessment and the field verification stages of the process, bypassing the ETV-AM screening stage. Proponents choosing to bypass the screening stage will undergo assessment and field verification based upon the technical standards established by the ETV-AM Program, and will be required to absorb all costs associated with the necessary assessment and field verification.

Screening

The formal screening of the technologies is based upon a decision matrix that integrates technical, social and fiscal criteria. The criteria are evaluated using recognized protocols, and when necessary, tailored to meet the specific needs of Bangladesh. The proposed matrix for ETV-AM incorporates a two-tier mechanism designed to allow for both the recognition of key parameters being met and for the weighted assessment of technologies.

Tier I – Decision Matrix

Tier I screening involves a detailed examination and consideration of the candidate technologies. Technologies will be scored based upon the established criteria as to their suitability for use in Bangladesh. The screening will consider the following aspects of the treatment system (Figure 2):

- *treatment/process* – including chemical/physical mechanisms, expected treatment performance, potential limitations on performance, process chemical requirements, power requirements, flow dynamics, hardware requirements, servicing requirements, media regeneration and waste disposal requirements;

- *social/cultural compatibility* – including feasibility of distributing the equipment and materials, ease of system use by women, and feasibility of local system maintenance;

- *capital/operating costs* – including installation/startup costs, operating and maintenance costs, and costs related to disposal of spent units and/or chemical wastes.

An objective scoring system has been developed to accomplish the screening, which results in an overall relative ranking of the candidate technologies in each end use category, based on the above-mentioned features of each treatment system. Technologies with the highest ranking will be those that can provide the most effective treatment, with the fewest potential problems, the greatest convenience and the lowest annualized cost[6].

Based on the ranking of candidate technologies in each category, the top 10 to 20 technologies will be selected for a further, more detailed evaluation in Tier II.

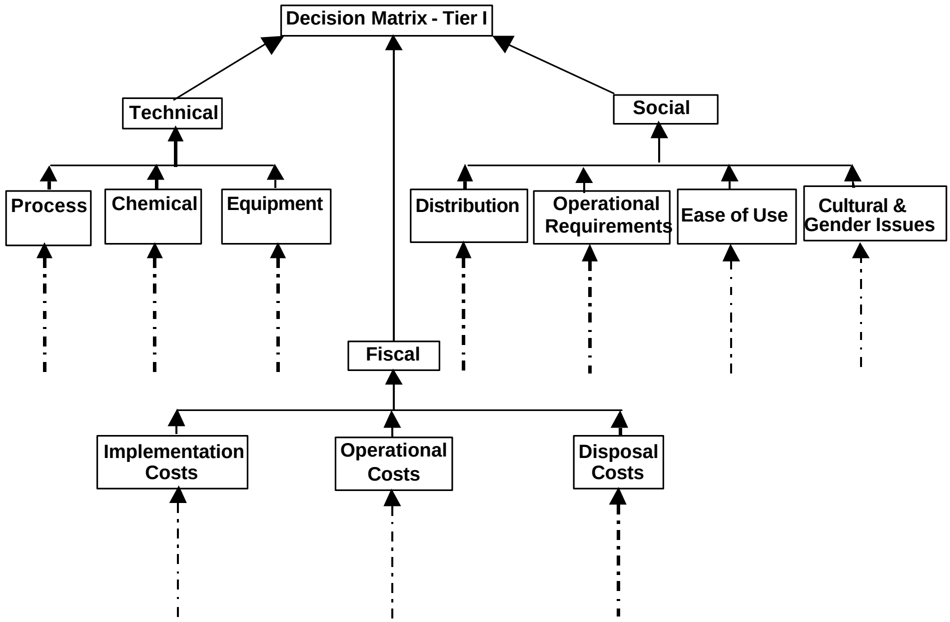

Figure 2. Fundamental Tier I Decision Matrix utilized to evaluate arsenic mitigation technologies for the screening stage of ETV-AM.

Tier II – Cost Benefit

The second tier of screening involves a quantitative cost-benefit evaluation of each candidate technology retained from Tier I. Each technology is evaluated according to its end use category. The Tier II evaluation considers the same types of information considered in Tier I, but with more precise quantitation of the costs and benefits associated with the technology.

For the purpose of this evaluation, the end use scenarios are precisely defined in terms of typical numbers of people and/or families served, treated water use rates, initial water quality conditions, site accessibility and social/cultural aspects. The technologies are evaluated in the context of these three reference scenarios. Cost to the consumer is estimated for each technology, to include annualized installation and startup costs, operating and maintenance costs, and costs for proper disposal of waste materials. The sum of these costs represents the overall system cost, expressed on a per capita basis.

The benefit to the consumer is estimated as a health risk reduction (e.g., from arsenic removal) minus any new health risk produced (e.g., from other elements added to the water, or from handling/disposal of process/waste chemicals). Risk quotients are used to quantify health risk, using standard risk assessment methodology, and considering both cancer and other health effects.

Factors contributing to the estimate of risk reduction include[7]:

- the likelihood of consumers bypassing the treatment system, based on ease of use and social/cultural considerations, and the quality of alternate water supplies;
- the likelihood of system failure due to factors such as possible process chemical instability, difficulties in maintaining the system in working order, or variability in effective lifespan of treatment media;
- the expected frequency of handling of toxic process and/or waste chemicals, their toxic properties and possible exposure routes;
- the expected concentrations and toxic properties of any process chemicals that might be elevated in treated water.

The cost-benefit ratio for each technology are calculated as the risk quotient reduction that it produces, divided by the overall annualized cost of the technology on a per capita basis. The top few technologies in each end use category are selected for subsequent laboratory and field verification.

Laboratory Performance Evaluation

The Laboratory Performance Evaluation (laboratory testing) allows all technologies to be evaluated under standardized conditions using synthetic water matrices developed from water quality data for shallow well aquifers (<150 m in depth, zone of arsenic contamination) in Bangladesh. This phase of the Program is designed to generated data in the laboratory that then undergoes third party review (Verification) to ascertain data quality and evaluate the conclusions.

The central concepts associated with the Laboratory Performance Evaluation are[8]:

1. The use of the synthetic water with characteristics similar to Bangladesh groundwater with regimes of low and high iron content;
2. Influent arsenic concentrations and speciation reflective of the distribution pattern observed in contaminated wells in Bangladesh;
3. The simulation of pumping and water usage in Bangladesh and its effect on the redox potential of Bangladesh groundwater;
4. The use of multiple (replicate) units of the same treatment system to evaluate consistency of performance between units;
5. Duration of testing to reflect water usage in households and extended households of Bangladesh;
6. Evaluation of the quality of the treated water primarily in terms of arsenic and other inorganic, organic and bacteriological water quality issues;
7. Definition of cycles of operation and evaluation of performance in-cycle and from cycle to cycle; and
8. Quantification and characterization of process waste.

Figure 3 illustrates the overall experimental methodology for performance evaluation of technologies.

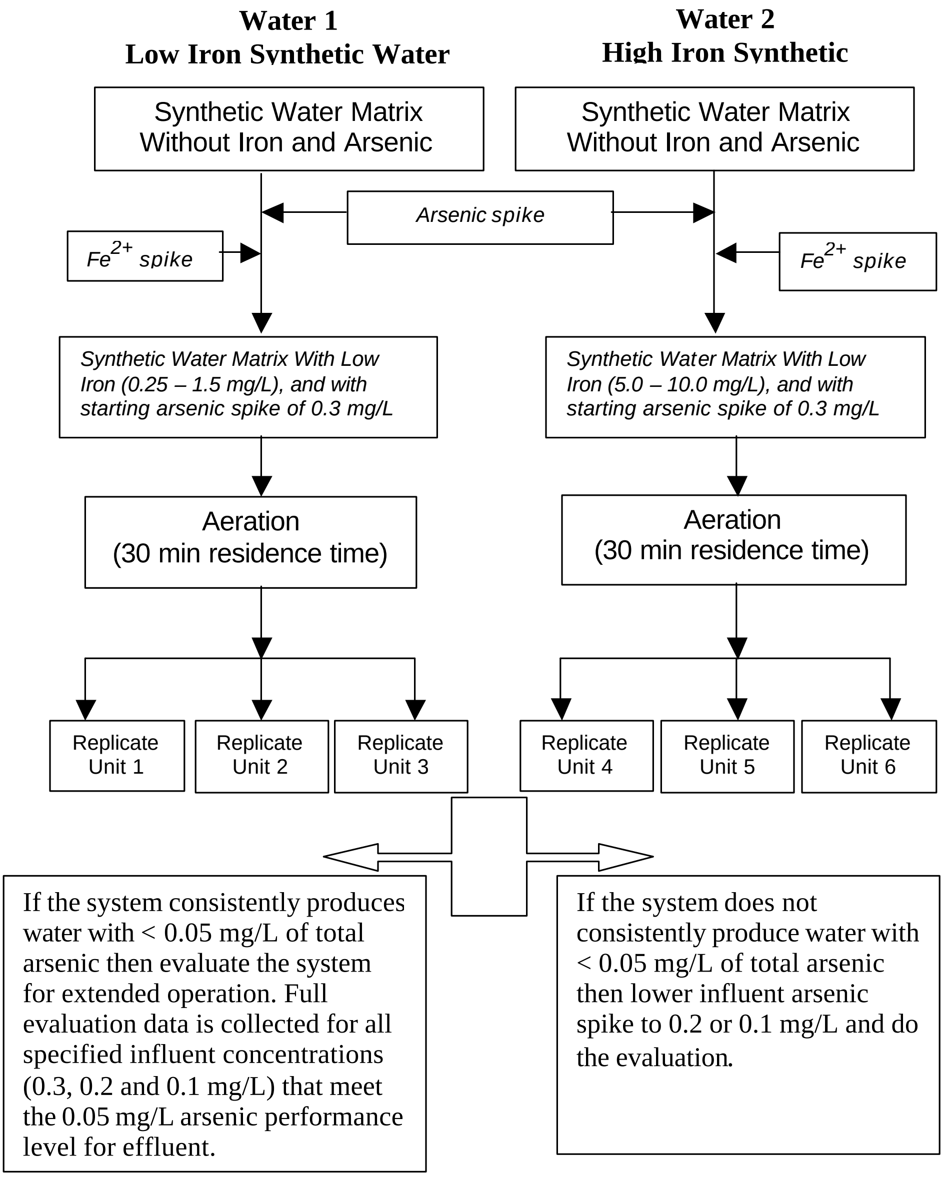

Figure 3. Overall outline of the experimental methodology

Note: If the system treats successfully at 0.3 mg/L influent arsenic concentration, higher concentrations of arsenic spiked water are then used to test limits of system performance in the same manner outlined in the overall experimental methodology.

Performance Review

The Verification Process will assist, as a minimum, in the determination of mandatory criteria (scientific soundness of technology, environmental benefits, etc) and any limitations to the arsenic mitigation technology and the validation of the data. The Statistical Analysis Worksheets (SAWs) are a tool to assist the Verification Entity (VE) in evaluating data supplied by the applicant or a testing agency. The SAWs are used to aid the VE in determining whether the data support the arsenic mitigation performance claim(s) made by the applicant.

The Verification Protocol (VP) is designed for use by a VE responsible for the validation of data and information that support the performance of any environmental technology. The verification process follows procedures and principles developed for the ETV process. All client technologies require third party independent data to support their performance claims and these are then verified by a different third party independent verification entity. It is designed for personnel who have expertise in the development or use of arsenic mitigation technologies. The Protocol may also prove useful to agencies and personnel who are involved in the development and evaluation of arsenic mitigation technologies.

The VP consists of five sections:

Section 1 - Review of Application, guides the VE through a review of the Formal Application Form and all other information and documents provided by the applicant. The VE should determine if adequate data or information is (or will be) provided. Section 1 ensures that the VE has a full understanding of the technology and claims to be verified.

Section 2 -Review of Technology, allows the VE to review the specific technology for which the performance claim(s) is being made. The objective at this stage is to ensure that the described technology meets the verification criteria.

Section 3 -Review of Data, involves the review of the verification study design, data validity and acceptability concerning the specific technology performance claim(s) being made. A series of Criteria Checklist tables allow the VE to determine the quality of the data provided with regards to statistical evaluation or mathematical analysis to support the performance claim(s).

Section 4 -Summarizes the results of statistical evaluation made on the performance claim(s).

Section 5 -Provides guidance on final report preparation.

Technologies that successfully complete the performance review will have a "Technology Fact Sheet", advising the GoB and development partners of the following:

- A description of the technology
- Performance claim(s)
- The fundamental principles behind the technology
- Operating parameters
- Anticipated cost of implementing the technology
- Possible restrictions associated with the technology

Field Testing

Field Testing is the final stage of evaluation to determine conclusively that the technologies perform according to their performance claims under varying conditions.

The goals of the field test program are listed below[9,10,11]:

- Evaluate the performance of a technology at pseudo steady state at a given well;
- Define performance under field conditions;
- Evaluation of technology-society interface of the technology;
- Not to summarily dismiss technologies with limited arsenic removal capacity;
- Provide guidance for choice of technology appropriate for use at a given well.

Figure 4 outlines the steps in the Field Testing Stage (FTS) for any candidate technology. Technologies successfully completing a performance review will have Technology Fact Sheets forwarded to development partners. Stage 3 commences with a workshop, involving GoB and development partners participating in the field verification of the technology(ies). Workshops focus upon addressing major components associated with the performance of the FVS: (1) technology overview, (2) required monitoring protocol, (3) performing socio-economic and environmental due diligence, and (4) training.

Technology Overview

Agencies undertaking field verification are provided with a detailed description of the candidate technology to be piloted, including the chemical and physical aspects of the technology, how these parameters are related to the criteria, and strengths and weaknesses of the technology identified during assessment.

The technology overview is designed to facilitate a better understanding of the candidate technology(ies) by agencies responsible for the field verification and ultimate implementation of the technology(ies). Technology overview is also used as a means for enhancing possible technologies and operational procedures through a feedback mechanism.

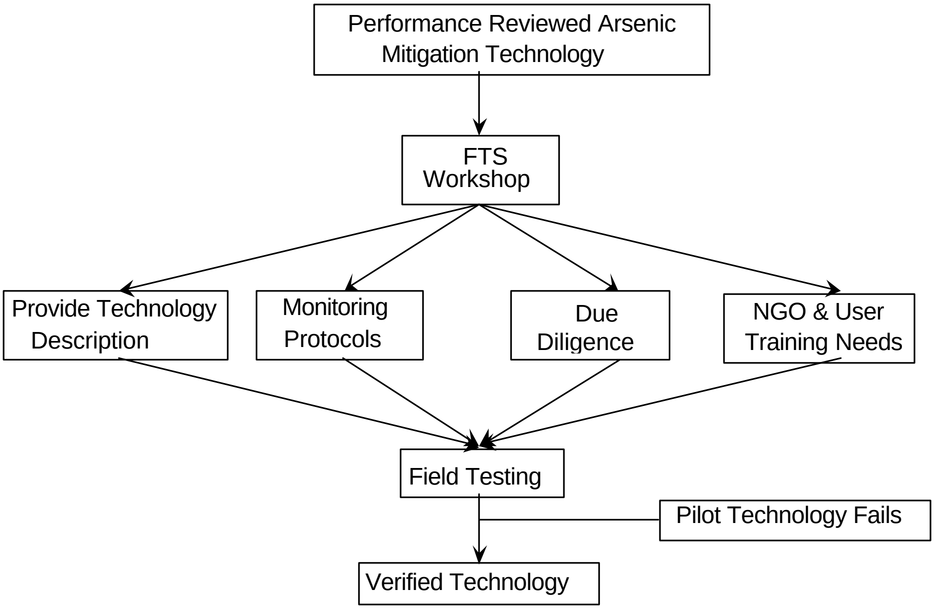

Figure 4 : Stage 3 - Field verification of certified arsenic mitigation technologies.

Technical Monitoring

The field-testing program generates performance data for verification and assesses the potential impact of the water quality parameters on technology performance[9]. The parameters chosen for inclusion in the analytical reporting reflect the expected water matrix in Bangladesh. The initial phase of the field evaluation program collects data required for verification of technology performance under field conditions. Technology performance can be impacted by interfering ions present in the water matrix (e.g. iron, phosphate, sulphates). Wellhead technologies lack the upstream pre-treatment train (e.g. sand filters, activated carbon) found in large-scale treatment plants. The experimental plan considers the impact of the interfering ions on the potential technology types that may be considered. The protocol recognizes performance curves generated under field conditions will differ from those derived in the laboratory using a synthetic matrix. Sufficient data is collected to generate new performance curves under field conditions.

Technologies are operated in accordance with the manufacturer's operating instructions. The manufacturer and/or laboratory tests provide cycle estimates. Refinements to cycle estimates occur during the field assessment as additional data is collected. The field assessment evaluates the technology's abilities to perform the following[9]:

(a) Reduce the effluent arsenic concentration to below 50 ppb, the Bangladesh standard for drinking water;
(b) Remove constituents near or at water quality guidelines. GoB Water Quality Objectives (WQO) will be used whenever possible. Constituent not noted in the WQO will be assessed using Canadian drinking water standards;
(c) Generate chemical by-products;
(d) Produce water at an acceptable rate over the entire cycle;
(e) Generate non-hazardous residuals.

Limited quantification and characterization of waste by-products is also undertaken during the field-testing stage.

Social Monitoring

"Soft" parameters must also be identified and assessed during field-testing of technologies. Input from individuals, families or communities regarding a given technology are important in determining long-term acceptance from a social perspective. The best technologies must not only meet the hard and fast quantitative parameters, but must also be ones that can be used by the target population.

The project has developed a 'social protocol', or standard set of indicators, to assess and measure objectively and quantitatively the social, cultural and gender dimensions for arsenic mitigation technologies in Bangladesh[10]. It is intended to establish a norm, which is used to measure the speed of technology diffusion, its acceptance in terms of ease of use, social and cultural values, water distribution and access in terms of power structure and other relevant issues.

An analytical framework provides a perspective and guideline for inclusion or exclusion of empirical issues and concepts in the final protocol. The framework deals with the cultural context, social structure, power structure, and gender relations at the community level. Perceptions and attitudes of end users of the technology, water users, technology providers, opinion leaders and other agents are captured in the framework. In short, the framework brings together in a logically consistent way the levels of analysis, range of issues and concepts relevant for the protocol.

The analytical framework guides the second order task of fleshing out a set of indicators for use in the protocol, with several questionnaires and checklists having been developed for field trials with a view to ensuring that indicators are empirically relevant.

Economic Monitoring

The costs anticipated for all technologies include capital cost items, installation/start-up costs, operating and maintenance costs, waste disposal costs, and costs associated with risk. The Fiscal Protocol evaluates all these factors in a systematic manner[11].

Capital cost items include the treatment unit hardware, any storage reservoirs to be purchased, and any pipes and plumbing to be purchased. These capital costs are amortized over the expected lifespan of the equipment.

Installation/start-up costs include costs for the delivery and professional installation of the equipment, and for training of local users and caretakers in operating and maintenance procedures. These costs are computed from professional hours times hourly rates, plus expenses. Equipment delivery/installation costs are amortized over the expected lifespan of the equipment. Training costs are amortized over a period representing the time between training sessions. Training sessions should be repeated at some defined frequency to ensure ongoing proper use and maintenance of the system.

Operating and maintenance costs include costs for caretaker salaries and service visits (based on hourly rates and hours per annum), and for replacement parts and media (including pick-up or delivery costs). These costs are expected to recur each year and are not amortized.

Waste disposal costs include costs for waste pick-up by, or delivery to, a disposal facility, any pre-disposal treatment costs, and any disposal fees. These costs are expressed per unit volume of waste generated and are computed separately for different waste streams if the different streams have different associated costs. While waste disposal facilities do not exist at present, such facilities will be part of the required infrastructure, and typical costs for use of such facilities are assumed.

It is possible that some costs are dependent on geographical location (e.g., accessibility) or on raw water quality (e.g., media use and waste generation dependent on iron in water). If such variations are expected to have a strong influence on overall cost, separate scenarios are considered to capture this variation in the cost analysis.

For up-front capital costs and installation/start-up costs, the amortization includes compound interest charges, on the assumption that a payment plan will spread these payments over the lifetime of the equipment. Training sessions are also assumed to have a lifetime, i.e., they are repeated/updated periodically, at least with each system installation. Depending on system complexity, more frequent sessions may be needed.

Based on a purchase price (PV), amortization over a number of years (Y) and annual interest rate (X), the annualized cost (R) can be expressed as follows[12]:

$$R = PV/(1 + X)^Y$$

The units of R are Tk per annum.

The probability of a potential impact and associated cost are integrated into the overall formula. Risk associated with any variable, such as; the transport of the technology or required chemicals, use of chemicals, operational accidents, negligence, and disposal of byproducts, are calculated and added to the unit cost.

Training Development Partners

The desire of people to have the necessary tools to develop their own knowledge base and determine their own destinies is critical in all development activities. Working with development partners, ETV-AM provides a mechanism through which important information regarding arsenic mitigation technologies can be disseminated by agencies currently on the ground in Bangladesh, thus providing people with the information people required for informed decision-making.

Environmental Technology Verification

Technologies completing field-testing are exposed to a final verification process that closely matches the initial Performance Review process. The additional component of the review is a detailed comparison of technology performance between the laboratory and the field. In addition to providing information regarding performance differences between the two testing environments, it provides a mechanism for review and possible modification of the laboratory performance testing.

Technologies that successful complete the final verification processes are then recognized as verified technologies within Bangladesh. A verification report is prepared that includes a final "Technology Fact Sheet" containing the concluding information regarding the following factors:

- A description of the technology
- Performance claim(s)
- The fundamental principles behind the technology
- Operating parameters
- Anticipated cost of implementing the technology
- Possible restrictions associated with the technology

CONCLUSIONS

Technologies for providing safe drinking water are known and being applied throughout the world. Groundwater can be treated using physical, chemical and/or biological methods. Furthermore, many regions of the world have adopted cost-effective "traditional" technologies, allowing for the delivery of clean, safe drinking water. The challenge lies in identifying the most suitable technologies for treating arsenic contaminated groundwater in Bangladesh. Technical and economic viability, indigenous capacity, in association with cultural sensitivity is of the essence for successful implementation of any technology. ETV-AM has been implemented to apply a systematic evaluation of arsenic technologies based upon technical, social and fiscal parameters relevant to Bangladesh. The importance is not just in finding a solution for Bangladesh, but finding a solution that is both viable and sustainable in the context of the nation.

ACKNOWLEDGEMENTS

The authors would like to thank the members of the ETV-AM Team from OCETA, ETV Canada, Beak International Inc, and various subcontractors for their contributions towards the various components of the Program, upon which this document is based. The authors would also like to acknowledge the Government of Canada, through the Canadian International Development Agency for the ETV-AM grant.

REFERENCES

1. DPHE/BGS, 2000. Groundwater Studies for Arsenic Contamination in Bangladesh. Draft Final Report. British Geological Survey (BGS) Technical Report WC/00/19, Volume 3.
2. Chen, C.J., Wang, C.J. 1990. Ecological Correlation Between Arsenic Level in Well Water and Age-adjusted Mortality from Malignant Neoplasms. *Cancer Research.* 50(17): 5470-5474.
3. Brown, K.G., Chen, C-J. 1994. Observed Dose Response for Internal Cancer and Arsenic in Drinking Water in the Blackfoot Disease Epidemic Region of Taiwan. *Ed. Sci. Technol. Lett.* 153-169.
4. US EPA, 1998. Research Plan for Arsenic in Drinking Water. Office of Research and Development National Center for Environmental Assessment U.S. Environmental Protection Agency. Cincinnati, OH 45268.

5. Stewart, D.K. and Boerschke, R.K. 2001. Potential impact of arsenic on social and economic parameters in Bangladesh. Submitted.
6. OCETA. 2001. ETV-AM Tier I Screening Protocol: Decision Matrix. Toronto, On. (Pending).
7. OCETA. 2001. ETV-AM Tier II Screening Protocol: Cost Benefit Analysis. Toronto, On. (Pending).
8. OCETA. 2001. ETV-AM Laboratory Performance Evaluation Protocol. Toronto, On. (Pending).
9. OCETA. 2001. ETV-AM Field Testing Protocol. Toronto, On. (Pending).
10. OCETA. 2001. ETV-AM Social Evaluation Protocol. Toronto, On. (Pending).
11. OCETA. 2001. ETV-AM Fiscal Due Diligence and Risk Assessment Protocol. Toronto, On. (Pending).
12. Shim, J.K., J.G. Siegel and A.J. Simon. 1986. The Vest-Pocket MBA. Prentice Hall Inc., NJ.