

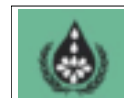
Arsenic 2002

An overview of Arsenic Issues and Mitigation Initiatives in Bangladesh

January - 2003

NAISU

NGOs Arsenic Information & Support Unit (NAISU)
NGO Forum for Drinking Water Supply & Sanitation



Supported by:

Foreword

The NGOs Arsenic Information & Support Unit (NAISU), a joint initiative of the NGO Forum for Drinking Water Supply & Sanitation and WaterAid Bangladesh, has updated the original WaterAid Bangladesh Arsenic 2000 report during the past year, resulting in this second report in the series "Arsenic 2002".

This report provides: an overview of the extent of arsenic problems and current issues in Bangladesh; activities being undertaken by different organisations to research and mitigate arsenic contamination of water supplies; alternate safe water options; arsenic removal technologies and other relevant technical issues. NAISU has published this updated reference which we believe will prove to be of vital utility to those who are interested in deepening their understanding of arsenic issues and mitigation options, organisations cooperating with others to support affected communities and those who share the belief that well coordinated national efforts will deliver effective mitigation to affected communities. We would like to express our thankfulness to those individuals and organisations that have rendered all out cooperation in preparing this document.

It has been nearly a decade since the arsenic problem in Bangladesh was identified. Various government and non-government organisations have developed diverse strategies to mitigate the problem. It is high time to ask ourselves whether we have assessed our progress and future plans properly. The number of reported arsenicosis patients is 13,333 at present (August 2002, DGHS source), these may be just the 'tip of the iceberg', the exact number is believed by many to be much higher. Everyday the symptoms of arsenicosis disease are becoming more visible amongst community people. The death toll from arsenicosis is gradually rising with time and thousands of arsenicosis patients are passing days in dismal hopelessness. Millions of people are craving alternative safe water supply options, as their long-used hand pumps are discharging arsenic contaminated water. In this national crisis, the responsibility falls automatically to the Government of Bangladesh to play the lead role in arsenic mitigation and national coordination. National efforts via the government's programme approach and the efforts of particular agencies programmes have taken a positive turn in the last year or so. However it is deeply disturbing that the sum of all government, non-government and private sector efforts to date has not been effective in delivering safe affordable water supply alternatives on a national scale to address the pressing needs of arsenic affected communities.

We need to pinpoint now what proportion of arsenic victims have so far received proper treatment and ensure treatment is provided to the remainder, we need to ensure no victims remain un-identified. We need to complete the national tubewell screening programme as soon as possible and accurately distil the information for planning the next phase of the national mitigation effort. We must thoroughly research and assess the potential risks and benefits of sourcing groundwater from deep aquifers. We need to accelerate the government's technical verification of household and community level arsenic removal technologies so that the effective options can be confidently recommended to affected communities. We need to further invest in alternative water supply options research and development. We need to be clear and unequivocal about the utility of arsenic field testing, ensuring that communities and the organisations supporting them develop effective long term water quality monitoring support systems.

We are still a long way away from a comprehensive national response to the crisis, but the enormity of the task should not daunt us. In order to bring a positive change in the present status of the national response, efforts from the government, non-government and private sectors should be accelerated under pro-active government coordination. Regular sharing of information and experience amongst all stakeholders must be ensured, to avoid duplication of mitigation efforts and eliminate the dissemination of inaccurate or confusing information amongst arsenic affected communities. We ought to work in a collaborative, coordinated and comprehensive manner to minimise the current and future death burden on the Bangladesh society. All those with resources, large or small, to support the national arsenic mitigation effort, should re-double their resolve to mitigate this ongoing crisis. The origin of this challenge is not by human design but the solution undoubtedly lies with us.

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Our Voice

NGOs Arsenic Information & Support Unit (NAISU) has prepared this document with an aim to provide an overview on the arsenic situation and mitigation activities by both the governmental and non-governmental organisations in Bangladesh. This documentation is the second successive update of the previous report 'Arsenic 2000' prepared by WaterAid Bangladesh. In this issue we have focused on the following issues on the basis of current knowledge and experience:

- the background to the arsenic contamination;
- the potential scale of the problem;
- the major work of key organizations working on arsenic mitigation;
- the methods of arsenic detection at both field and laboratory.
- the arsenic free alternative water option currently recommended for arsenic mitigation.

An additional primary objective of this document is to promote coordination and information sharing between organizations and to portray a picture of the current arsenic mitigation activities and enhance communication with “newcomers”, providing a directory of activities and agencies already active in this field. In this issue we have documented the type of mitigation activities with the intervening areas with an aim to forestalling any duplication of work which we believe will help to take appropriate arsenic mitigation strategy for the management of arsenic crisis in Bangladesh.

The NGOs Arsenic Information and Support Unit (NAISU), has been established to provide arsenic information support to small to medium sized organizations, to synthesise and disseminate appropriate arsenic mitigation related information, in plain language, for affected communities and for field workers at the grass roots supporting affected communities and households. To serve these objectives NAISU currently: publishes a quarterly newsletter 'Arsenic Bulletin' in easily understandable and accessible Bangla; provides training to small to medium sized organisations working with affected communities on arsenic issues and mitigation; develops and distributes communication materials for organisations and communities actively seeking deeper understanding on arsenic issues and mitigation options.

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We like to extend special thanks to the reviewers for their suggestions and comments.

We also here admit our failure in the case of any organisations which we could not reach and thus their initiatives could not be incorporated in this current report.

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NGOs Arsenic Information & Support Unit (NAISU)
A collaborative project of WaterAid Bangladesh and NGO Forum for DWSS.

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Introduction:

Bangladesh is located in the midst of one of the world's largest river systems. Although this vast amount of water provides a living for almost 1/3 of the country's population, the water quality is poor and the abundance of this water does little to meet the drinking needs of the people. Drinking water in Bangladesh is not largely a river based water purification system but instead, the most crucial source of drinking water remains groundwater. However, the discovery of "*Arsenic*" in groundwater in several areas of Bangladesh has aroused widespread concern from the last couple of years. The arsenic crisis in Bangladesh has been called the worst environmental catastrophe of the twentieth century. Arsenic, a metalloid element known for its toxicity and carcinogenicity, is soluble in water and occurs naturally in many minerals. Arsenic contamination of groundwater in Bangladesh is widely accepted to be of geological origin, though the exact mechanisms remain poorly understood. Arsenic occurs in different forms, organic and inorganic, with different toxicity. Humans get affected by arsenic mainly through ingestion and probably the nutritional status is important in relation to the development of arsenicosis. The World Health Organization (WHO) has set a provisional guideline value of 0.01 mg/l (10 ppb) for total arsenic in drinking water. The Government of Bangladesh has set a provisional water quality standard of 0.05 mg/l (50 ppb) arsenic for drinking water.

The groundwater of Bangladesh provides drinking water to about 97% of the rural population. This extensive coverage is indicative of the country's successful attempt to provide safe drinking water to its general population as surface water sources were often polluted and diarrhoeal disease was widespread. This respectable public health effort was overshadowed when in 1993 an alarming discovery confirmed of arsenic contamination in groundwater. The discovery of arsenic contamination was first identified in the northwestern part of the country. But it was soon evident that the contamination was more widespread and not confined to any one local area, but it is assumed based on different studies so far conducted that the population at risk may vary from 25 million to over 36 million (using the Bangladesh standard of 50ppb). As more chemical tests and research work were being performed and subsequently concluded, the extent of the problem became evident. Estimates vary on how many people are affected. Tens of thousands of people have already been showing skin discoloration and other more serious manifestations of arsenic toxicity. Children below the age of ten are also now showing signs of chronic arsenic poisoning.

Not only clinical symptoms but also a number of social and societal problems are aggravating the situation. Dissolution of marriage, avoidance of arsenicosis patients, arsenic panic in the affected areas etc. have been reported in many areas.

Many national and international organizations have come forward to work on arsenic for the mitigation of arsenic crisis in Bangladesh from the beginning of the problem. Many organizations are doing lot of researches on clinical, social and safe water technology aspect. Different information, education and communication (IEC) materials including participatory learning materials have been and are being developed by different agencies which are very much important for the mitigation strategy of arsenic catastrophe in Bangladesh.

The objective of this document and its subsequent updating is to compile the mitigation and research activities of different organizations and to make them readily accessible to all of them for information sharing and forestalling any duplication of work which will minimize our efforts and increase our efficiency to combat the deadly crisis of arsenic in Bangladesh.

A.0. Background to the Arsenic contamination and Potential scale of the problem

The arsenic in ground water is of natural origin, and the distribution of arsenic contaminated groundwater is related to the geology, with most of the arsenic contaminated tubewells drawing water from the Middle and Upper Holocene sediments.

The arsenic is believed to be released from soil under conditions conducive to dissolution of arsenic from solid phase on soil grains to liquid phase in water. Among the few hypothesis initially proposed to explain the possible mechanism of arsenic release most scientists have settled to two hypothesis: i) Oxidation theory - oxidation of arsenic mineral 'Arsenopyrite' or arsenic rich 'Pyrite' resulting in release of arsenic in ground water and ii) 'Reduction theory' - reduction of arsenic rich iron-oxi-hydroxides leaching the arsenic which remain at adsorbed state on its surface.

Mechanism of Arsenic release in underground water

In some of the arsenic affected countries including Bangladesh and West Bengal, India, two most probable (natural) sources responsible for arsenic contamination of under ground water are: i) Arsenopyrite (FeAsS) and Arsenic-rich pyrite and ii) Arsenic-rich iron oxi-hydroxides.

(i) Arsenopyrite and Arsenic-rich Pyrite (Oxidation Process):

Oxidation of arsenic bearing sulfide minerals [such as arsenopyrite (FeAsS) and pyrite (FeS₂)] in aquifer can release arsenic into underground water. The rate of oxidation of sulfide minerals is limited by the presence of an oxidizing agent, most commonly atmospheric oxygen (as O₂). Relatively deeper ground water is isolated from the atmosphere and the availability of oxygen in deep aquifers is limited by the amount of oxygen present in recharge water. Human activity that can significantly influence sulfide mineral oxidation and arsenic release into the aquifer is increased pumping of under ground water. Increased pumping and reducing recharge can greatly accelerate oxidation rates of arsenic-bearing minerals by lowering water table and exposing minerals to atmospheric oxygen. The whole process is also known as "Oxidation Process".

In the absence of oxygen, nitrate (No₃) can also act as an oxidizing agent and can promote oxidation of arsenic-bearing sulfide minerals. High nitrate concentrations from agricultural activities can therefore enhance arsenic release into under ground water.

(ii) Arsenic rich Iron Oxi-hydroxides (Reduction Process):

Arsenic derived from weathering of arsenic-rich base metal sulfides is often found to be associated with iron oxyhydroxides in downstream sediments. Arsenic (both arsenite and particularly arsenate) has high affinity for iron oxyhydroxides and becomes associated with them as a result of adsorption. Sediments in the Ganges delta region are known to have iron oxyhydroxides grains on the mineral coatings on the mineral grains and at many places these coatings have been found to be rich in arsenic.

Arsenic can be released from these arsenic rich iron oxi-hydroxides as a result of dissolution and desorption. A reducing redox environment (oxygen-deficient conditions) in the subsurface can promote dissolution of iron oxi-hydroxides and release of associated arsenic into under ground water. The normal burial of the alluvial sediments during the development of the delta leads to strongly reducing conditions due to the microbial consumption of oxygen during the process of organic matter oxidation. Introduction of organic waste into an aquifer can also promote a reducing environment. In addition, lowering of pH can also promote dissolution of iron oxi-hydroxides and subsequent release of associated arsenic. This process in general is known as the "Reduction Process".

The above two hypotheses may be operative in different parts of a country at a time. However the BGS report "Arsenic contamination of groundwater in Bangladesh" (Ref X, 2001) strongly supports the second hypothesis – the reduction process associated with iron oxides, although it does state that it is still a hypothesis and requires further study. The BGS study found that high arsenic concentrations were associated with strongly reducing conditions rather than oxidizing conditions. The oxidation hypothesis is not getting support in the absence of widespread arsenopyrite in arsenic-prone areas of Bangladesh, and arsenic concentrations showed a broad negative correlation with sulphate concentrations. The intensity of arsenic problem has not been found to have any relationship with ground water fluctuations. Similarly the hot spots in Bangladesh are not located in areas of high withdrawal of ground water for irrigation.

Natural processes of groundwater flushing would eventually wash the arsenic away, but this will take thousands or tens of thousands of years. The flushing is particularly slow in the Bengal basin due to the low hydraulic gradients in such a large flat deltas.

Arsenic Catastrophe in Bangladesh: The Scale of the problem

Bangladesh is very much dependent on ground water both for drinking and irrigation purposes. Until the discovery of Arsenic, groundwater was considered safe for drinking. Tubewells have, in the majority, replaced the traditional surface water sources and diarrhoeal disease has reduced significantly. An estimated 97% of drinking water of the rural population in Bangladesh is now supplied by groundwater. About 80% of the population is covered by manually operated shallow tube wells and 6% by manually operated deep tubewells (Table 2.1 in Ref 1), It has been estimated that about 8.0 million hand pump tube-wells have been installed under private initiatives and government has sunk about 1.2 million tube-wells. In 1993 DPHE first identified high concentration of arsenic in shallow tube-well in Chapai Nawabganj adjacent to an area of West Bengal which had been found to be extensively contaminated in 1988. Extensive contamination was confirmed in 1995 when additional surveys showed contamination of shallow tube-wells across much of southern and central Bangladesh. WHO declared arsenic contamination as a ' Major Public Health Issue' in 1996 and informed Bangladesh Government to deal with emergency basis.

Department of Public Health Engineering (DPHE) , British Geological Survey (BGS) and Mott MacDonald Ltd. survey (approximately 3500 samples) throughout Bangladesh, but excluding the Chittagong Hill Tracts, revealed that 27% of the shallow tube-wells are contaminated with arsenic above the level of 0.05 mg/l (50 ppb) and 46% of the shallow tube-wells tested are contaminated with arsenic above the WHO guideline 0.01 mg/l (10 ppb). Eight of the 61 sampled districts had no samples exceeding the Bangladesh standard for arsenic (0.05 mg/l) and all districts except Thakurgaon had at least one well exceeding WHO guideline value.

According to the study finding the worst affected districts (percent of sampled wells with greater than 0.05 mg/l arsenic) were Chandpur (90%), Munshiganj (83%), Gopalganj (79%), Madaripur (69%), Noakhali (69%), Satkhira (67%), Comilla (65%), Faridpur (65%), Shariatpur (65%), Meherpur (60%), Bagerhat (60%) and Lakshmipur (56%). The least affected districts were Thakurgaon, Barguna, Jaipurhat, Lamonirhat, Natore, Nilphamari, Panchagar, Patuakhali (and 0%), Rangpur (1%), Dinajpur (2%), Noagoan (2%).

Most of the arsenic has been found in the shallow aquifer, with only 1% of the deep tubewells (greater than 150m) tested in the BGS study (Ref X) having arsenic greater than 50 ppb and 5% greater than 10ppb. However there are some concerns regarding future arsenic contamination of the deep aquifer, particularly where the shallow and deep water is not separated by an aquitard.

DPHE /BGS/ MML in phase 1 studies estimated that the population exposed to arsenic contamination more than 0.05 mg/l (>50 ppb) would lie in the range 18.5-22.7 million. However the BGS-DPHE studies finally gave an estimation of the number of population exposed to arsenic concentration above 0.05 mg/l (50 ppb) and 0.01 mg/l (10 ppb) to be 35 million and 57 million respectively. (Based on upazilla-averaged statistics the exposure levels to arsenic exceeding 0.05 mg/l (50 ppb) and 0.01 mg/l (10 ppb) were computed as 28 million and 46 million respectively, but the BGS report states that they consider the larger figures to be more reliable).

School of Environmental Studies (SOES), Jadavpur University, Calcutta and Dhaka Community Hospital Trust tested water from 64 districts of Bangladesh. Their finding up to February 2000 shows that in 47 districts arsenic in ground water is above 0.05 mg/l and in 54 districts above 0.01 mg/l.

Chronic exposure to high doses of arsenic cause dermatologic, neurologic, vascular and carcinogenic effects. The most common symptoms of arsenicosis is dermatological which include dark/white pigmentation (melanosis) and gradual hardening of palms and soles along with appearance of hard nodular lesions over these areas (keratosos). Exposure to arsenic from drinking water increases the risk of skin, lung and bladder cancer and possibly that of other sites also. In a report WHO has predicted that in most of the southern part of Bangladesh almost 1 in every 10 adult deaths will be a result of cancer triggered by Arsenic poisoning in the next decade (*Contamination of drinking-water by arsenic in Bangladesh: a public health emergency - Alan H. Smith, Elena O. Lingas & Mahfuzar Rahman*). From the experience of Taiwan it has been forecasted that almost two million of people are at risk of developing cancer in the next decades.

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An estimate of Department of Public Health Engineering (DPHE) and DGHS reveals:

Total Arsenic Contaminated Districts:	61
Total Upazillas contaminated with Arsenic:	268
Total number of Patients:	13333 (August, 2002- DGHS)

Everyday new patients are coming in notice and the number of arsenicosis patients so far identified in Bangladesh is just the tip of an iceberg and the actual number is much higher than the present statistics. The current screening efforts (of wells and people) present a "freeze-frame" picture of the situation at one point in time. The true and dynamic picture will only start to appear once private testing becomes accessible to people and once the health service kicks in on the patient screening side (if arsenicosis was declared as a reportable disease, there would be chance that the patient numbers would more accurately reflect reality). The current arsenic situation of Bangladesh has been considered as the greatest environmental disaster of the world. So effective and appropriate mitigation program is urgently warranted for tackling this catastrophe in Bangladesh.

A.1. Summary of activities and developments since the Arsenic 2000 report

Although in 1993 the presence of Arsenic in a Bangladesh tubewell was first detected, the magnitude and extent of the problem was not known clearly before 1997. Various agencies conducted tests of tubewell water sample from different districts randomly and comprehensive testing could not be done due to lack of testing facilities in Bangladesh. After 1997 there was lots of initiative taken by the Government (through DPHE), various national and international NGO's, and research institutions. In particular, in recent years many small scale Arsenic removal technologies have been developed, field tested and used under action research programs in Bangladesh. Since the Arsenic 2000 report there have also been some improvements in field test kits such as the Hach EZ and Merck Sensitive.

DPHE with the donor agencies conducted various survey, study and mitigation activities in the country and some of these are still continuing. Under the assistance of DFID, DPHE and British Geological Survey conducted systematic and comprehensive groundwater studies (1997 to March 2000) in 61 districts (except in the Chittagong Hill Tracts), which helped identify the extent of arsenic contaminated groundwater within Bangladesh. The DPHE / UNICEF arsenic mitigation initiative to date consisted of several National-scale activities and a focused action research project. Under the 'Action Research into Community Based Arsenic Mitigation' project DPHE- UNICEF worked in five upazillas (with BRAC, Grameen Bank, DCHT and ISDCM/Rotary) and developed the second phase (2001 to 2003) of the project in 15 upazillas. Since the beginning of 2002 with funding received from UNF, WHO and UNICEF, are collaborating with DPHE and DGHS in an action-research community-based arsenic mitigation project in three upazillas under the 15 upazilla project.

In the second half of 2002 the program will be further expanded, when communication and well-screening activities will commence in further 25 upazillas. DPHE – DANIDA Arsenic Mitigation Pilot Project has been taken up in the south- eastern part of Bangladesh for three years and a half (up to June 2004). WHO, being an active partner of GoB, organised a National Co-ordination Conference (1999) and the International Workshop on Arsenic Mitigation (January 2002). From this International Workshop some short term and long-term outline recommendations, on alternative water supply options, hydrogeology and health were made.

The Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) was designed about four years ago (in August 1998)- when, the nature, magnitude and impacts of the Arsenic contamination problem were not adequately understood by all concerned. The US\$ 44.4 million project is co- funded by GoB, World Bank and SDC. The Arsenic contamination problem and its mitigation strategy being a multidimensional problem, the BAMWSP included multi- sectoral components for implementation. A large amount of screening of tubewells has been carried out under BAMWSP, but coming towards its proposed final date it can be seen that a huge amount of mitigation and institutional aspects of the problem are still to be addressed and BAMWSP alone is not sufficient for handling such multi- sectoral issues.

DFID funded "Rapid Assessment of Household Level Arsenic Removal Technologies" was jointly managed by WaterAid Bangladesh and DFID and implemented by WS Atkins International Ltd. This study (commenced in August 2000 and ended in March 2001) was focused on comparative assessment of the performance and acceptability of nine household level technologies and finally came up with seven. The study also included a comparative evaluation of field test kit also. The report was submitted to the BAMWSP Technical Advisory Group (TAG) and TAG reviewed the study and recommended four technologies.

In late 2001 ICDDR,B has started a research project in the Matlab area to study the effects of exposure to arsenic. This project is executed in collaboration with BRAC and supported by WHO, SIDA and USAID. In mid 2002 an annotated overview of all health research on arsenic undertaken in the last few years was published by the Bangladesh Medical Research Council (BMRC).

Many organizations, NGO- Forum, BRAC, DCHT, CARE and others are very much involved in arsenic mitigation: awareness raising, patient identification & management and small-scale research. BUET, DU and IDE are also involved in some research on mitigation options. In January 2002, the DFID funded (US\$ 49.3 million) Rural Hygiene, Sanitation and Water Supply Project has been started by DPHE with assistance from UNICEF.

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Initial studies have been undertaken to address the concern regarding the contribution to arsenic in the food chain by water contaminated with arsenic and used for irrigation or cooking. Studies undertaken by FAO, CSIRO/Australia & Dhaka University and AIHPPH/Kolkata with WHO, point to substantial contributions to the total arsenic content in green leafy vegetables, when grown with contaminated irrigation water. However a study by Australian National University (ANU) in collaboration with NGO Forum "An Intervention Trial to Assess the Contribution of Food Chain to Total Arsenic Exposure" in May 2000, which chose exposure based on arsenic content in irrigation water, failed to demonstrate a difference in arsenic content in the small number of raw food samples tested from the high and low contamination areas. Further studies investigating the arsenic content in different types of food from areas with high and low contamination of irrigation water, are recommended.

It is evident that since 2000 many Government, Non Government and Bilateral organisations are working on this issue and much action research has been carried out, however the situation of many communities has not improved greatly. The broad spectrum of institutional arrangement should be such that it ensures sustainable development. The services that are required, be it technological or financial, need to be delivered optimally. The situation now demands to review and reform the institutional arrangement to address sector issues appropriately.

To develop a more coordinated response to the arsenic crisis, GoB has taken new initiative to establish Arsenic Policy Support Unit (APSU) in the Local Government Division (LGD) to prepare and implement a National Arsenic Mitigation Programme (NAMP) through a partnership approach. It is an indication that GoB and donors wish to address the arsenic crisis in a more holistic way than has been possible under the BAMWSP. DFID is currently designing a Support to the National Arsenic Mitigation Programme (SNAMP) and would assist APSU in implementing the recommendations for action that resulted from the International Workshop held in January 2002.

**Who
Is
Doing
What**

**Current
And Proposed
Activities on
Arsenic**

Bangladesh Government Initiatives

Department of Public Health Engineering (DPHE) and Local Government Division (LGD)
 Bangladesh Arsenic Mitigation Water Supply Project-BAMWSP
 National Arsenic Mitigation Program-NAMP
 Water Development Board
 DPHE-DANIDA
 DPHE-UNICEF
 DGHS-UNICEF

DPHE and LGD are both key departments under the Ministry of Local Government Rural Development and Co-operatives (LGRD&C). DPHE has a number of different arsenic activities at various levels of implementation and is working with a wide variety of development organisations. A summary of the Government involvement in arsenic activities follows in Section 1. Further details of the programmes are contained under the partner and/or supporting organisations.

It is proposed under the planned National Arsenic Mitigation Programme (NAMP) that the Local Government LGD should be the focal ministry for arsenic mitigation and should co-ordinate cross-sectoral interaction through the Secretaries Committee.

1.1 Bangladesh Arsenic Mitigation Water Supply Project BAMWSP

The US\$44.4million Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) is implemented by Department of Public Health Engineering of the Local Government Division (LGD) under Ministry of Local Government, Rural Development and Cooperatives. BAMWSP is co-funded by GoB, World Bank and SDC. In August 1998 World Bank approved a credit of US\$32.4million to GoB to implement the four-year project. The project had a slow start and the project completion date is likely to be extended.

The objective of BAMWSP is to reduce mortality and morbidity caused by arsenic contamination of groundwater. The principal components of the project are:

- Improved understanding of the arsenic problem through national survey;
- Strengthening implementation capacity of the Local Govt. entities and Community Based Organizations; and
- Onsite Mitigation through sub-project development and implementation jointly by LGE and Community Based Organizations.

Major Activities:

- a) Screening, Community Development and Mitigation Program in 188 Upazilas.
- b) Screening and Mitigation in 100 Pourashava
- c) Training of 2000 Doctors and 11000 Health Workers
- d) Strengthening of existing DPHE Zonal Laboratories and establishment of 3 New Zonal Labs
- e) Partnership Approach
 - Technology Validation
 - Hydro geological Investigations
 - Health Relief
 - Media and Communication

Implementation Status (as of May 2002)

- a) Screening, Community Development and Mitigation Program in 188 Upazilas.

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- i) 41 Upazila (Phase I & II) - Screening Complete
 - ii) 6 Upazila (Phase I) - Community Development and Mitigation (ongoing)
 - iii) 35 Upazila (Phase II) – Emergency Mitigation and Community Development (ongoing)
 - iv) 147 Upazila (Phase III) - Screening (to be initiated in October, 2002)
- b) Screening and Mitigation in 100 Pourashava
- j) Production well screening (complete)
 - ii) Hand tube well screening (to be initiated in October, 2002)

c) Training of Health Personnel:

2000 Doctors and 11000 Health workers have been trained. The project is also providing emergency health intervention, including patient identification, and health referrals.

d) Strengthening of DPHE Zonal Laboratories and Setup of New labs:

Activity	Completion
Strengthening of 3 Existing DHPE Labs	By September 2002
Setup of 3 new labs at Barisal, Rangpur and Sylhet	By June 2003

e) Partnership Approach:

Partners	Approach
BCSIR	For technology validation. Agreement has been signed and validation of arsenic removal technology is underway.
Ministry of Health & DGHS	For training of medical personnel and health relief to Arsenic affected Patients.
Ministry of Information	For intensive dissemination of Arsenic related messages
GSB	For hydro geological investigation and Groundwater Mapping.

BAMWSP aims to co-ordinate arsenic interventions through its National Arsenic Mitigation Information Centre (NAMIC), to collect, collate and disseminate arsenic information from and to interested or active organisations. NAMIC has established a standardized format for nationwide screening and is receiving survey data collected under BAMWSP and by other stakeholders involved in screening, including UNICEF and a number of NGOs. A NAMIC website has been launched, and is available at:
<http://www.bamwsp.org/Namic/Namic.htm>

The BAMWSP Technical Advisory Group (TAG) have reviewed information on alternative water supply and removal of arsenic. They have recommended 4 non-chemical based technological options for short-term mitigation programs: Pond Sand Filter, Rainwater Harvesting, Dug Well; and Deep Tubewell (in the coastal belt). TAG have also recommended four technologies for arsenic removal based on their review of the Rapid Assessment report submitted to them by DFID. These technologies, recommended for use on an emergency pilot basis are:

- Alcan Enhanced Activated Alumina Filters
- BUET Activated Alumina Filters
- Steven's Institute of Technology Filters
- Sono 3-Pitcher Filters

Subsequently the BAMWSP Project Steering Committee (PSC) has endorsed the recommendation.

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1.2 “National Arsenic Mitigation Program (NAMP)” – A new initiative of the Govt. of Bangladesh for the mitigation of Arsenic Crisis in Bangladesh.

The arsenic problem is widespread and mitigation requires long-term processes and the involvement of many different ministries of the Government of Bangladesh (GoB). The National Arsenic Mitigation Programme (NAMP) is a new initiative of the GoB to develop a more coordinated response to the Arsenic crisis than before, through a programme through partnership approach. This program will be started by the end of September 2003. Two overriding problems in addressing the crisis have identified, these are-

- Extensive knowledge gaps to mitigate the effects of arsenic
- Lack of institutional capacity at all level particularly at the local level

The GoB is in the process of establishing an Arsenic Policy Support Unit (APSU) in the Local Government Division (LGD) to prepare and implement the NAMP. Its main role would be to liaise, co-ordinate and facilitate. It is proposed that APSU would co-ordinate the arsenic activities of GoB via the Secretaries Committee for Arsenic, including Secretaries from the Ministries of Local Government, Health, Planning, Water Resources, Science & Technology, Environment, Information, Energy and Agriculture.

In order to help GoB to move forward on the establishment of the APSU and the development of NAMP, DFID agreed to support the effort and is currently designing a Project Memorandum for the Support to the National Arsenic Mitigation Programme (SNAMP).

Arsenic Policy Support Unit (APSU):

The GoB is in the process of establishing an "**Arsenic Policy Support Unit (APSU)**" to assist in the development and implementation of new government policy and strategy, monitoring, and coordinating arsenic related activities. It is proposed that the APSU would coordinate the arsenic activities of the GoB via the Secretaries Committee for Arsenic including Secretaries from the Ministries of Local Government, Health, Planning, Water Resources, Science & Technology, Environment, Energy, Information and Agriculture.

The overall activities of APSU is to liaise, coordinate and facilitate all the activities of designing the national strategy and action plan for arsenic mitigation, and further details of proposed activities follow in Table 1.2. The main ministries with important roles to play in addressing the arsenic crisis are shown in Figure 1.2b. In addition to links with different ministries of GoB, APSU will also maintain links with other governmental and non-governmental agencies (see Figure 1.2c). APSU would give active support for activities to BAMWSP and the National Committee of Experts; and liaise with Donor Coordination Unit, all other non-governmental stakeholders and the Unit for Policy Implementation.

The APSU team is an informal interim unit to help create the National Arsenic Mitigation Program, & Support Unit. APSU is going to be started for 2 years initially with a review of progress after one year. Resources for APSU will come from variety of sources, both from donors mainly DFID and from Government of Bangladesh.

The Secretaries Committee agreed that LGD should be the focal ministry for arsenic mitigation and should co-ordinate cross-sectoral interaction through the Secretaries Committee. APSU would provide support to LGD and report to the Secretary LGD who would be the National coordinator of the Arsenic mitigation Program. The Secretary LGD would provide the cross-sectoral interaction through reporting on behalf of APSU to the Secretaries Committee and vice versa. According to the proposed structure of APSU is the following (Figure 1.2a):

Figure 1.2 a) Proposed APSU Structure

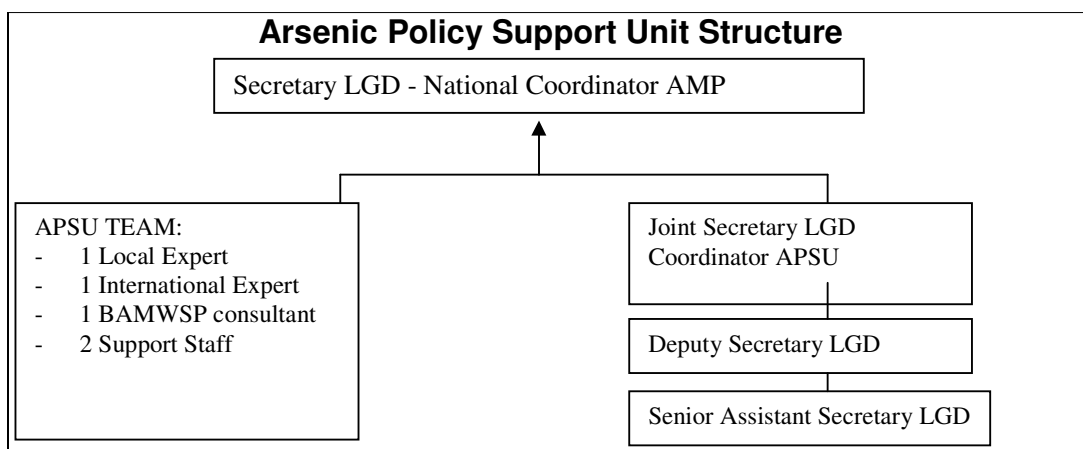


Figure 1.2 b) : APSU involvement in creation of the National Arsenic Mitigation Program & Support Unit, showing main ministries with important roles in addressing the arsenic crisis.

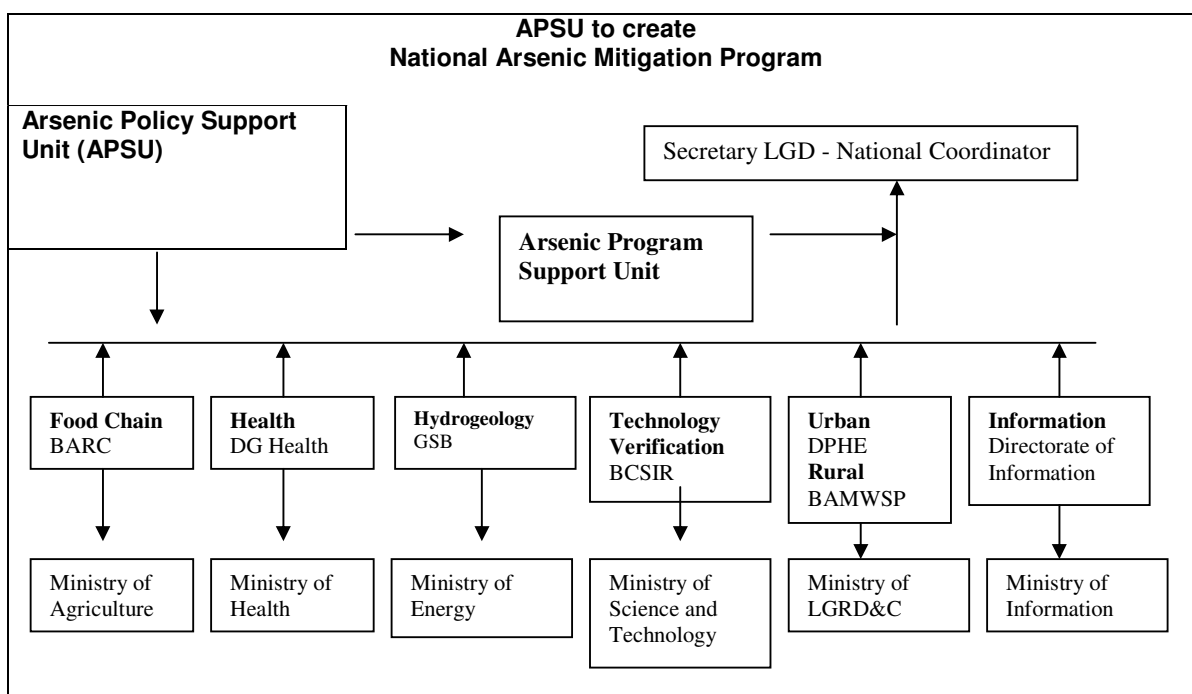


Figure 1.2 c) APSU links with other governmental and non-governmental agencies.



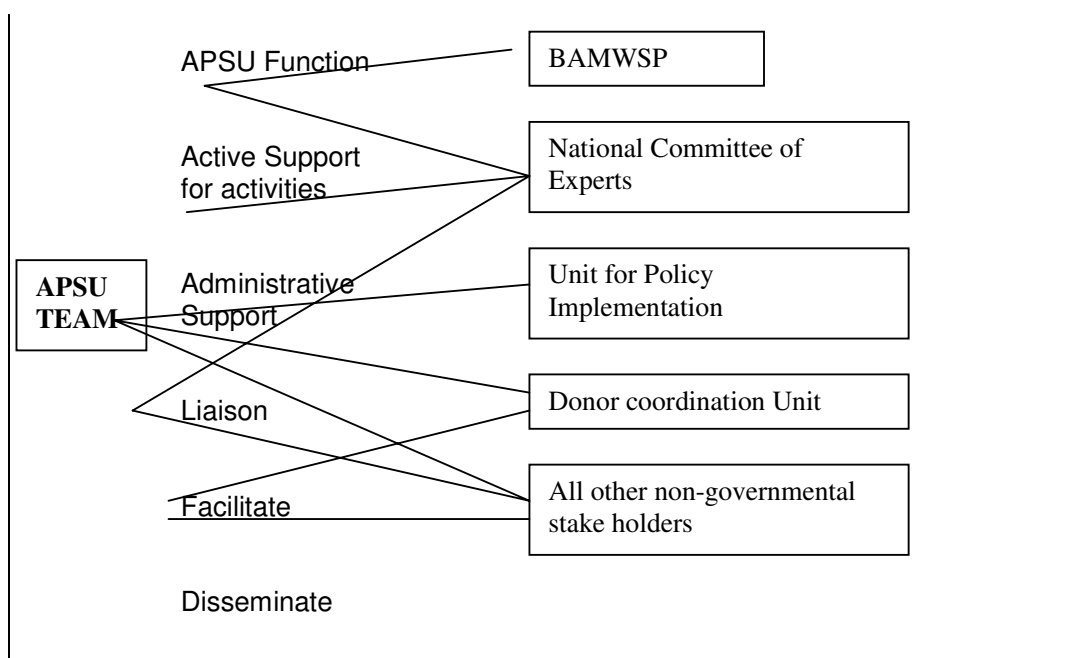


Table 1.2: The priority APSU activities that have been proposed are as follows:

1. Finalization of the National Strategy/ Action Plan for Arsenic Mitigation
2. Finalization of the design of the National Arsenic Mitigation program
3. Facilitate preparation of, and mobilize committed donor support to:
 - Deep aquifer/Holocene mapping
 - Local government capacity building for implementation of arsenic mitigation
4. Design the Partnership Program with the relevant Ministries and agencies, but with early attention on Ministry of Health and Information and on GSB
5. Prepare monthly status/co-ordination reports for Secretary LGD on BAMWSP, DPHE-UNICEF project, DPHE-Danida project, Watsan Partnership Project (SDC funded), World Vision Project, any other donor/GoB funded projects
6. Finalize strategy for rainwater harvesting
7. Assist relevant ministries and agencies in addressing the food chain issues
8. Formulate agreed national policy on cost-sharing for water supply facilities
9. Provide support to the Secretary LGD in ensuring effective co-ordination of arsenic related activities of different ministries and agencies
10. Facilitate development and implementation of BAMWSP's partnership with different government agencies, NGOs and development partners
11. Facilitate LGD's interaction with relevant development partners
12. Assist the LGD in preparing various arsenic related documents, strategy papers, and study proposals on current and emerging issues
13. Provide secretarial assistance through LGD to Secretaries' Committee and the National Committee of Experts on Arsenic
14. Keep the Secretary LGD informed about developments and findings of different arsenic related studies and recommendations of different workshops and seminars
15. Set up a mechanism for routine monitoring of the implementation of the new strategy, including the program partnerships, and for reporting to the Secretary LGD and other relevant partners
16. Assist LGD in undertaking professional and analytical work by drawing on the expertise available within different government agencies and development partners
17. Devise an effective dissemination strategy with NAMIC, ACIC, WARPO and Directorate of Information

1.3 Directorate General Health Services (DGHS)

Completed Activities:

Directorate General Health Services (DGHS) worked with UNICEF in eight upazillas for screening of arsenicosis patients. DGHS, with the assistance of NIPSOM, and financial and technical support of WHO

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has also developed a national protocol for the diagnosis of arsenicosis patients and a management protocol also which were presented and discussed in the 'International Workshop on Arsenic Mitigation' held on January, 2002.

Ongoing Activities:

Directorate General Health Services (DGHS) is currently developing a recording system all over Bangladesh through the health services network for the proper records of arsenicosis patients in Bangladesh and it will be finalized by this year with the technical support of UNICEF. DGHS has already provided training to almost 2000 doctors and 20,000 field workers on diagnosis of arsenicosis patients and its management and providing awareness campaign through the health care providers at government level. A training module on arsenic is currently being developed and expected to be finalized by October 2002.

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1.4 Water Development Board

Water Development Board (WDB) under the Ministry of Water Resources has been working on geological investigation for arsenic in different parts of the country. The experts from WDB have completed 36 shallow drilling and 6 deep drilling with different governmental and non governmental bodies like DPHE/NIPSOM, BAMWSP, Geohazard Research Group, Dept. of Geology, University of Dhaka. They collected both sediments and water samples of these areas for arsenic analysis and have identified different levels in these areas to be arsenic free. The reports are made available at the WDB and respective organizations.

As per the result of the investigation it has been opinioned that identification of the arsenic free water level in different areas is needed for providing safe drinking water on immediate basis. In order to formulate long term planning, strategy and community water resources development area wise identification of arsenic uncontaminated aquifers may be continued through drilling, study and research activities.

Publications:

- Arsenic Contamination of Ground Water in Bangladesh -- Syed Musleh Uddin & Lutfenur-1995
- The Hydro-geochemical of Western Border Belt of Bangladesh with Special Emphasis to Access Arsenic Contamination in Ground Water (Water Supply Paper 548) Kazi Shafiul Hossain - 1996
- Study Report on Source Detection of Arsenic Contamination in Bangladesh Ground Water & Mitigation Measure (Water Supply Paper 557) - Vol.1 & Vol. 2 - Mizanur Rahman & Kazi Shafiul Hossain - 1999.

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1.5 DPHE / DANIDA

An agreement between the Governments of Bangladesh and Denmark on the Danish Sector Programme Support (SPS) to the Water Supply and Sanitation (WSS) Sector was signed in June 1999. The SPS for the WSS Sector aims to facilitate implementation of the National Policy for Safe Drinking Water Supply and Sanitation. Among others the SPS includes support to Urban and Rural WSS Components and Arsenic Mitigation Component in the coastal area.

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The DPHE / DANIDA Arsenic Mitigation Component (AMC) commenced in January 2000 and supposed to end in June 2004. It aims to work within the visions of the National arsenic mitigation policy.

These are:

- Facilitating the access of all citizens to arsenic free water
- Bringing behavioral changes necessary for ensuring continued use of arsenic free water for drinking and cooking.
- Reducing the incidence of arsenic poisoning.
- Building capacity of the local governments and communities to deal more effectively with arsenic related problems.
- Creating awareness and promoting sustainable arsenic mitigation options.
- Promoting the use of surface and rain water in order to reduce the intake of arsenic contaminated water.

DPHE / DANIDA Arsenic Mitigation Component has another section " Research and Development " which is involved in the research and developmental activities like evaluation and monitoring of alternative safe water option and arsenic removal technologies, awareness campaign in the intervention areas.

Working Areas:

DPHE / DANIDA has been working in 11 Upazilas (Bakergonj, Banaripara, Barisal Sadar, Ujirpur under Barisal district, Pirojpur Sadar, Sonagazi under Feni district, Lakshmipur Sadar, Raipur, Ramgati under Lakshmipur district, Begumgonj under Noakhali district, Noakhali Sadar.

Completed Activities:

- ◆ Screening for tube-wells in some of the working areas and 85000 tube wells have been screened already (for details please contact DPHE/DANIDA Arsenic Mitigation Component).
- ◆ Installation of about 950 deep tube-wells up to June 2002.
- ◆ Evaluation of Bucket Treatment Unit (BTU) as arsenic removal technology.

Ongoing Activities:

- ◆ Evaluation of the following technologies as alternative safe water options in terms of water quality, monitoring of effectiveness, social acceptability.
 - Pond Sand Filter in Potuakhali and Noakhali
 - Minipipe Water Supply in Ramgati under Lakshmipur district.
 - Rain Water Harvesting System
 - Shapla Unit of International Development Enterprise (IDE) in Begumgonj under Noakhali district.
 - Steven's Star Filter in Lakshmipur.
 - Fill and Draw (F & D)
- ◆ Screening of tube-well for arsenic contamination.
- ◆ Awareness campaigning, patient detection and referral to hospital.
- ◆ Installation of deep tube-wells as safe water source.
- ◆ Geographical Information System (GIS) and mapping.
- ◆ Equipping and running one laboratory in Noakhali.

Duration of the Project:

The project commenced in January 2001 and supposed to end in June 2004

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1.6 DPHE / UNICEF

Completed Activities:

The DPHE / UNICEF arsenic mitigation initiative to date has consisted of several National-scale activities and a focussed 'Action Research' project in five upazillas.

The national-scale activities undertaken include testing of 51,000 tubewells in 1998 using field test kits (29% of the tubewells contaminated above 50 ppb) to give the first idea of the scale of contamination Nationwide. and the development and testing of a comprehensive communication campaign including radio and television spots.

The 'Action Research into Community Based Arsenic Mitigation' project has worked in five upazillas with BRAC (two upazillas), Grameen Bank, Dhaka Community Hospital Trust and the Integrated Service for the Development of Children and Mothers (ISDCM - with Rotary Funding). The project followed an integrated approach and included four main activities: testing of all tubewells in the upazilla; arsenicosis patient identification / support; implementation, monitoring and evaluation of alternative water supply technologies; communication about arsenic and arsenicosis. The technologies tested ranged from home-based solutions such as the 3-kolshi arsenic removal filter to community-based solutions such as the Pond Sand Filter (PSF) for treatment of surface water.

Ongoing and Future Activities:

2001-2003, 15 Upazilla Arsenic Mitigation and water supply project

DPHE / UNICEF developed the second phase of the project which has similar activities with further emphasis placed on sustainability, community involvement and monitoring, and community cost sharing. Other innovations and additions to the program include the implementation of pre-intervention baseline, and post-intervention follow-up arsenic-KAP surveys in the 15 upazilas, the introduction of GPS mapping of wells and the development of union-level "map booklets" for use as local planning and decision-making tools. The phase two project is being implemented in 15 upazillas. The project has on offer for interested parties an "arsenic database" which can be used to track (and report) testing results, with the collected data formatted according to the standard BAMWSP data collection form.

The communication and screening phase of the 15 upazila project was completed in the first half of 2002, with the help of a total of 8 NGOs. Some 300,000 wells were tested, of which 68% were found "red". An additional 2,300 patients were identified through a combination of house-to-house surveys and community health-camps. The safe water options component of this program will continue at least until the end of 2003. Safe water options currently being piloted under this program include low-cost household- and community Rain Water Harvesting, Pond Sand Filters, large-volume surface water treatment systems, improved dug wells, imported community-level arsenic adsorbent plants and locally manufactured household-level arsenic adsorbent plants (Shapla). Three of the 15 upazilas are funded by the UN Foundation, and work there is carried out in cooperation with the WHO.

2002-2004, 25 Upazilla Arsenic Mitigation and water supply project

In the second half of 2002 the program will be further expanded, when communication and well-screening activities will commence in a further 25 upazilas. Six more NGOs will be brought on board, bringing the total number of NGO partners to 14. Six of the new 25 upazilas will be covered exclusively by DPHE, in an attempt to increase government ownership and involvement in arsenic mitigation. It is anticipated that under this 25 upazila project 500,000 wells will be tested by end of December 2002. Safe water options implementation will start from January 2003, and continue at least until the first half of 2004.

DFID is the main funder of a US\$ 49.3million five year Rural Hygiene, Sanitation and Water Supply Project, implemented by DPHE with assistance from UNICEF. The water supply component is primarily aimed at low water table and underserved areas in 38 districts of Bangladesh. It is not specifically targeted at arsenic-affected areas but measures will be taken to ensure that all water supplies provided are free from arsenic. Implementation is expected to commence early in 2001, on completion of the inception phase.

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1.7 Directorate General of Health services / UNICEF

UNICEF have supported DGHS and Dhaka Community Hospital Trust to develop a patient treatment protocol and in training doctors and health workers in 80 districts across the country. DGHS and UNICEF are working together to build capacity of public health workers to identify and treat patients.

The health division of UNICEF also supports the following activities:

- Active patient identification in UNICEF working areas by house to house screening.
- Compilation of a patient profile with all related information such as - biological investigation results (including nail and urine) water information, sign-symptoms etc.
- Disseminate patient lists to relevant organisations, so that alternate options are prioritized to the areas with most patients.
- Distribute medicine (anti-oxidants and skin ointment) to the identified patients.
- Nationwide training of doctors and health workers through DGHS.
- Establish a referral and surveillance system with collaboration from DGHS and DCHT (link patient with alternate water options in addition to treatment facilities)
- Collaboration with CDC for epidemiological studies (study to commence January 2003).
- A collaboration study with DCHT to see efficiency of different treatment options for the patients.

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2 World Health Organization – Bangladesh

2.1 Department of Public Health Engineering (DPHE)/WHO

The WHO Environmental Health Team in Bangladesh has supported the Government of Bangladesh since the early stages of recognition of the arsenic problem (1993), mostly by providing technical expertise. This expertise included both technological aspects of arsenic removal and an epidemiological review of the health effects and immediate actions required for mitigation.

As a result in 1997, WHO informed GoB that arsenic in drinking water was a "Major Public Health Issue" which should be dealt with on an "Emergency Basis". Joint studies with local institutes have been carried out to test household arsenic removal techniques and the quality of alternative drinking water sources. An evaluation was made of the field test kits available (1998). WHO has been an active partner to GoB and in the context of interagency collaboration, through support to the organization of a National Co-ordination Conference (1999) and the International Workshop on Arsenic Mitigation (2002), support for various aspects of arsenic mitigation, and through the management of an inter laboratory comparison exercise aimed at improving capacity of local laboratories to determine arsenic contamination in water.

WHO has supported strengthening of laboratories within DPHE, and is a lead partner in DPHE's efforts to establish a national water quality monitoring and surveillance system.

In 2000 WHO, with the support of BAEC and IAEA, has executed an inter-laboratory comparison with 25 participating laboratories to improve laboratory practice and measurement of arsenic. A next round will be organized in late 2002.

WHO have been involved in an informal Emergency Arsenic Taskforce, requested by the LCG WATSAN which has documented an emergency action approach and funded a geographical information system (GIS) mapping of arsenic hotspot villages and working areas of various arsenic projects. This information is held by NAMIC who are responsible for updating the maps.

DPHE and UNICEF are collaborating in implementing a arsenic mitigation project in 15 upazillas. WHO and UNICEF have received funding to start a two-year action research project on arsenic mitigation in three upazillas, with funding from the UN Foundation. In addition to funding direct mitigation activities (through UNICEF), the project will support capacity building for screening of patients and tubewells, for development of laboratory capacity at upazilla level, and for community based project implementation and monitoring. An important element of the action-research will be to examine the effectiveness of the project interventions in sustainable reduction of exposure to arsenic. The project will start on April 1, 2002 and will have a duration of two years.

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2.2 Directorate General of Health Services (DGHS)/WHO

In the course of 2001, DGHS expressed a need to develop criteria for diagnosis of arsenic patients. DGHS, with the assistance of NIPSOM, and financial and technical support of WHO has developed a national protocol for the diagnosis of arsenic patients. First steps have been undertaken to prepare a similar protocol for the management of arsenicosis patients.

The two protocols were presented and discussed at the January 2002 International Workshop on Arsenic Mitigation. Training modules are now under preparation, and the protocol will be field tested during the first half of 2002. The protocols will be reviewed during a regional meeting in Thailand in October 2002 to arrive at an agreed protocol for identification of arsenic patients in Asia. Simultaneously further steps will be undertaken to improve the protocols that are for patient management.

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2.3 ICDDR,B Centre for Health and Population Research/WHO

WHO is co-financing a research project on Arsenic in tube well water and health consequences. Other financial support is provided by SIDA and AusAid.

The consequences of exposure to arsenic will be extensive and include excess incidence and mortality in cancers and cardio-vascular diseases. However, the knowledge base is weak on the weight of this new burden of diseases and on the speed by which it develops. Little is known about the reproductive health consequences, and about the possible aggravating role of the widespread malnutrition in Bangladesh on arsenic-induced health effects.

The overall objective of this project is to establish a strong epidemiologic platform of research on levels of arsenic exposure through drinking water, occurrence of arsenic skin lesions, consequences for reproductive outcome, effect on adult mortality, modifications of effects by the nutritional status, and effects of an intervention with alternative water sources.

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2.4 World Health Organisation (WHO) – Guidelines and Protocols

In response to the arsenic crisis the WHO Task Force dealing with the WHO Guidelines for Drinking Water Quality has given priority to the preparation of a technical monograph on the control of health hazards from arsenic in drinking-water. This work was undertaken as a joint endeavour of interested United Nations agencies including UNICEF, WHO and World Bank. As a result a UN Synthesis Report on Arsenic in Drinking Water has been prepared, covering the following areas:

- Sources of Contamination
- Environmental Health and Human Exposure Assessment
- Exposure and Health Effects
- Diagnosis and Treatment of Chronic Arsenic Poisoning
- Drinking Water Quality Guidelines and Standards
- Safe Water Technology
- Communication for Development
- Development of Mitigation Strategies

This report is a synthesis of the "state-of-the-art" arsenic knowledge. It is expected that planners, government officials, development aid agencies, and other stakeholders at the national and regional levels, as well as the scientific community in general, will use the report as a primer on arsenic and will promote necessary action. At the same time, the report will identify current knowledge gaps and research needs.

The final draft report is available since late 2001 on the WHO website at "www.who.int/water_sanitation_health/water_quality/arsenic.htm". An updated and edited version is now being readied for publication, by early 2003.

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Under the International Programme on Chemical Safety (IPCS), WHO, in conjunction with the ILO and UNEP has published an update of the Environmental Health Criteria (No. 224) on Arsenic and Arsenic Compounds in November 2001. EHC 224 provides an authoritative reference on environmental transport and distribution of arsenic; environmental levels and human exposure; kinetics and metabolism; and effects on laboratory animals and in vitro systems, on human health and on other organisms in the environment. The publication can be downloaded from www.inchem.org/pages/ehc.html

At the end of February 2003 WHO will publish the revised Guidelines for Drinking Water Quality. The Guidelines will provide guideline values about a wide range of microbial, chemical and radiation risks associated with drinking water. A special section on chemical constituents and on household water treatment and storage will be provided. In recognition of its growing importance as a source of drinking water, rainwater and rainwater quality will be discussed. Risk assessment techniques such as HACCP (Hazard Analysis and Critical Control Points) will be presented and complemented by Hygiene Codes.

Occasionally, WHO provides support for health research through its on-going country programme, or through the WHO South East Asia Regional Office in New Delhi.

At the Regional Level WHO provides support to countries suffering from arsenic problems through an intercountry programme. Among many issues, this programme intends to strengthen health capabilities in arsenic mitigation, including further development of protocols for diagnosis and management of arsenicosis patients.

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3 World Bank

The US\$44.4million National level **Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP)** is co-funded by GoB, World Bank and SDC. In August 1998 World Bank approved credit of US\$32.4million to GoB to implement the four-year project. BAMWSP aims to co-ordinate arsenic interventions and through its National Arsenic Mitigation Information Centre (NAMIC) collect, collate and disseminate arsenic information from and to interested or active organisations. See preceding Section 1.1 for a summary of the BAMWSP activities. BAMWSP's Project Management Unit (PMU) is headed by DPHE.

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Arsenic Public Health Project : A new IDA Credit has been proposed to assist the Government of Bangladesh in addressing the health aspects of the problem through the Ministry of Health and Family Welfare to complement the water sector activities being carried out under the Local Government Division. This project is at a very preliminary stage of preparation and is very tentatively indicated as a \$45 million effort to finance Behaviour Change Communication (health-related messages), Capacity Strengthening of the health sector, and Research activities, including some pilot operations to test some of the experimental treatment regimens for arsenicosis. If the Government undertakes preparatory activities expeditiously, project implementation could begin in the second half of 2003.

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4. Australian Agency for International Development (AusAID)

AusAID has initiated an arsenic mitigation program named 'Australian Arsenic Mitigation Program (AAMP)' with funding of \$A3 million over the period 2001-2004. The goal of the program is to contribute to the mitigation of arsenic poisoning in Bangladesh and West Bengal, India. In June 2000 proposals were requested from Bangladesh, India and Australia in a public tender. Among the three selected projects, two are being implemented in Bangladesh and one in West Bengal, India. A Subsidiary Agreement was signed on 21 May 2002 between the Government of Australia and the Government of Bangladesh in this regard. The projects are:

- *Bangladesh-Australia Centre for Safe Water and Food Project*- The Australian company, EGIS Consulting will be implementing this project in collaboration with Dhaka Community Hospital (DCH). The objective of the project is to provide a substantial contribution to the prevention of arsenic poisoning in the communities of Bangladesh through an integrated and sustainable set of programs including establishment of the Bangladesh-Australia Centre for Safe Water and Food at DCH and the implementation of a Community Health Education Program in the arsenic affected areas.
- *Health and Social Research Project*- This project will be implemented by the Australian National University in collaboration with the NGO Forum for Drinking Water and Sanitation, Bangladesh. The objective of the project is to assess the social and health costs of exposure to arsenic contamination and compare these to the monetary, social and health costs of arsenic mitigation programs.

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5 Canadian International Development Agency (CIDA)

CIDA are currently funding a three-year (2000/2003) Environmental Technology Verification (ETV-AM) - Arsenic Mitigation Project. The project works closely with the Technical Advisory Group (TAG) and BAMWSP (see section 1.1) and is implemented through the Ministry of Local Government, Rural Development and Co-operatives, Local Government Division and Ontario Centre for Environmental Technology Advancement (OCETA), and further details are given in Section 28??. The CIDA contribution to the project is approximately US\$2.7million.

The objective of the project is to develop a transparent process for assessing and verifying arsenic removal technologies and the transfer of the process and procedures to an entity designated by the Government of Bangladesh. The main outputs will include internationally recognised criteria for examining arsenic removal technologies; a process for certification of arsenic removal technologies and confirmed technology viability through a comprehensive field verification program.

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6 Department for International Development (DFID)

Completed Activities

1. Groundwater Studies for Arsenic Contamination in Bangladesh (DPHE / British Geological Survey (BGS) / Mott MacDonald Ltd). Phase 1: Rapid Assessment Phase.

The Phase 1 study commenced in January 1998, with the Final Report issued in early 1999. It included the compilation review and database of existing groundwater and sediment arsenic data from Bangladesh; a systematic groundwater quality survey using laboratory analysis for the 41 districts then believed to be worst affected in Bangladesh; a detailed geochemical investigation in three special study areas; modelling the movement of groundwater and arsenic in a typical Bangladesh situation. Covered 250 thanas - essentially that part of the country to the south of and including the Padma and Upper Megha flood plains, but excluding the Chittagong Hill Tracts.

2. Groundwater Studies for Arsenic Contamination in Bangladesh (DPHE / British Geological Survey (BGS) / Mott MacDonald Ltd). Phase 2.

Phase two continued from Phase one and extended the survey to the remaining districts of Bangladesh excluding the three districts of the Chittagong Hill Tracts. The final data set for this survey consists of a sample of 3534 well waters. In addition to arsenic it considers other elements of concern, such as manganese, boron and uranium. The principal findings were presented in March 2000 and the Final Report was completed in February 2001, and is now available in print. A limited number of further complimentary copies are available to bonafide organisations working within Bangladesh in the field of arsenic mitigation. Requests should be sent on headed paper to DFID Manager (Water & Sanitation), House No 42, Road No 28, Gulshan, Dhaka. Copies may also be purchased from Graphosman, 3/3-C Purana Paltan, Karim Mansion (1st Floor), Dhaka-1000. Enquiries from outside Bangladesh concerning further copies should be addressed to Dr D G Kinniburgh at the British Geological Survey (email dgk@bgs.ac.uk). Information can also be viewed and downloaded from the BGS website at www.bgs.ac.uk/arsenic/Bangladesh.

3. Rapid Assessment of Household Level Arsenic Removal Technologies (BAMWSP, WS Atkins, WaterAid Bangladesh).

This DFID-funded study evaluated nine arsenic removal technologies for technical and social acceptability. The studies commenced in August 2000, and the Final (Phase II) Report was issued in March 2001. The Final report is available on the WaterAid website at www.wateraid.co.uk. The report was submitted to the BAMWSP Technical Advisory Group (TAG) and TAG reviewed the study and have recommended four technologies to use in emergency basis water supply, in acute arsenic affected area on an experimental basis.

Ongoing Activities

DFID is the major funder of a US\$ 49.3million five year Rural Hygiene, Sanitation and Water Supply Project, implemented by DPHE with assistance from UNICEF. The water supply component is primarily aimed at low water table and underserved areas in 38 districts of Bangladesh. It is not specifically targeted at arsenic-affected areas but measures will be taken to ensure that all water supplies provided are free from arsenic. Implementation commenced in January 2002, with an initial two-year developmental phase in selected upazilas within seven districts (Rangpur, Gaibandha, Brahmanbaria, Jamalpur, Madaripur, Sirajgonj, Chuadanga, Rangamati, Khagrachhari, Bandarban).

DFID is also currently considering an upscale of its previous programme with the INGO, WaterAid, to further develop sustainable, people-centred approaches to community managed, safe water supplies including those in arsenic prone areas and through NAISU to improve the clear communication of safe water issues to communities and small NGOs.

Future Projects

The Government of Bangladesh has decided to establish an Arsenic Policy Support Unit (APSU) in the Local Government Division (LGD) to prepare and implement a National Arsenic Mitigation Programme (NAMP).

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DFID is currently designing a Support to the National Arsenic Mitigation Programme (SNAMP), and has recently approved preliminary funding of approximately 0.6 million UK Pounds over two years to support APSU in planning and coordinating its cross-sectoral response to arsenic. This preliminary DFID funded support to the APSU will include the funding of an international and local consultant. SNAMP itself is expected to be a three year programme, commencing in 2003, offering flexible assistance in knowledge generation, awareness raising and capacity building.

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7 Japan International Cooperation Agency (JICA):

Ongoing Activities:

i) The Study on the Groundwater Development of Deep Aquifers for Safe Drinking Water Supply to the Arsenic Affected Areas in Western Bangladesh (Chuadanga, Jenaidah and Jessore).

JICA are funding a Study Team to investigate groundwater development of deep aquifers for safe drinking water supply to arsenic affected areas in Western Bangladesh. DPHE is the implementation partner and the project duration is December 1999 to July 2002. The study has been conducted in three phases and a Draft Master plan has been prepared for Development of Groundwater in Deep Aquifers or Safe Drinking Water Supply to the Arsenic Affected Areas with target year 2010. After approval of JICA, this Masterplan is scheduled to be submitted to GOB in July 2002.

ii) Integrated Approach for Mitigation of the Arsenic Contamination of Drinking Water in Bangladesh (Sharsha upazilla of Jessore District covering 300, 000 people)

This partnership program is to improve the symptoms of arsenic patients and to prevent new cases of Arsenic poisoning by securing safe drinking water. The implementation partner is Asia Arsenic Network and the project duration is January 2001 – December 2004. The following activities are included:

1. Organize community workers and conduct training on Arsenic, arsenicosis and how to use test-kit.
2. Test all tubewells
3. Operation of a Mobile Arsenic centre to conduct awareness education with visual Aid
4. Identify arsenicosis patients
5. To install safe water options
6. Distribute medicine.

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8 Swedish International Development Agency (SIDA)

Ongoing Activities:

The following two Arsenic projects are currently supported by Sweden (Sida):

1) "ARSENIC IN DRINKING WATER AND HEALTH CONSEQUENCES"

This is a support to the International Centre for Health and Population Research in Dhaka, Bangladesh (ICDDR, B), working in close co-operation with BRAC (Bangladesh) and Linköping University. Sida finalised its decision to support to ICDDR,B in 2001 and the project is currently under implementation since 1 July 2001. Fieldwork started in late autumn 2001, and is geographically located to the Matlab district southeast of Dhaka. (A six-monthly technical report, covering the period Jan-June 2002, was submitted to the Embassy in July '02.) The total allocation to the project is SEK 3 500 00 for the two year period 2001-03.

Objective: The Centre wants to conduct epidemiological studies in their Matlab area (Upazilla) and where people have been exposed to different levels of arsenic contaminated drinking water. The area is known to be badly affected by arsenic. Hence the main focus is to assert/identify the different Health consequences of long-term exposure to dangerous water intake.

During the first six months of 2002 extensive training (skin screening & water testing) were provided to different field staff, which was provided by BRAC. Screening of approx. 12800 tube wells in the Matlab area have been identified and numbered by GPS (Geographic Positioning System) teams. Skin screening: Approximately 25.000 people have been examined (1/7 of all population). A referral routine has been established in cases where Arsenic related diseases are detected.

The use of tube well water as drinking water has been identified through interviews. Clinic activities undertaken and where selected cases and referents checked. Furthermore assessment of arsenic in tube wells has been conducted, done by field teams. Water samples are analysed by Karolinska Institute, in Stockholm, where also quality control of randomly selected samples from the batches analysed in Dhaka will be performed. Finally mitigation activities: Before testing as well as after completion of testing of tube well water, meetings are organised in the villages. Discussions are held with the Village Arsenic Mitigation Committees which mitigation options there might be. So far a number of 4-pitcher filters have been supplied, a pond sand filter system is planned to be implemented, and a few rainwater-harvesting systems have been installed.

2) ARSENIC MITIGATION ACTIVITIES IN GREATER FARIDPUR

This project has just been approved by Sida, Stockholm, and is yet awaiting final approval of ERD. The support is based on a request from Bangladesh Rural Development Board (BRDB) and is linked to the Productive Employment Project (PEP or RD-5) which is geographically located in the Greater Faridpur area since 1986-87. (Greater Faridpur consists of the five districts: Faridpur, Rajbari, Gopalganj, Madaripur and Shariatpur.)

Sida has approved support to a Pilot Phase, which will have a duration of one year 2002-03, and allocated a maximum amount of SEK 3 000 000 (Approx. 300.000 USD). The development objective is to provide PEP target group members as well as other nearby community members with sustainable sources of safe, arsenic free drinking water and thus reduce the risk of arsenic related diseases.

The more immediate objective of the pilot phase will be to establish linkages with different GOs and NGOs involved in arsenic mitigation activities in order to gain experiences and to identify, finalise the best suitable options and others related activities for PEP members and related community members:

- Implement arsenic mitigation approaches that include both technical and socio-economic strategies, alternative water supplies;
- assist improved access to information, equipment and other items needed;
- establish linkages between line at both national and local levels and to address the immediate and long term issues of arsenic problems in the project area; and
- generate increased awareness and provide training to the PEP group members on health implications of prolonged intake of arsenic contaminated water.

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9 Swiss Agency for Development and Co-operation (SDC)

SDC, with GoB and World Bank, is co-funding the US\$44.4million National level Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) as described in preceding Section 1.1.

The WATSAN Partnership Project (see Section 23) is SDC funded and is a collaborative community based rural water supply, sanitation and hygiene sector project currently undertaken in Rajshahi and Chapai Nawabgonj Districts. The problem of arsenic contamination in ground water has necessitated investigation and implementation of affordable new technologies for the most severely affected people in the project area.

Another project financed by SDC is the Rain Water Harvesting Project in Bangladesh. This project is an Action Research Project implemented by NGO Forum for Drinking Water Supply and Sanitation. The goal and objective of the project is to introduce the household rainwater harvesting system in combination with other alternatives as a safe, socially acceptable, low-cost and affordable water supply system in the areas where the ground water is contaminated by arsenic. The project commenced in June 2000 and is ongoing.

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10 Arsenic Crisis Information Centre (ACIC)

The West Bengal & Bangladesh Arsenic Crisis Information Centre was founded in 1997 in Dhaka. ACIC is a private not-for-profit service focusing on enhancing the visibility and accessibility of arsenic crisis related information using Internet technologies. Currently it maintains:

- A website at <http://bicn.com/acic>
- An opt-in email newsletter (1045 subscribers currently) to announce when new information is added to the website (email arsenic-crisis-news-subscribe@yahoogroups.com to subscribe)

- Three moderated email discussion groups at egroups.com,

- (1) [arsenic-source](http://egroups.com) , for those interested in all aspects of arsenic geochemistry (email arsenic-source-subscribe@yahoogroups.com to subscribe);

- (2) [arsenic-safewater](http://egroups.com), for those interested in water treatment technologies and alternative supplies (email arsenic-safewater-subscribe@yahoogroups.com to subscribe); and

- (3) [arsenic-medical](http://egroups.com), for those interested in arsenic disease diagnosis, epidemiology, treatment of symptoms, etc. (email arsenic-medical-subscribe@yahoogroups.com to subscribe)

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11 Asia Arsenic Network

Completed activities:

The Asia Arsenic Network (AAN), a Japan based NGO is a pioneer organization working since 1996 in Bangladesh to find out the ways of reducing the sufferings of victims and alternate sources of safe drinking water. In March 2000 AAN completed a 3-year pilot study project in the Samta village of Sharsha Upazilla under the Jessore district. The project consisted of three pillars; namely research, community participation and measures for safe drinking water and management of patients.

Major activities of the project included:

- 1) Screening of all the tube wells for arsenic;
- 2) Production of a “contamination map” illustrating the locations of tube wells with colours to show arsenic contamination level of each tube well;
- 3) Formation of, and collaboration with, Arsenic Prevention Committee;
- 4) Geological and hydrogeological surveys to find the reasons of arsenic contamination of aquifers;
- 5) Patient identification and management (including surgical operation and distribution of vitamins);
- 6) A pond sand filter was installed as safe community water source.

The results of these researches and activities were reported in an Interim Report titled “Arsenic Contamination in Groundwater in Bangladesh” (April 1999) by AAN, Research Group of Applied Geology (RGAG) and NIPSOM. Another report titled “Arsenic contamination in groundwater and hydrogeological background in Samta village, western Bangladesh” (July 2000) was published by RGAG with a supplement “Recommendation for mitigation of arsenic contamination in Bangladesh” by AAN and NIPSOM.

Ongoing and proposed activities:

On the basis of Samta experience AAN started a new project; namely, a **Mobile Arsenic Centre (MAC)** project, to extend their mitigation program to other arsenic affected areas surrounding the Jessore district. A Mobile Arsenic Centre is a team of experts consisting of a chemist/technician to analyze water quality, medical experts and environmental engineer to find most suitable safe water options and a social worker to conduct awareness education. The MAC is also equipped with transportable necessary instruments, chemicals and medicines for the patients.

The MAC team visits seriously affected villages to mitigate the arsenic problem there. The total project is implemented with the co-operation and support of community people and the local NGOs. Prior to the visit of a MAC, a local NGO conducts the screening of tube wells for arsenic in a village and prepare a contamination map. The data of screening and the map form the basis of MAC activities. In the arsenic affected village MAC conducts a house-to-house survey to identify arsenicosis patients, and awareness education is carried out in a village meeting and in small gatherings in yards. Villagers are encouraged to set up an Arsenic Prevention Committee to deal with the problems related to arsenic contamination and its mitigation in their village. MAC also provides guidance on acceptable and environment-friendly safe water options.

So far AAN has conducted three MAC programs in fourteen villages in Khulna division. The villages are Mazdia, Achintanagar and Bara Kamarkundu of Jhenidah, Agarhati, Marua and Durbadanga of Jessore, Benagari, Takpara and Gopenathpur of Chuadanga, Chhatian of Meherpur, Chupria, Noapara, Khalishkhali and Sreemantakati of Shatkhira districts.

In these villages about 700 arsenicosis patients were identified and are now under AAN’s medical supervision. Among them three cancer patients were found during the MAC operation and they received surgical treatment as well as anticancer therapy. So far four pond sand filters (PSF), three modified dugwell with filter and four deep tube well have been installed in eight villages as arsenic safe water options. And the installation of three PSF and three deep tubewells, modified dug wells with sand filter are in progress with the active participation of Village Arsenic Committees.

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For screening of tubewell water AAN utilize NIPSOM Field Kit which is a locally developed version of AAN Field Kit invented by Mr. Hiromi Hironaka, Environmental Chemist and member of AAN.

Regarding the arsenic safe water option AAN thinks that no single option can ensure to provide safe drinking water to the whole community throughout the year. In the MAC program AAN recommends the three options; namely a) Pond Sand Filter (AAN-NIPSOM Type), b) Modified Dug Well (with sand Filter), and c) Deep Tube Well (with seal) depending on the situation of safe water sources and geographical/geological condition of the village.

Home-based Arsenic Removal Unit:

After screening of tubewell water in highly arsenic affected villages, it is very important to withdraw the people from drinking arsenic contaminated tubewell water to safe one as early as possible. But within the timeframe of implementing the mitigation activities it is very difficult to provide arsenic safe water by installing any community based option. In that case AAN introduce one domestic arsenic removal unit "AAN Filter" which can remove arsenic effectively and also can provide arsenic and bacteriological safe water at a very low cost to the people.

Now AAN is going to implement a 3-year arsenic mitigation project under JICA Development Partnership Program in Sharsha Upazila of Jessore District

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12 BRAC

BRAC, is one of the largest national non-governmental organisations and has a proven capacity for field-level programme implementation, socio-economic research, a strong institutional network and experience in training of community members in testing tubewell water for arsenic.

Completed Activities:

BRAC initiated arsenic mitigation activities through testing all 802 tubewells in its field offices. 12% were found to be arsenic contaminated.

In Hajiganj upazilla 93% of the 11,954 tubewells tested by BRAC in this upazilla showed the presence of arsenic. When the results of field testing by Village Health Workers (VHW) were cross-checked with laboratory results 93% were consistent. The testing program in Hajiganj upazilla was completed in just over a month.

In 1998 BRAC completed a countrywide testing of tubewells, which were installed by the Department of Public Health Engineering (DPHE) during 1997-1998 with assistance from UNICEF. A total of 12,604 tubewells were tested under this project using field kits. It took 35 days to complete the testing.

Ongoing Activities:

In 1999 BRAC, in collaboration with UNICEF and DPHE, initiated a pilot project on community-based arsenic mitigation in one union of Sonargaon upazilla under Narayanganj district. The project followed an integrated approach and included four main activities: communication about arsenic and arsenicosis; testing of all tubewells in the upazilla; arsenicosis patient identification / support / implementation; monitoring and evaluation of alternative water supply technologies. The technologies tested ranged from home-based solutions such as the 3-kalshi arsenic removal filter to community-based solutions such as the Pond Sand Filter (PSF) for treatment of surface water.

In June 1999 BRAC extended the action research on community-based arsenic mitigation to two upazillas: Sonargaon of Narayanganj district and Jhikargacha of Jessore district. Working closely with DPHE/UNICEF, BRAC actively involved communities in assessing and mitigating the arsenic crisis.

Once tubewells have been tested for arsenic BRAC then involve communities in highly affected areas in finding alternative sources of safe drinking water. This project attempted to test different options of safe drinking water in the two upazillas. As very little was known about the effectiveness and acceptability of different safe water options at the beginning of the project, it was essentially an 'action research' to assess the different options.

BRAC have now started an arsenic project in 4 new upazillas. The upazillas are Borura, Haimchar, Bhanga and Monirampur. The objectives of the project in these areas are to test all tubewells for arsenic and mark with appropriate paints red or green and building awareness among the people. Testing have already completed. Awareness raising has been done through training, workshops etc. In addition to the action research into community based arsenic mitigation project activities, BRAC implemented a rural multipurpose piped water supply in Pakunda village of Sonargaon. The capacity of the overhead tank is 50,000 litre. It has the provision of providing water for both drinking water through domestic supply line and agricultural purposes as well. People have contributed 20% of the total installation cost and they have agreed to pay the maintenance cost.

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13 CARE

The arsenic activities of CARE Bangladesh are associated with three programmes. The **Sanitation And Family Education Resource (SAFER) project** in Sitakunda, Chittagong; the **WATSAN Partnership Project (WPP)** in Rajshahi, Nawabganj (see section 3.22??); and the Integrated Food Security Program (IFSP). These address arsenic issues as part of their programme activities. **The Integrated Food Security Program (IFSP)** is addressing the arsenic problems through their Flood Proofing Project in Kurigram, Netrokona (FPP) and SHAHAR in different parts of the country. Accordingly SAFER and WATSAN is also addressing the issue in Sitakunda and Rajshahi respectively.

Completed Activities:

SAFER project:

This project has been closed after December 2000. The duration of the project was September 1999 to December 2000 and the working area was Amirabad village in Sitakunda in Chittagong. The activities under this project have been withdrawn and handed over to Para Committee with collaboration of PNGO-YPSA.

The activities completed under this project are the following:

- Screening of tube wells for arsenic contamination.
- Creating public awareness
- Identified alternative water sources.
- Installed an 'Arsenic Removal Plant' presently being used by about 200 households.
- Provided 'Bucket Treatment Unit',

Ongoing Activities:

Integrated Food Security Program:

This component of Care, Bangladesh is addressing the arsenic issues through its FPP and SHAHAR projects with a project duration from 2000 to 2004.

The activities under these projects are the following:

- Tube-well screening for arsenic contamination.
- Creating arsenic awareness
- Implementation of arsenic mitigation water options.
- Identification of patients and referrals.

The Working Areas are:-

Netrokona, Kishoregonj, Sunamganj, Kurigram, Gaibandha, Sirajgonj, Dinajpur (Dinajpur Pourashava), Jessore (Jessore Pourashava), Mymensingh (Mymensingh Pourashava), Gazipur (Tongi Pourashava).

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14 Dhaka Ahsania Mission (DPHE-DANIDA Arsenic Mitigation Component)

Within the broad framework of the objectives of the DPHE-Danida Arsenic Mitigation Component, Dhaka Ahsania Mission signed an agreement with Royal Danish Embassy in July 2001 to implement the activities of the component. The objective of the component is to contribute to the national objectives of the removing arsenic from drinking water and supply arsenic free water from alternative water sources in arsenic affected areas and to reduce arsenic induced mortality and morbidity.

Target Group:

The arsenic mitigation component will mainly target the 4.0 million population of 148 unions of 5 districts under Noakhali and Patuakhali region for the duration of July 2001 to June 2004.

Completed Activities:

- ◆ Base line survey
- ◆ Finalization of implementation plan
- ◆ Orientation and training for central, district and upazilla level staff about the implementation of arsenic mitigation component.
- ◆ Screening of 90,000 tube wells
- ◆ Installation of 1000 deep tube Hand Tube wells (DHTW)
- ◆ Registration of visible manifestation of arsenic poisoning.

Ongoing Activities:

- ◆ Tube well screening
- ◆ Patient identification
- ◆ Awareness raising
- ◆ Hygiene promotion
- ◆ Promotion of household mitigation options.

Future Plan and Activities:

- ◆ Installation of 5000 DHTWs in the component area.
- ◆ Social mobilization program
- ◆ Promotion of three household treatment options (BTU, 3 Kolshi unit and Bashi Pani method) as an intermediate arsenic mitigation measure.
- ◆ Distribution of BTUs or 3-Kolshi units to the real poor at a highly subsidized price.
- ◆ Establishment of 20 mini pipe schemes at community level.
- ◆ Implementation of rainwater harvesting and pond sand filter (PSF) in areas which are not technically feasible for DHTW installation.

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15 Dhaka Community Hospital Trust (DCHT)

DCH, a private sector, non-profit institution, has contributed significantly towards raising arsenic awareness at Government and international level and have alerted the general public to the incidence of arsenicosis. In 1996 DCH identified the first arsenicosis patient in Bangladesh and made the issue public.

Main Objectives of DCH in this regard: The target of Dhaka Community Hospital is to provide safe drinking water for the people and treatment for the arsenicosis patients through-

- a) Taking sustainable and community acceptable water options
- B) Consulting the community for taking mitigation measures
- C) Operational and maintenance activity must be directed by the community and community based organization
- D) Drives for screening of patients
- E) Facilitating the rural centres to identify and management of patients
- F) Develop a patients management protocol

Completed activities:

In 1999 DCH completed a UNDP/WB supported survey (Rapid Assessment Project - RAP) in 500 villages on behalf of MoH&FW, to verify the extent of contamination and arsenicosis. Using its own resources, DCH has also completed a country-wide sampling survey of tubewell water and found evidence that 41 of a total of 64 districts could be at risk. DCH undertook an extension to the RAP, within a further 300 villages. This study was managed and executed through MoH&FW (section 3.2), UNDP funded and completed June 2000.

DCH, in collaboration with NGO Forum, Village Education Centre and WaterAid Bangladesh, have undertaken small scale arsenic action research into the effectiveness of community mobilisation and information systems.

On going Activities (From 1996 to date)

The ongoing projects of Dhaka Community Hospital are listed below and more information on activities can be found in Annex YY:

1. **Arsenic Problem, Causes and Remedies in Bangladesh** (July 1996 – ongoing)
Executing and Funding Agencies: Dhaka Community Hospital & SOES, Jadavpur University, Calcutta, India.
2. **Community Based Arsenic Mitigation Project** (Support: UNICEF-DPHE-DCH)
Project Area 1: 182 (all) village of Sirajdikhan Upazila of Munshiganj district
Duration: June 2001 to May 2003
Project Area 2: 171 Village of Bera Upazila of Pabna District
Duration: July 1999 and ongoing (2 years support by UNICEF-DCH)
3. **Emergency Arsenic Screening Project:** (Support: BAMWSP and DCH)
Project Area: 558 (all) village of Laksham Upazila of Comilla district
Duration: November 2000 to continue (BAMWSP provided funds for 6 month, now DCH is continuing its activities by its own funds)
4. **Assessment of Arsenic Contamination in Hand Pump Project:** (Support: CARE-Bangladesh)
Project Areas: 225 village of 11 Upazilas; & 4 district towns of 4 Districts
Duration: October 2001 June 2002
5. **Arsenic Patient Identification and Management in 14 Upazila** (Support: UNICEF and DCH).
Project Areas: All the villages of 14 Upazila. (DCH alone in 7 Upazilas and DCH and DGHS jointly in 7 Upazila)
Duration:

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- 6. Patient Identification and Management:** (Funding: DCH)
Project area: 25 Areas of 21 Upazilas
Duration: 1996 to date
- 7. Arsenic Patient Management at Hospital:** (Funding: DCH)
Number of Patients Treated: 587
Duration: July 1996 and ongoing
- 8. Establishment of Bangladesh-Australia Arsenic Mitigation Resource Centre**
(Support: AusAid)
Project area: 30 village of Bangladesh
Duration: 2002 to 2003 (2 years)
- 9. Molecular Epidemiology of Arsenic Exposure and Skin Lesions in Bangladesh** (Support: Harvard University, USA and DCH)
Sample size: 1600 case and control
Duration: 2001 to 2003 (3 years)
- 10. Pilot Study on Community Based Arsenic Mitigation:** (Support: UNDP and DCH)
Project Area: 2 village
Duration: August 2000 to July 2001 (DCH is continuing the project on its own)
- 11. Assessment of Arsenic Contamination of Town Water:** (Funding: DCH)
Project area: All the districts
Duration: 2000 to continue
- 12. National Screening of Arsenic Contamination:** (Support: BAMWSP)
Project Area: 31 Upazila
Duration: September 2002 to December 2002
- 13. Arsenic Mobile Clinic:** DCH has been running its mobile arsenic clinic since the problem emerged. The mobile clinics screen the arsenic patients and give them treatment. If necessary the clinics refer patients to its hospital. The clinics also screen tube well that is being used by the patients.
- 14. Arsenic Training Programme:** Dhaka Community Hospital is well-reputed training organisation nationally and internationally. So far it has trained up 371 doctors, 420 village doctors, 200 government officials, 80 donor and international agency officials, 15 00 NGO staffs, 410 community leaders, 4043 community workers nationally. DCH also trained up medical personnel and other officials of Nepal and Vietnam government.
- 15. Patients Referral System:** Dhaka Community Hospital is the only hospital in the country that is working as an arsenic patient's referral centre. Our rural health clinics, mobile clinics refer patients to its hospital. Government hospitals, NGOs, donors are also referring arsenic patients to DCH. Dhaka Community Hospital is developing an Arsenic Patients Management Protocol in collaboration with international universities and research institutions.
- 16. Water Testing Laboratory:** Dhaka Community Hospital has set up an water quality testing laboratory by its own with the technical help of SOES, Jadavpur University, Kolkata, India in 2000. It is regularly testing parameters of water quality like Arsenic, Iron, Phosphate, Potassium, Aluminium, Sulphate, Fluoride, Sodium, Chloride, Nitrite, Nitrate, Alkalinity, **Salinity, Calcium, Turbidity, COD, BOD**, Bacteriological analysis are being done here. We offer individuals, institutions, NGOs to use the facility at a cheaper rate.
- 17. Communication Materials:** Dhaka Community Hospital has produced leaflets and posters for creation awareness in the community. DCH has 9 video documentary on arsenic issue both in Bangla and English. It is available in CD also. In our project areas, rural health clinics and the mobile clinics are showing the videos among the people. The training department developed other communication materials like flip chart, patients identification protocol etc.

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- 18. Dissemination of Information:** Dhaka Community Hospital is very sincere and careful for disseminating information. We share all information with the community, stakeholders, NAMIC and other government offices and other concerned agencies nationally and internationally. Through monthly newsletter (publication and email system), press briefing and press release, stories published in the newspapers and various radio and television programmes DCH is distributing information all over the country and abroad. It conducts regular meeting with community people, community leaders and media people. Besides these Dhaka Community Hospital hold meetings with universities, colleges, schools and other educational institutes and organisations.
- 19. Advocacy at Policy Level:** Dhaka Community Hospital is continuously lobbying at the policy level to combat arsenic menace. It has been emphasising to use natural and indigenous resources to make mitigation programmes sustainable. DCH is taking part in the policy planning and implementation. From the very beginning it has been suggesting about the use of surface water, banning further tubewell installation, to give VGF card to the arsenic victims, providing free treatment for the patients and reducing safe level of arsenic in water at 0.01 mg/l.
- 20. Conference/Seminars:** Dhaka Community Hospital is organising conference, seminars and workshop in regard of arsenic poisoning in ground water in Bangladesh. Besides hundred of seminars-workshops at the national and local level DCH has organised 4 international conferences in Dhaka. The conferences made 4 DHAKA DECLERATIONS. The last conference was organised in January 2002 and the Honourable President of the People's Republic of Bangladesh was present as the Chief Guest.

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16 Grameen Bank (Grameen Shikkha)

Grameen Bank, with assistance from UNICEF and DPHE, started its testing programme in 1997 in Chandpur district. The project followed an integrated approach and included four main activities: communication about arsenic and arsenicosis; testing of all tubewells in the upazilla; arsenicosis patient identification / support; implementation, monitoring and evaluation of alternative water supply technologies. The technologies tested ranged from home-based solutions such as the 3-kalshi arsenic removal filter to community-based solutions such as the Pond Sand Filter (PSF) for treatment of surface water.

Ongoing Activities:

Grameen Shikkha and UNICEF are jointly working with the Building Community Based Arsenic Mitigation Response Capacity Project in Muradnagar upazilla, Comilla, and Shahrasti upazilla, Chandpur. Muradnagar upazilla has 22 unions and 304 villages, while Shahrasti upazilla has 9 unions, one pourashava and 176 villages. Work commenced on the project in early July/2001, tube-well testing was completed in December 2001 and awareness building work is ongoing and will continue up to May 2002.

Grameen Bank has tested 30199 tube-wells in Muradnagar upazilla out of which 28234 are found highly contaminated with arsenic. Only 1965 could be painted green, 421 are out of order (not tested). In percentage 93% tube-wells are arsenic contaminated and only 7% arsenic free. We have tested 16360 tube-wells in Shahrasti upazilla out of which 16211 are highly contaminated. Only 149 tube-wells are Green. 462 tube-wells are out of order (not tested). In percentage 99% tube-wells are arsenic contaminated and only 1% arsenic free. In 149 out of the 304 villages in Muradnagar upazilla there is not a Green tube-well at all. And in 108 out of the 176 villages in Shahrasti upazilla there is not a single Green tube-well. As they are working with the awareness work Grameen is experiencing huge demand in the community for different safe water options.

Community involvement is one of the approaches in dealing with the situation and in the solution to the problem. Another approach is communication campaign including distribution of posters, brochures, flash cards etc. Grameen Shikkha conducted district and upazilla level workshops up to April 2002. In the campaign and workshops, they demonstrated various safe water options to the villagers. Grameen also discussed with them about installation of various water options and the feedback was highly satisfactory.

Proposed activities:

Grameen Shikkha are planning, contingent upon financial assistance from UNICEF, to install in Muradnagar upazilla 35 units of PSF and 500 units of Rain Water Harvesting. We are planning to develop a RWH model village in Muradnagar with 350 RWH units, and the remaining 150 RWH units will be installed in the other villages of the upazilla for demonstration (7 units in one union). Ten test dug-wells will also be installed in the project area. Under the same project, we will install in Shahrasti upazilla 23 units of PSF and 370 units of Rain Water Harvesting. We will develop a RWH model village (similar to that in Muradnagar) with 250 RWH units, and the remaining 120 RWH units will be installed in the other villages of the upazilla for demonstration (15 units per union). Ten test dug-wells will be installed in Shahrasti.

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17 International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)

ICDDR,B is an independent, international, non-profit organization for research, education, training, clinical services, and information dissemination.

ICDDR,B is running a health and demographic surveillance system in 142 villages of the Matlab upazilla, encompassing a 220,000 population. The Matlab health and demographic surveillance system (HDSS) was initiated in 1966. The database records all vital events and health information upgraded on a monthly basis. The databases include child health, maternal health and nutrition information, and are linked to a GIS (Geographic Information System) database.

Completed Activities:

ICDDR,B has been involved in small-scale research on arsenic exposure and mitigation. A pilot study was performed in Matlab with a sample of tube wells from all areas. In Matlab surveillance systems revealing more than three quarters of samples had total arsenic above the Bangladesh permissible limit of 50 ppb.

Ongoing Activities:

ICDDR,B are currently (since 2000) initiating large-scale epidemiological studies on arsenic and health consequences. This project is co-financed by WHO and SIDA. The consequences of exposure to arsenic will be extensive and include excess incidence and mortality in cancers and cardio-vascular diseases. However, the knowledge base is weak on the weight of this new burden of diseases and on the speed by which it develops. Little is known about the reproductive health consequences, and about the possible aggravating role of the widespread malnutrition in Bangladesh on arsenic-induced health effects.

The areas of Matlab are heavily affected by the arsenic contamination of drinking water. Screening for skin lesions in the 220,000 population, assessment of arsenic content of the 9000 (? or 15000) tube wells of the Matlab surveillance area, and an establishment of a data base for epidemiological studies of levels of arsenic exposure and manifestations of arsenicosis in the population will take place. Immediate analyses will be performed on the risk for arsenic related skin lesions and effects on reproductive outcome and mortality. A village-based arsenic mitigation activity is coordinated with the surveillance, and priority will be given to the areas with the highest exposure. Reversibility of skin changes will be assessed. The consequences of a shift to other water sources will also be evaluated, including monitoring of diarrhoeal diseases through the surveillance system in Matlab.

The mitigation activity is collaborated with BRAC, a major national NGO with the longest experience of arsenic mitigation programmes in Bangladesh. Collaboration is suggested with the Institute of Environmental Medicine, Division of Metals and Health, Karolinska Institutet, Sweden, in the area of arsenic biochemistry. The project will assist ICDDR,B to purchase analytical instrumentation for analysis of water and biological samples for arsenic and provide funds for the field research.

Prof. Lars Ake Persson is the project coordinator. The project has started in late 2001 and present WHO funding will be exhausted by end of 2002. The overall project will be completed in late 2003.

ICDDR,B has been working through local and international NGOs on arsenic monitoring and mitigation efforts which have included testing household level arsenic removal technologies, pond sand filter testing and piloting low cost rainwater harvesting techniques.

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18. IDE (International Development Enterprises)

IDE is a not-for-profit development organization based in Denver, Colorado, USA. Their mission is to improve the social, economic and International Development Enterprises (IDE) environmental conditions of the world's poorest people by identifying, developing, and marketing affordable technologies that can be manufactured locally and sold at a fair market price through a private sector supply chain.

As part of its efforts to address the arsenic crisis, IDE concentrated its activities on the imperative of exploring a variety of arsenic mitigation technology options and to look for alternative sources of safe drinking water. The critical factors IDE took into consideration are:

- a. provision for household level solutions,
- b. affordability (offer multiple technology/price options),
- c. reliability and effectiveness.

Low Cost Rainwater Harvesting System and Shapla Arsenic Removal Filter are specific technologies that IDE has developed through intensive laboratory and field-testing and are ready for rural use.

The Shapla filter has been developed in collaboration with Dr. Fakhru Islam, Professor of Applied Chemistry and Chemical Technology, Rajshahi University. It uses an inexpensive filter media of iron salt solution bonded to crushed brick particles. Further details are given in Annex 5 J. Tests of the Shapla filter have been undertaken in Bangladesh by IDE in conjunction with UNICEF, Danida and WorldVision as well as BRAC and Grameen.

Beginning in April 2000, the development of Rain Water Harvesting Systems (RWHS) has evolved through several stages each providing an option for safe drinking water. The original design costs varied between 4,500 Taka and 7,500 Taka for a 2,000 and 3,000-liter storage tanks. In September 2001, at IDE's research center in Savar, IDE innovated a "breakthrough" technology, which reduced the cost of the conventional 3,000-liter rainwater storage tank, dramatically. The current cost per liter is 1.3 Taka of this tank to the customer for a 3,000-liter system, which includes guttering systems and a reasonable profit for private sector supply chain. IDE continues research on further reduction of cost per liter.

Up to now, clean, safe, Rainwater Harvesting Systems have only been available to a small number of households in arsenic affected rural communities. IDE is currently working closely with SDC, DPHE, UNICEF, World Vision and local partner NGOs on rainwater harvesting systems with a goal to achieve the following:

1. To increase public awareness through education on the arsenic contamination of ground water in Bangladesh
2. To test arsenic levels in tube-wells and other water sources
3. To develop low-cost arsenic mitigation options which includes rainwater-harvesting systems (RWHS) and Shapla Filter.

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19 NGO Forum for Drinking Water Supply & Sanitation

NGO Forum for Drinking Water Supply & Sanitation was formed in 1982 in line with the International Drinking Water Supply and Sanitation Decade (1981-90) under the joint auspices of the leading national NGOs and UN Steering Committee on IDWSSD in Bangladesh to support safe water supply and environmental sanitation activities of the grassroots NGOs in Bangladesh. NGO Forum functions on partnership approach. Through forging of alliances with 533 NGOs & Community Based Organizations (CBOs), NGO Forum has spread its WatSan (Water & Sanitation) network throughout Bangladesh.

The discovery of arsenic in groundwater has generated great concern in the public health sector of Bangladesh. NGO Forum has been striving to mitigate this arsenic problem as far as its resources permit. A brief account of the activities that has so far been performed by NGO Forum in relation to arsenic is outlined below:

19.1 ARSENIC CELL

As an apex service delivery agency of WatSan programme implementing NGOs and CBOs in Bangladesh NGO Forum is responsible to provide all its possible effort to meet any WatSan related crisis such as the acute environmental hazard due to the presence of arsenic in groundwater. In this regard, NGO Forum has established an “**Arsenic Cell**” to focus and priorities its involvement in arsenic mitigation activities to supply safe water.

Objectives of the Cell:

The ultimate goal of the Arsenic Cell is to provide safe drinking water for the people in the intervention areas through –

- I. Exploring the possibilities of applicable and sustainable mitigation measures as well as seeking alternative water supply sources.
- II. Implementation of arsenic mitigating activities for safe water supply through NGOs & CBOs.
- III. Setting up a decentralised organisational structure capable of implementing operating, and maintaining the mitigation measures.

The above mentioned objectives will be attained by –

- I. Networking and collaboration with the NGOs, CBOs, government & external support agencies, multilateral organisations, researchers and academics working on this issue.
- II. Optimal utilisation of NGO Forum’s resources - both software & hardware - in implementing arsenic mitigation measures.

19.2 TESTING OF WATER SAMPLES

NGO Forum started detecting the presence of arsenic in ground water through its regional offices since October 1997. It has tested 35912 water samples so far with the help of available field testing kit. Out of this total number of tested samples, 8618 were found arsenic contaminated.

All these tests were conducted in 2882 villages in 257 Upazilas of 58 districts. Out of those tests 782 villages were found having arsenic above the permissible limit. The concentrations of arsenic were detected from 0.10 mg/L to 3.0 mg/L and the depth of the affected tubewells varies from 26 feet to 960 feet. The lowest depth of tubewells were found in Laxmipur, Chandpur, Barisal districts and the highest depths were found in Jessore, Satkhira, Sylhet, Moulvibazar, Sunamganj districts.

This information are shared regularly with National Arsenic Mitigation Information Centre (NAMIC).

Beyond the establishment of the Arsenic Cell and the water quality testing, NGO Forum is also giving due emphasis on the following areas:

19.3 INTER-AGENCY & TRANS SECTORAL COLLABORATION

NGO Forum has been maintaining close collaboration with relevant government agencies (DPHE, NIPSOM, LGED, etc.), Universities, UN bodies (UNICEF, World Bank, etc.), Donors, DPHE-DANIDA, Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) as well as with other NGOs in relation to arsenic by

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sharing findings of its field level interventions. NGO Forum is also extending necessary cooperation to other stakeholders at the field level to identify arsenicosis affected patients and also to test water samples. NGO Forum is playing a vital role in Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) as a member of the steering committee as well as also in the implementation of the project including selection of Partner NGOs and CBOs for implementation in the selected area. NGO Forum is also working as one of the support organisations (SO) of BAMWSP to implement arsenic related activities at Harirampur Upazila of Manikganj.

19.4 FACILITATION OF ARSENIC RELATED TRAINING COURSES

NGO Forum is well recognized by nationally and internationally both as one of the training providing organization on arsenic issue. NGO Forum has a good experience to conduct arsenic related training courses with the collaboration of BAMWSP.

19.5 DEVELOPMENT COMMUNICATION MATERIALS

NGO Forum has developed and produced posters and leaflets and an 'Arsenic communication material package' on arsenic issue. These materials have been distributed among the affected community people through the partner NGOs & CBOs of NGO Forum and also among other stakeholders including mass media and NAMIC. The 'arsenic related communication material package' has been developed by Development communication cell in collaboration with Arsenic cell. The package specially developed for grassroots level NGOs, CBOs and people contains an arsenic booklet, 3 posters, 2 stickers, 2 leaflets, a manual on arsenicosis patient identification and a flip chart on arsenic free, safe water options.. The Arsenic cell also developed 2 videocassettes on arsenic related issues (1 in Bengali & 1 in English) in collaboration with Training cell. These materials are also available for sale.

19.6 INFORMATION DISSEMINATION

NGO Forum has been disseminating research-oriented information relating to arsenic and arsenicosis through its monthly Bengali newsletter titled "PANIPRABAHO" and quarterly English newsletter "WatSan". These newsletters are distributed among various NGOs, government offices and other concerned stakeholders all over the country.

NGO Forum has been discussing the arsenic issue on priority basis at different WatSan related gatherings such as workshops, seminars, discussion forums, etc. with the partner NGOs & CBOs, and also with all relevant agencies. Moreover, the issue is regularly being discussed in the community level through NGO Forum's promotional activities such as courtyard meetings, local discussion forums, school programmes, etc. in order to avoid possible panic of the community people on arsenic issue rather to help them in taking necessary preventive measures. (For details please see Annex 3)

19.7 PROVISION OF SAFE ALTERNATE WATER OPTIONS

NGO Forum is providing alternate water options such as;

- ◆ **DANIDA's Bucket Treatment Unit (BTU),**
- ◆ **Rainwater Harvesting System (RWHS),**
- ◆ **Pond Sand Filter (PSF), Dug Well,**
- ◆ **Iron Arsenic Removal Plant (IARP),** etc to the arsenic affected community.

19.8 RESEARCH ACTIVITIES

In the year of 2000, Arsenic cell completed 4 important arsenic related studies.

i) Study on Chronic arsenic exposure and respiratory effects:

A prevalence comparison study of respiratory effects among subjects with and without arsenic exposure was conducted. An article based on this study results has been accepted by the 'Journal of Occupational health' and is expected to be published in its July / September 2001 issue.

ii) A study on Evaluation of BTU in terms of Social acceptability, Arsenic removal efficiency, Health hazards and cost effectiveness.

A detail report of the study is available at Arsenic cell of the NGO Forum and can be collected on request.

iii)..A Study on Evaluation of Arsenic Detecting Field Kits

The published report is available on request.

iv) An Intervention Trial to Assess the Contribution of Food Chain to Total Arsenic Exposure in collaboration with Australian National University.

The report of the study is available on request.

19.9 WATER QUALITY TESTING LABORATORY

NGO Forum has established a water quality-testing laboratory. It is the first of its kind full-fledged water-testing laboratory in NGO sector. Funded by Danida, the laboratory has been developed with the technical assistance of School of Environmental Studies (SOES), Jadavpur University, Calcutta, India. Various parameters of water including Arsenic, Iron, Residual Chlorine, Chloride, Fluoride, Nitrite, Nitrate, Phosphate, Sulphate, Aluminium, pH, Total dissolved solids, Suspended solid, alkalinity, Total hardness, Salinity, Conductivity, Turbidity, Sodium, Potassium, Calcium, COD, BOD, Dissolved Oxygen, Bacteriological analysis, etc are being tested regularly in this laboratory at a cheaper rate.

19.10 CAPACITY BUILDING OF PARTNER NGOS & CBOs ON ARSENIC ACTIVITIES

NGO Forum has also been endeavouring to build up the capacity of its partner NGOs & CBOs by delivering different messages, imparting necessary training, and supplying communication materials such as posters, leaflets, etc.

NGO Forum has organised some 3-day long training courses on arsenic in different districts, which was participated by more than 1000 staff of a number of partner NGOs & CBOs. Necessary knowledge on how to test water sample and disseminate information to the community was imparted by those training courses. They also offer training services on arsenic to different external agencies, and already have trained staff of CARE, Action Aid, Save the Children Fund (Australia), Save the Children, USA, World Vision, IDE, Bangladesh etc.

Recently NGO Forum offered training services to BAMWSP for its 'Emergency Screening and Arsenicosis Patients Identification' programme involving local community people at Singair Upazila of Manikganj district. It also provided 'TOT' training to the staff of the SOs of BAMWSP, who are involved in implementing BAMWSP activities in different Upazila.

19.11 OTHER ARSENIC RELATED PROJECTS OF NGO FORUM

i). Community- Based Safe Water Supply and Arsenic Mitigation Project

Geographical Location: Babuganj Upazila under Barisal district

Funded by : UNICEF

Collaborating agency : DPHE

Project Duration : June2001- May 2003

Objectives:

- To provide basic information among community people regarding arsenic and its related health hazards to raise their awareness as regards the calamity and how to get arsenic free water;
- To determine the extent of arsenic contamination through testing of tube-well;
- To identify arsenic affected patients and support them taking possible treatment measures;
- To mobilize the local communities into arsenic mitigation through local government and existing NGO and CBO;
- To strengthen the capacity of local government for arsenic mitigation in the health and water supply sector;
- To provide the communities in selecting alternative water technologies that provide arsenic and bacteria free safe water and
- To develop a replicable model of community based arsenic mitigation that can be executed in other affected areas of the country in a wider scale.

ii) Sensitization against Arsenic and Training Help Initiatives (SATHI)

Location : All the 13 Unions of Nasirnagar Upazila

Funded By : Save the Children USA

Project Duration: Sep 2001-August 2003

Objectives :

- To increase the community awareness about arsenic contamination problem and its mitigation;
- To motivate the arsenic affected families to adopt water use for drinking and cooking purpose from the arsenic free safe water sources given the current arsenic contamination of ground water;
- To make the people aware about the low cost alternative options of arsenic free safe water;

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- To increase the capacity of the community on operation and maintenance of the alternative water options;
- To check the water quality of the alternative water options;

iii). Risk and Benefits of Arsenic Mitigation Programs in Bangladesh: Evaluation of Water Treatment Option"

NGO Forum has started a new project in collaboration with Australian National University titled "Risk and Benefits of Arsenic Mitigation Programs in Bangladesh: Evaluation of Water Treatment Option"

Objective:

The objective of this study is to assess the effectiveness in the field of interventions currently in place in Bangladesh as part of the arsenic mitigation program. The two interventions to be assessed are the three-pitcher filter and the sanitary protected dug-well.

The project has been started in September 2001 and will be continued until February 2003. Data analysis and report writing is expected to be completed by June 2004.

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20. NGOs Arsenic Information and Support Unit – (NAISU) A new initiative of NGO Forum

NGO Forum recently launched a project titled 'NGOs Arsenic Information and Support Unit (NAISU)' in collaboration with WaterAid, Bangladesh. The main objective of this project is to increase the access of the general people as well as grassroots level NGOs & CBOs to essential arsenic related valid information through different participatory approaches. With the view of its objectives "NAISU" publishes quarterly arsenic bulletin which disseminates arsenic related valid information in easy Bangla. Besides, NAISU has already prepared a "Training Manual" with most urgent and valid information regarding arsenic readily accessible to field workers using the most effective way of communication. It has prepared the communication material, "Charai Charai Arsenic" (already published and available at NAISU), and "Bornomalai Arsenic", Procholito Charai arsenic, "Flip Chart" "Namta Pathe Arsenic" which are going to be published very soon. NAISU has a vision to work as a focal point for arsenic related information collected a collated from different governmental and non-governmental organisations.

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21. Ontario Centre for Environmental Technology Advancement (OCETA)

The Government of Bangladesh is implementing the ETV-AM (Environmental Technology Verification – Arsenic Mitigation) Program for the assessment and verification of arsenic removal technologies for drinking water. This program will ensure that arsenic mitigation technologies being proposed for use in Bangladesh meet Bangladesh drinking water quality standards.

A partnership agreement outlining the roles and responsibilities for implementation of this program has been signed between the Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) of the Ministry of LGRDC, and the Bangladesh Council of Scientific and Industrial Research (BCSIR) of the Ministry of Science and Technology (MoST). The development of a formal technology verification program by BCSIR through partnership with BAMWSP requires that goals and timeframes for achieving goals be clearly identified. Therefore BCSIR has developed a work plan to provide a clear strategy for implementing the ETV – AM Program over the next two years. The work plan describes BCSIR's roles, responsibilities and activities, including the establishment of the necessary management structure, process, resources and infrastructure within BCSIR and training requirements.

Meanwhile the arsenic removal technology verification process has already begun by inviting the first batch of candidate technologies to register with BCSIR prior to participating in the ETV-AM Program. The advertisement went to the newspaper on 24th of January 2002. BCSIR started the registration process on 9th February 2002 and last date of registration was 28th February 2002. Technology proponents went to BCSIR to register with the ETV-AM Program. After completing the registration forms, the BCSIR provided proponents with the electronic application forms. Proponents submitted the electronic and hard copy of the completed application forms to BCSIR. Last date of submitting forms was 9th March 2002. Technical, social and fiscal information are required for the screening process. BCSIR is responsible for safe custody of all confidential and proprietary information.

The ETV – AM staff of OCETA and BCSIR are now proceeding with the first batch technology screening according to the Screening Protocol. Government of Canada will fund the testing and verification of up to 12 technologies that are selected using criteria in the Screening Protocol. The Screening Protocol will enable the team to rank technologies according to how well they meet Bangladesh requirements.

Technologies with adequate laboratory and field test data generated by an independent testing agency can bypass laboratory and field testing and proceed to verification. Technologies requiring laboratory and field test data must undergo an independent laboratory and field assessment based on the requirements and guidelines described in the Laboratory Protocol and the Field Testing Protocol.

The ETV-AM team of OCETA is working intensively with the ETV-AM team of BCSIR and providing necessary assistance and training such that BCSIR personnel gain the experience and management skills to manage the ETV-AM Program.

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22. PROSHIKA

In the context of the arsenic crisis in Bangladesh PROSHIKA is working to ensure arsenic free water to the community through surface water treatment technologies and arsenic treatment technologies with giving more emphasis on surface water treatment. PROSHIKA in collaboration with international agencies has experimented and tested with two types of surface water treatment plant and two types of arsenic removal plant from existing tube-wells – that is;

- ◆ Household level slow sand filters for surface water treatment.
- ◆ Community based surface water treatment plant.
- ◆ Household arsenic removal filter.
- ◆ Community based arsenic treatment plant.

A. Surface Water Treatment Technology:

- a. Household filter Bashundhara
- b. Community Based Surface Water Treatment Plant- Nirapod (please see annex)

B. Arsenic Removal Technology:

- a. Household Arsenic Filter
- b. Community Based Arsenic Removal Plant

Besides the installation of the water purification plant, 30,000 tube-wells are tested for arsenic and marked according to the level of arsenic contamination, awareness building (staff and community), advocacy program and referral of suspected arsenicosis cases.

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23. Village Education Resource Center (VERC)

VERC are actively involved in the tubewell screening and development of community led arsenic mitigation strategies and approaches. As a partner organization of BAMWSP, VERC implemented the activities of survey and identification of arsenicosis patients in six Unions of Bhairab Upazila in Kishoregonj District and seven Union of Belabo Upazila in Narsingdi. The activities such as conducting of advocacy workshop, imparting training, the task of testing tube-well water for arsenic and arsenicosis patient identification in all Unions were completed within the project period. The data are available on request.

Activities on Arsenic in BAMWSP Project

Project Area – 1	Project Area – 2
<p>District: Kishoregonj</p> <p>Upazila: Bhairab</p> <p>Union: Shibpur, Kalikaprasad, Sadekpur, Shimulkandi, Aga Nagar, Gazaria</p> <p>Project Period: Nov. 2000 – Feb. 2001</p>	<p>District: Narsingdi</p> <p>Upazila: Belabo</p> <p>Union: Belabo, Binyabaid, Sallabad, Narayanpur, Amlabo, Patuli, Bajnabo</p> <p>Project Period: June 2001 – Aug. 2001</p>

The main components of this project are:

- Orientation and training for different types of stakeholders
- Household survey
- Tube-well water testing
- Identification of Arsenicosis patient

Water Aid Supported Activities:

VERC and WaterAid Bangladesh are working together in the piloting of household level arsenic removal technologies, tubewell screening, community awareness raising and community led mitigation activities in their project areas of Sitakunda and Nawabgonj.

i) *Water point screening activities:*

In all 1616 water point have been tested for arsenic. Verc tested the shallow tube-wells, ring wells, deep tube-wells and Tara Pumps in different areas as Sitakunda, Chittagong, tekna in Cox's bazaar, Lalmohan in Bhola, Chapai Nawabganj, Barishal, Rajshahi and Naogoan. The data regarding this is available on request.

ii) *Motivational Activities for Awareness rising on Arsenic contamination issues:*

Two field workers are disseminating information on arsenic among the community people intensively in Muradpur and Sayedpur Union under Sitakunda Upazila in Chittagong District

The following issues are discussed in the sessions:

- Not to drink and cook with red colored tube well water.
- Eat more green vegetables.
- Share green color tube well water for drinking and cooking.
- Showing the symptoms of arsenicosis using posters.

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24. WaterAid Bangladesh

WaterAid Bangladesh is actively involved in: community level arsenic screening, awareness raising and mitigation, through their rural, urban and national NGO partner organisations), plus; advocacy of best practice and co-ordination at national and policy level. WaterAid emphasizes the need to consider arsenic within the overall context of water quality and public health.

Completed Activities:

8.1 WaterAid Bangladesh researched and produced the original report "**Arsenic 2000: An Overview of the Arsenic Issue in Bangladesh**" which was finalized in February 2001. Developments in this sector have occurred rapidly in the past year and WaterAid Bangladesh is supporting NAISU in their updating of this report. WaterAid Bangladesh participated in the expert panel of the arsenic awareness raising public meeting held in the British House of Lords, December 2000.

8.2 WaterAid, working in collaboration with British Geological Survey (BGS), developed a six page **Arsenic Fact Sheet** (see Annexe 10) summarising the health effects, occurrence in groundwater, field testing methodologies and remediation techniques.

8.3 WaterAid Bangladesh and a rural partner NGO, the Village Education Resource Centre (VERC), have worked together in the **piloting of household arsenic removal technologies, screening and mitigation** in their project areas of Sitakunda and Nawabgonj.

8.4 Village Education Resource Centre (VERC) in collaboration with WaterAid Bangladesh, DCHT and NGO Forum undertook small-scale **action research into the effectiveness of community mobilisation and arsenic information systems**.

8.5 WaterAid Bangladesh and VERC have provided **alternative water supply options** such as deep tube wells in arsenic prone areas. They have assessed the safety risks involved with the excavation of ring wells and have developed safe working methods using the Reverse Chicago Method which is detailed in the illustrated VERC *Ring well Manual*.

8.6 **The DFID-funded Rapid Assessment of Household level Arsenic Removal Technologies** was jointly managed by WaterAid Bangladesh, DFID and implemented by WS Atkins International Ltd. The consultancy focussed on household level arsenic removal technologies with a first phase concentrating on field testing technical parameters and a second phase of technical and social parameter testing. The final report (March 2001) was reviewed by the BAMWSP Technical Advisory Group (TAG) who then recommended five arsenic removal technologies to use in acute arsenic affected areas on an experimental basis, and also fed its rapid response results into longer-term initiatives in Bangladesh. Canadian CIDA have supported a substantial intervention in partnership with Bangladeshi agencies to assist BAMWSP to develop an Environmental Technology Verification (ETV-AM) protocol and OCETA is assisting with the long-term assessment of technological options.

Ongoing and Proposed Activities

8.7 WaterAid Bangladesh and its partners are continuing to focus on providing safe water and sanitation through people-centred approaches. WaterAid Bangladesh have evaluated **existing best practice in arsenic field testing methods and test kits**, and have produced an **Arsenic Field Testing Protocol** for use by their partner organisations. They are continually updating these approaches as new information and technologies become available. They are also providing practical training in arsenic issues and field testing. WaterAid and partners are continuing to provide **alternative water supply options** such as rainwater harvesting, surface / deep wells in arsenic prone areas.

8.8 A formal partnership between NGO Forum for Drinking Water Supply & Sanitation and WaterAid Bangladesh exists, for funding and support to the **NGOs Arsenic Information and Support Unit (NAISU)** which commenced in early 2001. NAISU's objective is to assist in the synthesis and promotion of easily understandable, appropriate and reliable information dissemination to communities affected by arsenic and field workers involved in arsenic mitigation initiatives. WaterAid Bangladesh has recently been supporting NAISU in the update of the Arsenic 2000 report to provide an Arsenic 2002 edition. WaterAid Bangladesh is currently proposing to strengthen funding support to NAISU to expand its range of activities.

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The NAISU target information group is an important aspect of the approach as the aim is to ensure understanding of the cause, effect and mitigation measures of arsenic and other water quality issues in groundwater. The target group will include communities, field workers and office workers. These target groups require different levels of information presented in an appropriate format. In order to reach the broadest possible network the NGO Forum regional offices will have access to information via email, telephone and the postal service.

NAISU's immediate objectives are to reach out and support small to medium sized NGOs across Bangladesh who are trying to understand the issues surrounding arsenic contamination of water supplies and support them to assist their beneficiaries to address and tackle these issues. NAISU will also further develop and disseminate layman's (easily understood) Bangla and English language material and training to a target population of affected communities and non-technical field workers.

8.9 The WaterAid Bangladesh Programme Support Team have developed **two sets of participatory arsenic awareness tools** which encourage discussion and understanding at community level, and continue to carry out training and refresher training to trainers and field staff in the use of these tools.

8.10 WaterAid Bangladesh is currently designing an expansion of their rural and urban programmes for sustainable environmental health. As part of an integrated approach to hygiene promotion, sanitation and water supply, WaterAid Bangladesh and partners will be seeking to further develop sustainable, people-centred approaches to community managed, safe water supplies including those in arsenic prone areas.

WaterAid Bangladesh actively encourages **coordination and information sharing** amongst all stakeholders involved in arsenic mitigation.

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25. Water and Sanitation Programme (WSP) Bangladesh

Established in 1979, WSP is an international partnership whose mission is to help the poor gain sustained access to improved water and sanitation services. WSP is administered by the World Bank, and enjoys financial support of many of the world's foremost international development agencies. WSP has presence in Latin America, Africa, East Asia and South Asia. In South Asia, WSP has country offices in India, Pakistan and Bangladesh.

The WSP is involved in piloting innovative approaches for rural and urban water and sanitation services. WSP helps governments in strengthening and refining policies with the lessons learned from the pilots and other best practices. WSP disseminates knowledge through publications and learning events.

WSP Bangladesh has been involved in arsenic mitigation initiatives in Bangladesh since the identification of the problem. It worked closely with the World Bank in identifying the key requirements to handle the crisis. As a result, a groundwater study was launched with financial assistance from DFID. Similarly, UNDP launched a rapid appraisal project in suspected hard-hit areas. WSP assisted the World Bank and the Government of Bangladesh in the preparation and undertaking the Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP).

Currently WSP Bangladesh is conducting a number of pilot projects in rural piped water supply with one-point water quality monitoring and treatment. It is also assisting BAMWSP in implementing arsenic mitigation activities in urban areas. In addition, it is looking into ways to strengthen the local government bodies for decentralized service delivery.

WSP Bangladesh has recently conducted two major studies on arsenic mitigation and sustainable water supply. The first one is a need assessment for local government involvement for decentralized, scalable and sustainable water supply. The second one is entitled "Fighting arsenic – listening to rural communities: willingness to pay for arsenic free safe drinking water in Bangladesh". This is an investigation about people's preferences for various arsenic mitigation options and their willingness to pay for such alternatives. This study used a state-of-the-art contingency valuation method. Both studies were carried out by internationally renowned experts. Study reports are available from WSP.

WSP Bangladesh has strategic partnership agreement with the Local Government Division and the Rural Development Academy of the government. It also co-chairs the Local Consultative Sub-Group on Water and sanitation – the main coordination body of donor agencies and other stakeholders. Through these instruments of partnership, WSP promotes the best knowledge and experience among its partners.

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26. WATSAN PARTNERSHIP PROJECT (WPP) / SDC

The WatSan Partnership Project (WPP) is a unique partnership initiative of SDC to create sustainable access to water and sanitation facilities. The WPP has been working in the districts of Rajshahi and Chapai Nawabganj of Bangladesh since 1998. The prime focus of the WPP was on testing new strategic orientation and partnership for WSS service in particular and development in general. The Project aimed to develop mutual beneficial relationships among organizations, where roles, responsibilities, and accountabilities are clearly defined. The WPP partnership is based on three international NGOs - CARE, DASCOH and IDE - act as support organizations to facilitate the development of community level organizations and building their capacity in working towards sustainable community-based organizations. SDC plays an important role as the initiator of the approach and funding the project. It also extends its cooperation through co-ordination and management of the project partners and providing technical assistance through the Project Management Unit (PMU). The WPP has selected and trained 15 local NGOs to works as implementing/ facilitating organizations. The Project furthermore collaborates with local set-up of government line agencies of different ministries and the Union Council.

The WPP partners, having worked together for a number of years enjoy significant positive synergies and provide an opportunity for the implementation of the community based arsenic screening and mitigation program in the WatSan Project Area. Accordingly the WPP has completed the arsenic screening and mitigation program in 640 villages distributed in 10 Upazillas under Rajshahi and Chapai Nawabganj districts 2001. The report is made available on request to the organization.

Objectives of the WPP Arsenic Program were:

- Create arsenic awareness.
- Capability building for arsenic testing.
- Build capacity of VDCs for CAP and self-monitoring.
- Screen all operational groundwater sources in WPP area.
- Identify arsenic patients and linkage with Upazilla Health Program.
- Provide support for emergency mitigation (Rx, Safe water).

To mitigate the arsenic problem, WPP has been working with arsenic reduction technologies and alternative safe water sources. The arsenic reduction options tested are Shapla Filter, DPHE/ DANIDA Bucket Treatment Unit (BTU), Three Pitcher Method, Safi Filter, BCSIR filter, Alcan filter and SORAS. The alternative water source options are rainwater harvesting, dugwells (with handpump, with rope pump and open with protection) and SODIS and terra cotta filter for improving the bacteriological water quality. The village piped water supply action research is also being implemented in collaboration with the Water and Sanitation Program of the World Bank.

The successful completion of the arsenic screening and mitigation program in 640 villages has resulted a great demand to complete the whole two districts. BAMWSP has also pleased to welcome the partnership efforts in mitigation of arsenic problems in the Rajshahi and Chapai Nawabganj districts. SDC is convinced and has planned to carry out the program in the rest of the areas of the two districts. The 2nd phase program has been started from April, 2002 and expected to be completed by December, 2003.

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27. WORLD VISION BANGLADESH (WVB)

In the context of Arsenic crisis in Bangladesh, World Vision Bangladesh has taken initiatives for its mitigation. Many of the existing technologies and approaches for provision of arsenic free safe water are considered in Food Security Enhancement Initiative Program (FSEI) covering 16 Upazila /Area Development Program (ADP) to mitigate safe drinking water contamination that described as below:

1. Coordination:

- National level coordination with Bangladesh Arsenic Mitigation and Water Supply Project (BAMWSP), UNICEF Bangladesh, CARE Bangladesh and USAID
- Upazila Coordination with Upazila Arsenic mitigation committee
- Union level Coordination with Union Arsenic mitigation committee
- WVB also coordinate with other agencies involved in Arsenic mitigation activities beyond above.

2. Water testing:

- Under ADPs (Area Development Program) in known arsenic contaminated Upazilas, 100% tube-well would be tested and marked all within June 2002. *HACH* Arsenic Test Kit is being used to make it competitive with BAMWSP. The findings on ground water testing are being forwarded to BAMWSP to incorporate in National database.
- ADPs (Area Development Program) in Upazilas where arsenic contamination yet to find will test 100 to 200 tube wells randomly across the Upazila.
- World Vision Bangladesh (WVB) has MoU with BAMWSP in 16 Upazilas (names are mentioned in Table 1 (Annex 10) and WVB will carry out ground water testing under its Food Security Enhancement Initiative Program in these areas. Table 1 shows a total of 146,691 Tubewells tested up to 30 April 2002.

3. Water facilities:

World Vision Bangladesh adapted the appropriate technology to the community considering the number of community people benefits, location, status, communities preference, working technologies & its cost and future maintenance aspect, i.e.:

- Rehabilitation of existing dug wells (**RDW**)
- Digging new dug wells (**DW**)
- Arsenic filter
- Community sand filter for arsenic contaminated tube-wells (**CSF**)
- Rain water reservoir (**RWR**)

The above can be reviewed time to time and considerable change can be made as per requirements. The plan and implementation of different technologies for Arsenic Mitigation is shown in Annex 10, Table 2.

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28. Unit for Policy Implementation (UPI)

Completed Activities:

Rapid Appraisal: On request from LGD, UPI did a Rapid Appraisal of Phase - I of Arsenic Mitigation. The main objective of the study was to assess the achievement and failures of the service delivery process with the intention of improving future projects process and implementation. The study report is currently under internal review.

Ongoing Activities:

Process Monitoring

UPI, on request from LGD, is involved in Process Monitoring (PM) of the Phase - I (pilot phase) of BAMWSP. The main focus of PM was to identify problems, and work with users/stakeholders in recommending solutions to improve subsequent projects implementation. UPI expects to continue the activity in future.

Rain Water Harvesting (RWH)

UPI has been working closely with LGD, IDE and BAMWSP in testing delivery of guttering system for rainwater harvesting leaving the responsibility for rainwater storage to the users. This system is expected to lead to a strategy to promote local initiative and private sector in production and delivery of RWH systems.

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29 Environment and Population Research Center (EPRC)

Environment and Population Research Center (EPRC) is a multi-disciplinary non government research organization. It is conducting arsenic mitigation action research in two rural and one urban sub-district. It is also conducting a study on contamination of water at household level which includes arsenic and other water quality parameters. It coordinates a network, Global Applied Research Network, South Asia for Water and Sanitation (GARNET-SA) in collaboration with WEDC, Loughborough University. The main objective of the network is to contribute towards capacity building of its member organization through exchange of information, training and collaborative project. Arsenic is one of the main themes under GARNET-SA. There are about 420 member organizations in GARNET-SA. It is working on further development of Emergency GARNET (About Emergency GARNET Filter, see annex- 05G). EPRC also runs an Environmental Laboratory.

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30. Bangladesh University for Engineering and Technology (BUET)- International Training Network-ITN

A. ITN-BUET Research:

- 1) Development of a domestic arsenic removal unit based on activated alumina,
- 2) Improvement of the two-bucket unit using ferric chloride as a coagulant,
- 3) Development of a domestic arsenic removal unit based on iron coated sand,
- 4) Development of arsenic-iron removal unit, and
- 5) Management of arsenic sludge from arsenic removal unit.
- 6) Evaluation of the performance of pond sand filters and Rainwater Harvesting as alternative sources of water supply.

B. ITN-BUET Publication:

- 1) Technologies for Removal of Arsenic from Drinking Water,
- 2) Alternative Water Supply Options for Arsenic Affected Areas in Bangladesh,

C. Workshop and Seminars

- 1) Assisted GoB in holding the International Workshop on Arsenic Mitigation in January 2002. The Proceedings has been prepared and submitted to the Government for formal publication.
- 2) Jointly organized the International Workshop on Technologies for Removal of Arsenic from Drinking Water, in May 2001 (With United Nations University).

D. Human Resource Development to Address Arsenic Issue

- 1) Organised a Specialised Course on Arsenic Contamination of Groundwater and Mitigation Options (18-23 May 2002)
- 2) Upcoming Specialised Course on Arsenic Contamination of Groundwater and Mitigation Options (10-15 August 2002)

BUET has an extensive array of arsenic measurement equipment including AASGF, AASHG, SDDC units and Field Test kits.

In addition M. Feroze Ahmed, Professor of Civil/Environmental Engineering, BUET is an active member of the BAMWSP Technical Advisory Group (See Section 1.1).

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31. Dhaka University

The University of Dhaka has undertaken a number of arsenic related research works within the Department of Geology, the Department of Soil, Water and Environment and the Department of Chemistry. These are summarised under the relevant departments below. A detailed list of the research papers produced features as Annexe 2.

Department of Geology

Department of Geology, Dhaka University has been involved in arsenic research since the very beginning of the problem. Different faculty members of the department undertake individual research, as well as there is collaboration with national and international institutions/organisations. The main area of research is the origin and occurrence of arsenic in groundwater. Some research has also been undertaken in the field of mitigation. Currently there are collaboration with national organisations such Bangladesh Water Development Board, Department of Public Health Engineering. Among the international collaborators are: British Geological Survey (UK), Columbia University, New York (USA), University College London (UK), Royal Institute of Technology of Stockholm (Sweden), Delft Technological University (the Netherlands), etc.

There are a good number of research papers published by the faculties and students of the department. Also a large number of scientific reports and thesis has been completed. The Geohazard Research Group of the department takes the leading role in arsenic research (activities has been described separately).

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Department of Soil, Water and Environment

The department runs a joint ACIAR (Australia)-Dhaka University project on the "Transfer of Arsenic in water-soil-plant systems in Bangladesh and Australia". The project duration is initially for a period of three years extendable to five years. The department is working on the arsenic load from irrigation water to the soil and its subsequent transfer to the human body and other biological systems through the food chain.

Relationships between the nutritional status of a patient and the manifestation of the contamination are being studied. Some statistical models on the whole system are being produced. The Australian team leader is Dr. RAVI NAIDU from CSIRO, Adelaide. The co-partners in the project are DCHT and INFS, Dhaka University, those in Australia are Ballarat University, CMIS, Adelaide.

Under this project the bio-accessibility of arsenic through food chain is being studied. The project started in May 2002 in Australia and the experiment will be studied on pig.

Transfer of arsenic from geological source is being studied which started in May 2002. Under this research several gangetic alluvium prone areas (30 villages) of Bangladesh are selected and the geological arsenic content of these areas will be ascertained and then the transfer of this arsenic to households, crops, irrigation, human body, neighbouring areas will be determined.

The project duration is two years and UNICEF is co funding in this project.

The laboratory at the Department of Soil, Water and Environment is equipped with AAS hydride generator to analyse Arsenic in ppb levels.

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Department of Chemistry

Research and development of the three kolshi household level arsenic removal technology in collaboration with the Sono Diagnostic Center Environment Initiative. The original sono-3-kolshi filter during this year has been totally modified in its design and operational aspects and the commercial name has been given as 'Sono Filter - model MP-ZVI (45-25)' and the patent of the technology is pending. The filtering materials are same with addition of bricks. The whole technology is under technical evaluation by the BAMWSP for its large scale application. The original published scientific document of original version is published in the 'International Conference on Bangladesh Environment 2000 and 2001' proceeding.

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32. Department of Occupational and Environmental Health (DOEH) / National Institute of Preventive and Social Medicine (NIPSOM)

The arsenic contamination in ground water in this sub-continent was first reported in the year 1983 in West Bengal, India. Having a similar geological formation and socio-economic context, Bangladesh could not escape from this catastrophe. The Department of Occupational and Environmental Health (DOEH), NIPSOM in the year 1994 started to find out the existence of this problem in Bangladesh. Getting a report from DPHE about the high arsenic content in some tubewells of Nawabganj district, DOEH performed a survey and found 8 patients in the village of Chamagram in Baroghoria union of Nawabganj district. These 8 cases were the first reported cases of Bangladesh.

Following the confirmation of these arsenicosis cases DOEH started extensive activities on arsenic contamination, which are as follows:

- 1) Formation of “ Committee for Reviewing the Situation of Arsenic in Drinking Water In Bangladesh” as per instruction of Director General Of Health Services in May 1994. NIPSOM, DPHE, Atomic Energy Commission, Geological Survey of Bangladesh, Department of Environment, WHO, UNICEF were the members of the committee and Head of DOEH was the member secretary of the committee.
- 2) Initiated a Fact Finding Survey which was carried out in 40 districts during the year 1995 – 96 and submitted report time to time to the Ministry of Health and Family Welfare.
- 3) Participated in an International Conference on Arsenic Problem held in February 1995 at Calcutta, India.
- 4) Development of Arsenic Test Kit: To identify the contaminated tubewells as well as exposed people, DOEH considered rapid screening program. With this objectives DOEH developed an effective, simple, cheap and user-friendly field level arsenic test kit which is popularly known as NIPSOM Arsenic Test Kit. Since, 1996 this Arsenic Test Kit is being used to detect arsenic in tubewell water. At present this test kit is being used widely by different national and international NGOs to test the tubewell water for arsenic.
- 5) Management of the Arsenicosis patients: Due to unsatisfactory result of treating arsenicosis patients by chelating agents like d-penicillamine, DMSA and DMPS, from 1996 DOEH started to treat and manage the patients by giving a regimen comprising Vitamin A, E & C and keratolytic ointment along with arsenic safe water. The regimen has been found effective to remove the arsenicosis manifestations quickly. This regimen is still being used through out the country to treat the arsenicosis patients.
- 6) Training Programme on Arsenic Contamination and Mitigation: In October’ 96, DOEH organized a training program on Arsenic contamination and its mitigation for different interested and related organization with the collaboration of Disaster Forum and Ministry of Health and Family Welfare. This was the first training programme on Arsenic contamination in Bangladesh. Subsequently a number of training programmes were arranged by this department.
- 7) Arsenic Removal from contaminated water and Arsenic safe water Options:
At the initial period (upto1996) DOEH advised the people to remove arsenic from the contaminated tubewell water by adding alum and distributed some arsenic removal filter of School of Environmental Studies (SOES) with the collaboration of WHO and Asia Arsenic Network(AAN)

After that they developed (1997) a chemical powder which packet was found more effective to remove arsenic. That powder was manufactured under a project of Ministry of Health and Family Welfare and distributed through out the arsenic affected areas. Due to some human behavioral and technical reasons this chemical powder could not be continued.

DOEH does not encourage the use of underground water, but rather the use of surface water for all purposes including agriculture. DOEH believes that whatever is the arsenic treatment plant or to keep arsenic inert on the surface today or tomorrow this huge amount of arsenic which will be withdrawn from the ground water will be another disaster. As such DOEH encourage to surface water more for all purposes. They are also advocating to use rain water through simple and affordable devices

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With the collaboration of AAN they are installing Pond Sand Filter (PSF) in various arsenic affected villages, which have been found cost effective surface water treatment plant and accepted by villagers. They have also installed some modified dug wells in some arsenic affected villages.

- 8) Arsenic Mitigation Activities: DOEH conducted comprehensive arsenic activities in some villages (Rajarampur of Nawabganj, Samta of Jessore, Hossainpur, Tilchandi and Nilkanda of Narayanganj,) to identify the Arsenicosis cases, management of cases, identification of contaminated tubewells, distribution of arsenic purification domestic filter and arsenic removal chemical packets for purification of water and awareness program.

In Samta the activities are still going on as a cohort study with the help of AAN, Beside regular treatment and management of patients they successfully treated 18 severe arsenicosis patients having cancer and other neoplastic manifestations due to arsenic. In other villages they are conducting arsenic mitigation program by treatment and management of the patients and providing arsenic safe water options.

- 9) BCC activities: DOEH also conducted Information, Education and Communication (IEC) activities including development and propagation of radio jingle. TV spot & posters on arsenic contamination issues for awareness and motivation of the people.

- 10) Arsenicosis case definition and case management protocol: DOEH faculty members were involved in the formulation of draft protocol for arsenicosis case definition and arsenicosis case management in collaboration with DGHS. The final documents (national consensus protocols for arsenicosis case definition and arsenicosis case management) were thus formulated in national workshops and in International workshops in the year 2002.

- 11) Research and Publications: For dissemination of information and knowledge gathered through research experience DOEH members published many research articles in national and international journal and participated in many seminars. They have published two books on arsenic contamination for easy understanding of the problem by the related personnel.

DOEH continuing their research activities on various aspects of Arsenic Contamination and Mitigation to find out a way to mitigate the arsenic contamination problem, manage the arsenic victims effectively and affordably. Every year a number of students conduct research on arsenic contamination under guidance of DOEH faculty members.

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33 Harvard/MIT projects.

Scientists from Harvard University and Massachusetts Institute of Technology (MIT) became involved with understanding, and advertising the Bangladesh arsenic problems in February 1997.

The present work has three prongs:

(1) Professor Charles Harvey and others from MIT are collaborating with Professor Feroze Ahmed and other scientists from BANGLADESH University of Engineering Technology (BUET) in attempting to understand the hydrochemistry of the problem. Highly instrumented test wells were sunk in April 2000. Cores were analysed and the water has been monitored continuously. Preliminary work has been presented at several conferences.

(2) Professor David Christiani of Harvard School of Public Health and others are performing an epidemiological study involving biomarkers. This is in collaboration with Dhaka Community Hospital.

(3) Professor Richard Wilson of the Physics Department at Harvard University started in 1998 a website: http://phys4.harvard.edu/~wilson/arsenic_project_main.html with a shortcut: arsenic.ws to advertise the worldwide nature of the arsenic problem. This site has several auxiliary pages with:

- (i) a list of all relevant arsenic references of which we are aware: [arsenic_project_references.html](#)
- (ii) a list of remediation options and technologies: [arsenic_project_remediation_technology.html](#)
- (iii) links to every website of which we are aware.
- (iv) Lists of conferences, past and future, with abstracts of papers when available: [arsenic_project_conferences.html](#)
- (iv) A searchable address list of persons concerned about arsenic.

These are updated as information becomes available. Please send comments and information of potential links to wilson@huhepl.harvard.edu and yakovlev@fas.harvard.edu This site is still widely used. The main page receives 50 hits a day.

(4) Professor Wilson has located some small funds to help Dhaka Community Hospital with test equipment (including some for project 2) and giving help to villagers get pure water in the places where we have visited.

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34 London School of Hygiene and Tropical Medicine (LSHTM)

LSHTM is co-ordinating an epidemiological research programme funded by the European Union on cancer risk related arsenic in drinking water in Europe. Tony Fletcher of LSHTM is a member of the Steering Committee for the WHO-UNF/UNFIP-UNICEF Project: "Building Community Based Arsenic Mitigation Response Capacity in Muradnagar, Serajdikhan and Bhanga Upazillas".

LSHTM, has a contract with DFID to provide occasional technical support as required to the DFID funded, Unicef managed Rural Hygiene, Sanitation and Water Supply Project.

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Methods of Detection of Arsenic

Methods of Detection of Arsenic:

Arsenic can be detected either at the field level using portable test kits or by laboratory testing. Field kits are very important given the scale of testing required but are not accurate for determining the exact arsenic concentration in water at the low concentrations important for human health. The Bangladesh standard of 50 parts per billion (ppb) for arsenic in drinking water. The equivalent of ppb is micrograms/litre or $\mu\text{g/l}$. The World Health Organisation (WHO) guideline value for arsenic in drinking water is 10ppb.

A semi quantitative result of arsenic concentration can be obtained using the field kits, most of which depend on comparing the colour obtained during the test to a colour chart with the kit.

Weaknesses of field testing include the issues such as:

- (1) the field test kits being subject to fluctuations in sensitivity and accuracy depending on the model of the kit;
- (2) excess light and certain other water quality parameters encountered in the field, are thought to interfere with the analysis,
- (3) individual differences are inevitable when many field workers are involved (i.e. operator error in the procedure or reading of result, such as confusion over decimals) and reading of the colour chart can be subjective.
- (4) field storage conditions of reagents of some kits can dramatically decrease the working life of the reagents.

Field kits users are usually from a non-technical background, and may feel pressurised to read the resulting colour to tend towards expected results. However proper training to the field workers does improve results. Some crosschecking of field results is important.

For the purpose of screening of the tube wells field testing is being widely used in spite of its limitations. Laboratory testing is much more expensive than field kit since laboratory testing has a cost of approximately US\$ 8 to US\$ 15 and the cost of field kit testing is about US\$ 0.50 per sample.

Field test kits that are commercially available use the mercury bromide method or the Silver Diphenyl Dithio Carbamate (SDDC) method. Laboratory analytical equipment used includes atomic absorption spectrometry (AAS), ICP (Inductively Coupled Plasma), Neutron Activation Analysis (NAA), ICP/MS (Inductively Coupled Plasma/Mass Spectrometry) and Anodic Stripping Voltametry, TXRF and PIXE.

Field Test Kit Methodologies

Mercury Bromide stain method

Most of the current field-test kits (e.g. Merck, Asian Arsenic Network -AAN, General Pharmaceuticals Limited -GPL, NIPSOM, HACH) are based on the "Gutzeit" method. This involves the reduction of arsenite and arsenate by zinc to give arsine gas, which is then used to produce a stain on mercuric bromide paper.

There have been several studies on the sensitivity and reliability of these kits, although some of these are rather out-of-date since not all of these studies were carried out using the most recently available kits. The most extensively field tested of these kits were until recently the E-Merck, AAN and GPL kits. The evaluations have generally shown these kits to be reasonable at detecting high concentrations (greater than 100ppb) but less reliable at lower concentrations. Merck and Hach therefore focussed on improving the kits at low concentrations and have developed the Merck-Sensitive kit and the user-friendly HACH EZ. The Arsenic Cell, NGO Forum is intending to update their earlier conducted evaluation study on different field kits available in Bangladesh.

The newly developed HACH EZ is a simplification of the HACH 5-stage kit, in that it uses only 2 reagents and is therefore quicker and more straightforward for field workers. This HACH kit has currently undergone field-testing and to date has produced encouraging results on both reliability and accuracy when cross-checked with laboratory testing. HACH EZ is now recommended by Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP), UNICEF, WaterAid Bangladesh and many other organizations for arsenic screening at field level. These organizations are currently using this field test kit for screening purpose.

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The PeCo75 is a handheld instrument developed by Professor Walter Kosmus of the Karl Franzens University in Austria. This field kit is a development of the standard Gutzeit method in that it replaces zinc with sodium borohydride and so removes the problem of obtaining low-arsenic zinc. The PeCo75 uses a calculator-style device to measure the stain developed photometrically rather than by eye and is easily calibrated. The PeCo75 has shown good reliability and accuracy to 5ppb in laboratory environments. The kit is not currently in commercial production, but Professor Kosmus has joined with Wagtech in a partnership/joint venture to produce and market the Peco commercially. Wagtech is intending that the product will be available for its official launch at the Kolkatta WEDC Conference in November 2002. Presently it is being redesigned to be more user friendly and to give digital readout down to 2ppb. Consumables will be readily available in refill packs (together with colour comparison charts - so the refill pack will become a direct alternative to other kits in its own right - but can then also be use in conjunction with the instrument for a more accurate reading).

Information on Field-test Arsenic Kit:

Field Test Kit	Capital Cost (approx)		Commercially & Locally available?	Manufactured by	Waiting time taken per test -minutes	Shelf Life	Contact
	US \$	Tk.					
E. Merck Or Merck Sensitive	50	About 2600-2800 Taka (per 100 tests) depending on quantity of order	Yes	Merck KGaA Germany	30	3 years. (15 ⁰ -25 ⁰ C) May reduce once opened due to field storage conditions.	gat@bdmail.net
GPL	43	2000-2500 depending on quantity	Yes	General Pharmaceuticals Bangladesh	20	Bromide strip: 1yr but when opened best to use within 45 days Other 2 chemicals: 5 years. Storage: 20 ⁰ -25 ⁰ c	zac@aitlbd.net
NIPSOM	18	1000	Yes	NIPSOM Bangladesh	10	Unopened: 6 months Opened: 1 month	anon@bdcom.com
HACH 5-stage	150	9000, (per 100 tests) less on large quantity order.	Yes (but large orders may require 6-8 weeks delivery time)	HACH, USA	35	Reagents: 3-5 years.	worth@bangla.net
HACH EZ	80	4700, (per 100 tests) less on large quantity order.	Yes (but large orders may require 6-8 weeks delivery time)	HACH, USA	20	Reagents: 3-5 years.	worth@bangla.net

However it is generally recommended that all the test kits which use strips should be used within six months of opening.

Further Contacts:

Mr. T. Ali
Proprietor, G.A. TRADERS
Tel: 9557299, 9559275
Fax: 9562591
E-mail: gat@bdmail.net

Mr. Zaki Azam Choudhury
Marketing Manager
General Pharmaceuticals Limited
Tel: 9132594, 8120081, 017681072, 017811642
Fax: 9120657
E-mail: zac@aitlbd.net

Mohammad Abdul Baten
Marketing & Technical Supports Manager
TECHNOWORTH Associates Limited
78, Motijheel Commercial Area, 1st floor,
Dhaka -1000.
Phone: 9555646, 9559776, 9568461, 9567981,
9568794, 018241772
Fax: 880-2-9562215, 880-2-8616947
E-mail: worth@bangla.net

Dr. S. Akhtar Ahmad,
Associate Professor,
Dept. of Occupational and Environmental Health
NIPSOM, Mohakhali, Dhaka - 1212
Phone: 602776
E-mail: anon@bdcom.com

Colorimetric methods

Other field test kits use the SDDC (Silver Diphenyl Dithio Carbamate) method which relies on arsine generation and the colour reaction with SDDC. Arsenic hydride is absorbed into a solution of silver diphenyl dithio carbamate; the orange to red-violet soluble compound that is produced is analyzed by absorption spectrophotometry. The absorption line is measured to find the arsenic concentration. If no substances that obstruct the process are present then detection of arsenic concentrations to below 50ppb is feasible.

Two addresses of companies that manufacture and supply field spectrophotometers include Spectrochem Instruments Pvt. Ltd. (AsDETECT) and HACH Company.

Contact 1) Madhav Tenneti
Managing Director
Spectrochem Instruments Pvt. Ltd.
B-23 Huda Complex, Saroornagar
Hyderabad, Andhra Pradesh
500 035 INDIA
Ph: 91-40-4053341 or 4053342
Fax: 91-40-4146308
Email: madhav@spectrochemindia.com
Web: www.spectrochemindia.com

HACH Company, USA
(Bangladesh Distributor)
Contact: Mohammad Abdul Baten
Marketing & Technical Supports Manager
TECHNOWORTH Associates Limited
78, Motijheel Commercial Area, 1st floor,
Dhaka -1000.
Phone: 9555646, 9559776, 9568461, 9567981,
9568794, 018241772
Fax: 880-2-9562215, 880-2-8616947
E-mail: worth@bangla.net

Web: www.hach.com
International Enquiries: intl@hach.com

Wagtech Portable Trace Element Analyzer (PTEA)

This is a portable device for measuring metals in water, including arsenic (but also lead, copper, etc). The operating principle is voltaic stripping. Due to price and complexity you cannot consider it equivalent to a field test kit, but it can be used in the field. It can attain the same accuracy and precision as a AAS, at a fraction of the cost (also without need for reliable electricity, airconditioning, etc.). Potential uses are as system for cross-checking field kit results, or for use as part of a mobile laboratory (e.g. setting up a temporary water supply analysis facility at union or upazilla level). The PTEA is marketed by Wagtech in the UK. Further details from:

Nick Price, Export Manager
Wagtech UK Ltd., Wagtech House
137-139 Station Road, Thatcham
Berkshire RG19 4QH
nick.price@wagtech.co.uk

Laboratory Methodologies:

The following are the different methodologies for determining arsenic concentration.

- a) Atomic Absorption Spectrophotometry
 - Flow Injection Hydride Generation AAS
 - Graphite Furnace AAS
 - Flame AAS
 - Electrothermal AAS
- b) Neutron Activation Analysis
- c) Inductively Coupled Argon Plasma Emission Spectrometry (ICP)
- d) Anodic Stripping Voltametry
- e) Spectrophotometry
- f) X-ray spectroscopy
 - Particle-induced X-ray emission spectrometry (PIXES)
 - X-ray fluorescence (XRF) spectroscopy
 - X-ray absorption fine structure (XAFS) spectroscopy

The minimum detection level of Flow Injection Hydride Generation Atomic Absorption Spectrophotometer is 0.003 mg/l and that of Spectrophotometer is 0.03 mg/l.

Many governmental and non-governmental organizations and different institutes have laboratory set up where arsenic analysis facilities are available on commercial basis. NGO Forum for Drinking Water Supply & Sanitation has set a laboratory where arsenic analysis and other 30 parameters of water are tested on commercial basis. NGO Forum analyses arsenic by spectrophotometer. Bangladesh University of Engineering & Technology, Atomic Energy Commission, BCSIR, Dhaka University (Soil, Water & Environment Dept.) have AAS facilities in their laboratory.

Due to the nature of laboratory testing being remote good co-ordination is necessary with the field to ensure correct tubewells are marked with correct concentrations (i.e. painted red or green). Collaboration with field staff as well as map information and efficient transportation are essential.

Arsenic Mitigation Options

Arsenic Mitigation Options

Safe water is the prerequisite for improved public health situation of a country. In addition to the arsenic problem, numerous water borne diseases toll lot of lives every year in Bangladesh. Both the GoB and NGOs have been working with great emphasis in this field since last few decades for ensuring safe drinking water to the people.

Concept of Safe Drinking Water:

- Water has no objectionable taste, colour and odour.
- Water that does not contain harmful biological agents,
- Water that does not contain toxic materials & chemicals,
- Water that contains permissible limit of minerals.

Drinking water can be obtained from groundwater, surface water or rainwater sources. Each source has characteristics relating to quality, quantity, reliability, user acceptability and costs that will determine use. While it was claimed that about 95% of the total population of Bangladesh have been brought under safe water supply, the current ground water arsenic contamination is a severe blow to that perceived success. Now it has become urgent to seek alternative water source other than shallow tube-well in the arsenic contaminated areas.

When considering sources and water supply technologies for arsenic mitigation, selection should be on the basis of avoidance or of a substantial and consistent reduction of the ingestion of arsenic.

In assessing best alternative water options and / or arsenic removal technologies the following basic criteria should be evaluated:

- Water Quality (i.e. does the system consistently provides bacteriologically and chemically safe water?)
- Water Quantity (e.g. flow rate, access to water at peak times)
- Affordability (capital, operation & maintenance)
- Reliability
- Life expectancy (e.g. how does one know when to change filter media)
- Convenience (e.g. time & effort involved)
- Time considerations
- Gender issues (e.g. ergonomically appropriate, division of labour)
- Environmental risks (e.g. sludge disposal, excess water / drainage issues)
- Operational safety (e.g. user accidental misuse, physical and chemical safety, robustness)
- Risk substitution (e.g. introduction of bacteriological contamination)
- Logistical sustainability of system (e.g. are reagents available locally, life time of system, market base, involvement of private sector)
- User acceptability
- Necessary operation and maintenance training
- Information, Education & Communication

Different field studies revealed that arsenic free alternative safe water options should be area specific depending on the features and geological structure of that area. Rain water Harvesting System (RWHS) or deep tube wells will be a better source of drinking water in the coastal areas where the shallow aquifer is contaminated with arsenic and less potable because of high salinity. In some areas, particularly those without an aquitard separating the shallow and deep aquifers, there are concerns about the deep aquifer also coming contaminated with arsenic. So many experts consider that the long-term recommendation of an alternative water supply option should be aimed at the best proper use of surface water, but this must consider the treatment of typically high pathogen loadings.

Alternative Safe Water Options

Alternative safe water options can be provided at either household or community level.

The household level options include:

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- accessing water by sharing safe (green) tubewells,
- using protected dug wells,
- rainwater harvesting,
- treating surface water (e.g by use of household filter or solar disinfection).

Community level alternative options include:

- Deep tube well with hand pump,
- Deep tube well with motorized pump, overhead tank and series of stand posts (below tank or distributed in the area),
- Rainwater harvesting,
- Surface water treatment through pond sand filters,
- Other surface water filters or treatment technologies,
- Disinfection systems

Arsenic Removal technologies

Household and community level arsenic removal technologies should be subjected to rigorous testing in idealized field conditions, in real household conditions, and in laboratory conditions. It is imperative that the performance of the technologies is adequate and as anticipated in the household or the community - not only in the laboratory or in supervised field conditions. They should produce an adequate quality and quantity of water even when the technology is subject to a certain degree of "misuse" such as may be caused by improper mixing, use beyond assumed safe removal capacity of a filter, shortcuts, etc. Removal technologies should be such that their presentation (sachet, pill or adsorbent layer), operation and functioning (mixing, settling), storage and abstraction, favour the adequate operation at the household and community level to ensure provision of safe water.

There are four main methods of arsenic removal:

- co-precipitation (coagulants form flocs that bind arsenic and are then filtered out)
- adsorption (arsenic adsorbed onto surface of media)
- ion-exchange (arsenic ions attracted to charged polymer resins)
- membrane filtration (selectively permeable membranes remove arsenic by filtration)

Some stakeholders have expressed doubts about the viability of household arsenic units, and suggested that community level arsenic removal units are preferable. They note the difficulties associated with persuading millions of households to use arsenic removal units, and in ensuring that they are used correctly, and the advantages of centralized operation and maintenance, including arsenic testing, by trained caretakers. They also express concern about the effect of private sector involvement, with its emphasis on commercial viability, on the poor. However, these compelling arguments ignore history. The failure of concerted efforts to provide community water supplies for all is what led to the massive growth in private hand pump tubewells in the first place, and existing investments in community water treatment units, such as pond sand filters, or iron removal plants, have rarely produced safe or sustainable water supplies.

This listing of technologies does not indicate that they are safe technologies to use or that they consistently remove arsenic to below 50ppb. This listing should be used as an information point and organisations are encouraged to seek further detail either from organisations testing the technologies or the technology proponents. The responsibility for safe implementation lies with the respective implementing organization.

Household level Arsenic Removal Technologies

Rapid Assessment of Household Level Arsenic Removal Technologies:

The DFID funded the project 'Rapid Assessment of Household Level Arsenic Removal Technologies' which comparatively evaluated the first nine of the household level technologies listed below and was carried out as part of the Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) with management support of WaterAid Bangladesh. It was carried out by WS Atkins International with the assistance of the Bangladesh Engineering and Technological Services (BETS), the Intermediate Technology Development Group (ITDG) and Imperial College, London.

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The study was conducted in two phases. Phase I sought to answer the question "Does the technology consistently reduce arsenic concentration below the Bangladesh Guideline Standard of 0.05 mg/l". Seven of the nine technologies passed and were included in Phase II.

Phase II was concerned with:

- ◆ Arsenic removal under normal conditions
- ◆ Fourteen other water quality parameters
- ◆ Bacteriological contamination
- ◆ Breakthrough
- ◆ User acceptability
- ◆ Affordability
- ◆ An evaluation of field based arsenic testing kits.

The household level arsenic removal technologies that were considered during Phase I are:

1. Passive Sedimentation
2. DPHE / DANIDA Bucket Treatment Unit
3. Stevens' Institute Technology
4. Adarsha Filter
5. GARNET home-made filter
6. SONO- 3 kolshi method
7. BUET Activated Aluminium Filter
8. Alcan Activated Aluminium Filter
9. Tetra Hedron
10. Ion exchange resins
11. Rajshahi University / New Zealand iron hydroxide slurry
12. SORAS (Solar Oxidation and Removal of Arsenic)

The seven technologies that passed to second stage (Phase II) are the following:

- ◆ Alcan Enhanced Activated Alumina
- ◆ BUET Activated Alumina
- ◆ Sono 3 - kolsi
- ◆ Stevens Institute Filter
- ◆ DPHE/DANIDA Two Bucket
- ◆ GARNET Home-made Filter
- ◆ Tetrahedron Ion Exchange Resin Filter.

The first four were consistently good at removing arsenic, with no apparent negative impact on any of the other key water quality variables. The last three were most unpredictable, two of them struggling to cope with high arsenic concentration in ground water. Of the four consistent technologies, the Alcan and the Sono were the most acceptable to householders, whilst the BUET and Stevens were less so. Key factors for acceptability were cost, ease of use, waiting time and flow rate. The full report is available on-line at the WaterAid web site (<http://www.wateraid.co.uk>) under 'Research and campaigns' and the Arsenic Crisis Information Centre site (<http://bicn.com/acic/>) .

Household arsenic removal technologies:

Household level arsenic removal technology options include the following (see Annexe 5 for further details of the technologies):

1. **Passive Sedimentation**
No proponent
2. **DPHE / DANIDA Bucket Treatment Unit**
Contact: DPHE-Danida Water Supply and Sanitation Components, Arsenic Mitigation Component, 2888, Central Road, Harinarayanpur, Maijdee Court, Noakhali. Ph. 0321 5582
3. **Stevens' Institute Technology**

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- Professor Meng, Center for Environmental Engineering, Stevens Institute of Technology, Hoboken, NJ 07030. E-mail: xmeng@stevens-tech.edu
Ms. Nasrine R. Karim, Director General, Earth Identity Project, F 6/1 House 2, Road 17, Block - C, Banani, Dhaka-1213. Tel: 8812049-53
4. **Ardasha Filter**
Mr. Sounir Mojumdar, CRS-Ardasha Filter Industries, Chagalnaya Bazar, Chagalnaya, Feni.
5. **GARNET home-made filter**
Mr. Tofael Ahmed, Programme Officer/, GARNET-SA, 1/7, Block-E, Lalmatia, Dhaka-1207, Tel: 9117421
6. **SONO- 3 kolshi method**
Professor A.H. Khan, Department of Chemistry, University of Dhaka, Dhaka-1000, E-mail: ahkhan@udhaka.net
Dr. A.K.M. Munir, Director, SDC-Environment Initiative, College More, Courtpara, Kushtia 7000 Ph: 07153144
7. **BUET Activated Aluminium Filter**
Dr. M.A. Jalil, Department of Civil Engineering, BUET, contact: e-mail: majalil@ce.buet.edu
8. **Aican Activated Alumina Filter**
M. Saber Afzal, MAGC Technologies Ltd, House 15, Road 5 Dhanmondi, Dhaka-1205. Tel: 861 5279, 989 3747 Fax: 861 5279 E-mail: magc@bdmail.net Website: www.magctech.com
9. **Tetra Hedron**
US: Dr. Waqi Alam, tetrahedron@prodigy.net
Bangladesh: Wazir Alam or Md. Masud Rana
9882770, 601852, 017171376 10.
10. **Ion exchange resins**
Contact: BAMWSP, email: pdamwsp@bol-online.com??
11. **Rajshahi University / New Zealand iron hydroxide slurry**
Contact: BAMWSP, email: pdamwsp@bol-online.com??
12. **SORAS (Solar Oxidation and Removal of Arsenic)**
Contact: Martin Wegelin, Daniel Gechter and Stefan Hug,
Swiss Federal Institute for Env. Science and Technology (EAWAG), Dept. of Water & Sanitation in Developing Countries (SANDEC), 8600 Duebendorf, Switzerland
internet: www.eawag.ch, www.sandec.ch
Abdullah Mahmud and Abdul Motaleb,
Swiss Agency for Development and Cooperation (SDC), GPO Box 928, Dhaka, Bangladesh
13. **Shapla Filter**
Contact: David B Nunley, Country Director, International Development Enterprises (IDE) – Bangladesh, House 15, Road 7, Dhanmondi, Dhaka 1205, Phone: 8614485, 8619258, Fax: 8613506
E-mail: dbnunley@agni.com Webpage: www.ide-bangladesh.org

Community level arsenic removal technologies:

Community level arsenic removal technology options include the following (see Annexe 6 for further details on the technologies):

1. **Arsenic / Iron Removal Plants**
18 District Towns Project,
Rotary International / UNICEF,
DPHE / DANIDA,
NGO Forum for safe drinking water and sanitation.
- 2 **SIDCO**
Mir Moaidul Huq, General Manager, Sidko Limited
Paragon House (7th Floor), 5, Mohakhali C/A., Dhaka-1212
Phone: 880-2-9881794 / 8827122
Fax: 880-2-9883400
E-Mail: sidko@neksus.com
- 3 **Alcan**
M. Saber Afzal, MAGC Technologies Ltd, House 15, Road 5 Dhanmondi, Dhaka-1205. Tel: 861 5279, 989 3747 Fax: 861 5279 E-mail: magc@bdmail.net Website: www.magctech.com
- 4 **Arsen-X System**
Contact: Ostertech Inc. 37 North Forge Drive, Phoenixville, Pennsylvania 19460, USA
Phone / fax: +610 935 066
Email: lewo@att.net
- 5 **Tetra Hedron**
US: Dr. Waqi Alam, tetrahedron@prodigy.net

Bangladesh: Wazir Alam or Md. Masud Rana
9882770, 601852, 017171376 E-Mail:
- 6 **Nirapad**
PROSHIKA / Altech
- 7 **Apyron System**
Contact: Forrest Cookson, American Chamber of Commerce Dhaka (c/o. Sheraton Hotel)
Phone: 011852337
- 8 **READ-F**
Contact: Brota Services International, Al-Islam Chamber (2nd Floor), 91
Agrabad, Chittagong. Phone: 031-712183, 725865. Dhaka Office: 262/KA Fakirapool,
Dhaka 1000. Phone: 9350390

'An international workshop on Arsenic Mitigation'

In the Context of arsenic crisis in Bangladesh the Govt. of Bangladesh has given due emphasis to address the issue. 'An international workshop on Arsenic Mitigation' was held at Dhaka on 14th - 16th January 2002 to find way to the mitigation of the problem. The inaugural session was addressed by our prime minister Begum Khaleda Zia. The workshop was participated by numerous national and international experts on arsenic. The experts were categorized into three different groups depending on the background of the participants. The three groups were

- ◆ Health Group
- ◆ Alternative Water Option Group
- ◆ Hydrogeology Group

A number of different recommendations were propounded in the workshop by the experts. The strategies recommended in the workshop were aimed to address the arsenic issue on emergency, short term and long term basis. A diagnostic and management protocol was presented at the conference so that there may not be any confusion regarding diagnosis and management of the arsenicosis patients.

A review report on the recommendation made in the workshop are summarized below.

ALTERNATIVE WATER SUPPLY COMPONENT

GENERAL OBSERVATIONS

The alternative water supply groups recognized that:

- alternative technologies are area dependent and cannot be prioritized for the whole country;
- the country is broadly divided in Shallow Water Table Area, Low Water Table Area, Coastal Saline Area, Stony Area and Chittagong Hill Tracts Area requiring technological variations;
- no single option can serve the purpose of the people having different social & economic conditions;
- choice of the communities should be given priority in the selection of technological options;
- there exists knowledge gap in some areas that impedes decision making regarding selection of alternative technologies for arsenic affected areas

RECOMMENDATIONS

1. Alternative Water Supply Options

Despite many constraints the following alternative water supply options are recommended:

Emergency Option:

In acute arsenic problem areas an alternative safe water point appropriate in the area is to be provided in each village on an urgent basis following ongoing national screening program.

Short-term Options (Alphabetically, not in order of priority) :

- Deep Tubewell (where suitable aquifer is available).
- Dug/Ring well (where technically feasible).
- Rainwater harvesting.
- Treatment of surface water (adequate quality and quantity).
- Treatment of arsenic contaminated water.

Long-term Options:

- Proven safe and sustainable technologies implemented under short-term options.
- Piped water supply.

2. Site Specific Selection of Options

The possible sites for different alternative technologies are given below:

Deep Tube Wells

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Manually operated deep tubewells are source of safe and reliable water supply in many parts of the coastal area. In other areas, safe deep aquifers may be available to produce water of acceptable quality for water supply.

Requirements

- It is important to first delineate the areas where such deep aquifers are available that are separated from shallow contaminated aquifers by relatively impermeable layers.
- The annular space of bore holes of the deep tubewells are required to be sealed at the level of impermeable strata to avoid percolation of arsenic contaminated water.

Dug/Ring Wells

Dug wells may be constructed where feasible for arsenic safe water supplies. The areas with aquifers at shallower depth and the hilly areas are suitable for construction of dug wells. The areas with thick consolidated clay layers are not suitable for dug well construction. There should be a sanitary protection and provision for disinfection of dug well water.

Caution

Dug/ring wells are to be tested in an acute arsenic problem areas for arsenic content under following conditions of :

- Continuous withdrawal of water for few days
- Complete sanitary protection

Possibility of Contamination from on-site sanitation

Rainwater Harvesting

Rainwater harvesting has good potential for water supply in arsenic and salinity affected areas in Bangladesh. It is suitable in the coastal islands, south-western part of coastal area and hilly regions of Bangladesh.

Requirements

- Standardization catchments area and storage tank in relation to rainfall intensity and distribution in Bangladesh.
- Monitoring of water quality, particularly during the lean period.

Surface Water Treatment

Treatment of surface water can be a option in any part of Bangladesh having perennial surface water of adequate quantity and of good quality. The flowing rivers, reservoirs, oxbow lakes protected ponds are preferred sources. The technologies include:

- Slow Sand Filters/ Pond Sand Filters (PSFs)
- Pressure filtration followed by disinfection.
- Small-scale conventional or prototype treatment plants
- Conventional surface water treatment plants

Requirements:

- Removal of impurities of any health concern.
- Desired level of clarification and disinfection.

Treatment of Arsenic Contaminated water

Some units developed for treatment of arsenic at household and community levels and installed for experimental use in different parts of Bangladesh have shown very good potentials for use in water supply in all arsenic affected areas.

Centralized arsenic removal plant for urban water supply is possible.

In period of scarcity, arsenic treated water may supplement other sources.

Caution

- Protocols for management of sludge and wastewater rich in arsenic are needed to be developed.
- Validation of technologies is essential prior to mass scale use.

Piped water Supply

Piped water supply is the long-term objective. In an urban center with piped water supply, the people dependent on shallow tubewells can shortly be brought under piped water supply through expansion of existing areas of service coverage. Piped water supply should also be introduced in the urban centers fully dependent on contaminated shallow tubewells. Arsenic removal would be required for the few urban centers having arsenic contaminated production wells.

Piped water supplies are also possible for clustered households in villages, growth centers and the rural areas having good rural road network.

Arsenic safe water for piped water supplies may be available from any sources such as deep tubewell, treated surface or arsenic contaminated water or water from community dug wells.

3. Monitoring and Surveillance:

Performance and quality of water of the existing safe tubewells and the proposed short-term options need regular monitoring and surveillance.

4. Institutional Arrangement for Implementation of Alternative Water Supply

4.1 Vision Statement:

Safe and adequate amount of water will be provided for drinking and cooking in all households through effective, efficient and sustainable institutions. Services will be provided and managed locally, which will be transparent and accountable to the people. National interests and public goods issues will be addressed by the Central Government.

(Safe: arsenic-safe, free from other chemical and microbiological pollutants)

4.2. Role of the Central Government

- a. A national legislation for water quality and supply for regulation, monitoring and implementation should be developed. National Water Council must play an important role in this process.
- b. The regulatory capacity of DPHE to provide technical guidance and monitoring for supply of safe water should be strengthened.

4.3. Role of Local Government

- a. The governmental policy of decentralized provision of services related to safe water options through the Union Parishads (UP) should be operationalized immediately. This will lead to a much closer involvement of local government in the implementation of safe water options.
- b. UPs should also be involved in mobilizing resources, monitoring and information management; more specifically registration of tube wells can be undertaken by the UP.

4.4. Role of Communities and NGOs

- a. Local communities must be facilitated and empowered to undertake planning, implementation and management of safe water options. This should be based on informed choices. NGOs must play a vital role in this process.
- b. There should be a strong focus on capacity development at the local and/or community level for technical implementation and monitoring.
- c. Formation of user groups for local implementation and monitoring should be encouraged throughout the country with support from NGO's and the local government.

4.5. Role of the Private Sector

- a. The private sector can play a key role in implementation of safe water options and interacting with the end users. This role should be included in the mainstream national policy for provision of safe water options and development of innovative, enterprising solutions should be encouraged.
- b. Involvement of private sector in financing of well monitoring and safe water options should be encouraged through tax relief and other incentives.

4.6. Capacity Development

- a. Institutional capacity development for the regulatory functions and monitoring should be undertaken by the Central Government (Ministry of LGRD and Cooperatives).
- b. Capacity development at the local and community level should include technical capacity for installation, operation & maintenance, and monitoring should be a key element of the national policy. This should also include the capacity for information management and reporting.

4.7. Information Management and Applied Research

- a. Knowledge and information should be managed centrally to ensure transparency of the implementation process. Ready accessibility of information to all stakeholders is essential. Governmental institutions, such as NAMIC, should undertake this sustained role of functioning as an information warehouse at the national level.
- b. Centers of excellence on relevant research on safe water options should be developed. These centers should focus on existing information and knowledge leading to identifying and conducting research on key areas.

5. Task Force

A Task Force led by DPHE may be constituted to undertake prioritizations of safe water options and develop strategies for their implementation.

The Task Force should focus on: (i) a clear time frame for implementation; (ii) the formulation of a protocol that includes technological and socio-economic criteria; and (iii) a strategy for information management and dissemination.

The Task Force will formulate the roles and responsibilities of the ministries, departments and directorates, local government institutions, research institutions, private organizations, NGOs and CBOs.

The information emerging from the Task Force should be adequate for making informed choices by communities.

6. Researches and Development

There are many areas of research and development in diverse fields of alternative water supplies in Bangladesh. Some of them are listed below:

- Leaching characteristics of arsenic rich sludges under different conditions and possible contamination from arsenic rich effluents produced by arsenic removal technologies.
- Development of construction, operation and maintenance manuals for each of the following:
 - Rainwater harvesting
 - Dug wells
 - Water treatment plant
 - Piped water supply
- Effect of sanitary protections on arsenic content of dug well water.
- Development of an accurate and reliable field kit for measurement of arsenic at the village level.
- Development of effective, affordable and environment friendly arsenic removal technologies for use in rural areas of Bangladesh.
- Analysis of water supply situation including population exposed to arsenic contamination based on updated data available from on-going studies and national screening program.
- An evaluation of effectiveness, impact and replicability of arsenic mitigation initiatives in Bangladesh.
- Study of water treatment plants in operation in Bangladesh: identification of problems and possible solutions for application in the design of alternative water supply technologies.

HEALTH THEME GROUP

Preamble:

The overriding priority for the health of the people of Bangladesh is to ensure access to wholesome and pure, arsenic free, and bacteriologically safe, water. Time is too short, we need to act now!!!

Implication of health effects and impacts were presented and discussed by more than thirty experts from home and abroad. Three key presentations in the fields of diagnosis, treatment and research were debated and recommendations made thereon.

•Case Diagnosis Guideline

- Prof. M A Khaliq Barbhuiya

•Management Protocol

- Prof. M Mazibul Haque

•Research Priorities

- Dr Harunur Rashid

Case diagnosis guidelines: - Summary

- Three Flow Diagrams were suggested as diagnostic guidelines by Professor MA Khaliq Barbhuiya
- Following extensive discussion amendments were made and one comprehensive flow chart was agreed that can be used at the field level. (Please see Annex)

Recommendations(diagnosis)

- Issues related to Arsenicosis both clinical and public health should be incorporated in the Undergraduate Medical Curriculum as well as Training of Paramedics
- Set-up and maintain an effective and proper referral chain for clinical case management of Arsenicosis cases
- Preventive and Social Medicine should be incorporated
- Health Workers need to be trained as soon as possible on case detection and management
- Detection and reporting of cases should be implemented - the hierarchical classification was endorsed
- Establish a Multidisciplinary National Task Force for identification, monitoring and recommendations on (mitigation of) health impacts

Case Management - Summary

- The Management Protocol provided a table containing - Manifestation, Stages and Recommended Management process.
- As the asymptomatic patients won't seek any clinical intervention - it should be deleted from the management protocol.

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- Scientific proof is necessary before incorporating the anti-oxidants like Beta Carotene and vitamin C and E in the recommended management protocol.
- The structure of the Management Protocol should not contain any staging
- Add follow-up and counseling to the management protocol
- The role of Keratolytic Agents is merely palliative - if given, then 5-20% salicylate should be used.
- The management protocol should include a footnote as follows:

Beta carotene, Vitamin C and E is thought to be helpful for Arsenicosis Management but are yet to have a proven role.

Appropriate nutritional supplement should be given to those who are malnourished.

Research- Summary

- Up to this date 73 research studies have been conducted or are ongoing on health impact of Arsenic Exposure - 8 on management or clinical trials
- There is a need for coordinated research - both interdisciplinary and intersectoral was highly emphasized
- A multi-disciplinary, autonomous, International Centre for Arsenic Mitigation should be established in Bangladesh
- High quality laboratories for epidemiological and diagnostic investigation should be established in Bangladesh
- A multi-disciplinary, autonomous, International Centre for Arsenic Mitigation should be established in Bangladesh
- There is a need to coordinate research - including interdisciplinary and intersectoral research.
- Keep room for Investigator Initiated Research

Seven Priority Areas for research in health are:-

- Prevalence study - exposure, cases including the dose-response relationship
- Clinical trials - showing the effect of antioxidants and other drugs
- Effects on young, especially neonates and infants
- Effects on Reproductive Health
- Health effects/impacts of alternative water options
- Long-term cohort - interdisciplinary
- Bio-availability and food chain

Other Priority areas for research in health are:-

- Low cost management
- Natural History
- Pre-clinical - GI tract (absorption role)
- Non-cutaneous manifestation and involvement of other organs
- Long-term risk associated with arsenic-caused carcinoma
- Pharmacodynamics and kinetics of arsenic in the body
- Factors related to Arsenicosis

Recommendation of the Hydrogeology Group

Screening of Tubewells

1. Government has given due priority of screening of all tube wells. It is recommended that the process be accelerated and screening of all the tube wells both hand pumps and irrigation wells (approx. 10 million) be completed by field kits on Priority Basis in highly contaminated areas in accordance with the guide lines of the Government's Policy for Safe Water Supply and Sanitation, 1998 . (Short term)
2. Reliable testing facilities should be available to people at a reasonable cost. (short term).
3. Quality control of field surveys is essential for which Reference Laboratories to validate field test results be established on a priority basis (short term).

Monitoring of screened tubewells

1. System be developed to monitor the presently found safe wells, if possible once a year (mid term goal).

Aquifer Mapping

1. Immediate mapping be based on existing data of tubewells on Arsenic concentration and depth of wells if location is available. This should be used as local level guide for new tubewells (short term).

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2. Priority Project should be undertaken to find criteria for mapping the Upper, Middle and Lower aquifers (Holocene and Plio-Pleistocene sediments) on Upazila as units. Union level exercise may be tried at a later date (mid term).
3. Because arsenic is related to geology, a priority project should be undertaken for mapping of facies, geometry and chemistry, and classification of the Holocene sediments and correlate them to the aquifer systems.

Groundwater Management

1. In those areas where groundwater is known to be safe, it should continue to play a role in providing safe water supplies. But this must be supported by a monitoring program (short term).
2. In arsenic affected areas, no new irrigation wells should be installed in the arsenic safe aquifer to protect the presently safe water supplies. This aquifer is frequently found at greater depth. (Short term).
3. The abstraction rate of the safe aquifers needs to be determined to assess the potential for sustainable future water supplies from this resource (short term).
4. Ensure that the entire population has access to arsenic safe water (mid term).
5. Determine uses that require arsenic safe water such as cooking, drinking and agricultural, etc (short term).
6. Monitor the quality and quantity of groundwater for those purposes requiring safe water particularly for arsenic (mid term).
7. Develop enforceable standards for water well construction to prevent cross-contamination of aquifers (short term).

Research

Investigate the source, release mechanism and mobilization of arsenic in the ground water on a priority basis (short term).

#Detailed analyses and transport properties of the aquifer sediments should be undertaken (mid term).

#Research on soil build-up of arsenic through arsenic laden irrigation water and bio-availability of arsenic and its subsequent entry into crop, agriculture and food chain (mid term).

#Evaluate methods of in-situ arsenic removal from groundwater as an alternative method for supplying arsenic safe water (mid term).

1. Evaluate the effects on hydrologic and geochemical systems to actual and future development of the groundwater resource (short term).
2. Identify isotopic signature of arsenic contaminated water from arsenic safe deeper aquifers and to study the interactions between shallow and deeper aquifers (mid term).
3. Investigate the seasonal changes in arsenic concentration and other information required to develop a reliable and cost effective monitoring program (short term).
4. Develop simple tools to assist local drillers in site and depth selection (mid term).

Administrative and Legal Issues

1. Groundwater is a valuable natural resource. A suitable "Groundwater Act" should be enacted to control all activities regarding sustainable groundwater exploration, development and management (short term).
2. A national standard should be established for arsenic content of irrigation by groundwater (short term).
3. There is no single organization in the country that deals with all aspects of groundwater although all our neighboring countries have organizations such as "Groundwater Commission", "Groundwater Board" or "Groundwater Agency". The Government should create or identify an organization bringing all the personnel working on groundwater under one umbrella organization.
4. Government should coordinate all stakeholder activities in the sector based upon their approved strategy.
5. Local Government Institutions should be given sufficient resources in recognition of its key role in ensuring provision of arsenic safe water to the people.
6. An international center for groundwater related research and training needs to be established in the country

Actions following the January International Workshop 2002

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After the Workshop the Govt. of Bangladesh has formed an "**National Expert Committee**" (please see annex:02) on arsenic with the approval of '**Secretariat Committee**'. The national experts were assigned to prioritize the recommendation of the workshop to determine the immediate programs needed to be taken by the government.

The experts on "Alternative Water Supply Option", "Hydro-geology" and "Health" group submitted their report on prioritized issues that need to be addressed on immediate basis.

Prioritized Actions:

The Priority Actions in respect to hydrogeological issues and alternative water supply option that has been approved by the "Secretariat Committee" are the following:

A. Hydrogeological Issues:

- a) *Aquifer Mapping*: To know the position and characteristic of aquifers in Bangladesh. This will provide data as to where and at what depth safe ground water can be found.
- b) *Enactment of Ground Water Act* for regulation of use of ground water.

The priority action on hydrogeological issues has been already started. The **aquifer mapping** has been started since May, 2002.

The Govt. of Bangladesh has planned to incorporate the **ground water act** in the "**Water Act**" which is in the final process of formation. If not possible a different ground water act will be enacted.

B. Alternative Water Supply Option:

- a) Development of guidelines for arsenic mitigation activities by partner organizations for uniformity in practices and assurance of acceptable standard of services.
- b) Development of a strategy for rain water harvesting for the ensuing rainy season.
- c) Development of construction, operation and maintenance manuals for each of the following:
 1. Surface water treatment
 2. Piped water supply
 3. Dug wells
 4. Rain water harvesting
- d) Study on the effect of sanitary protections on arsenic content of the dug well water.
- e) Validation of arsenic removal technologies
- f) Study on leaching characteristics of arsenic rich sludge under different conditions and possible contamination form arsenic rich effluents produced by arsenic removal technologies.
- g) Preparation of project implementation plan for emergency water supplies.

Among the above stated prioritized actions several of them have been started. For the development of **Strategy for rain water harvesting** a pilot project named "**Rain Water Harvesting Pilot Project**" has been started in May 2002.

Objective: The main objective of the pilot project is to habituate the people of arsenic affected areas to rain water at least during rainy season.

Project Area: The study is being conducted in 20 villages of different arsenic affected areas of Bangladesh.

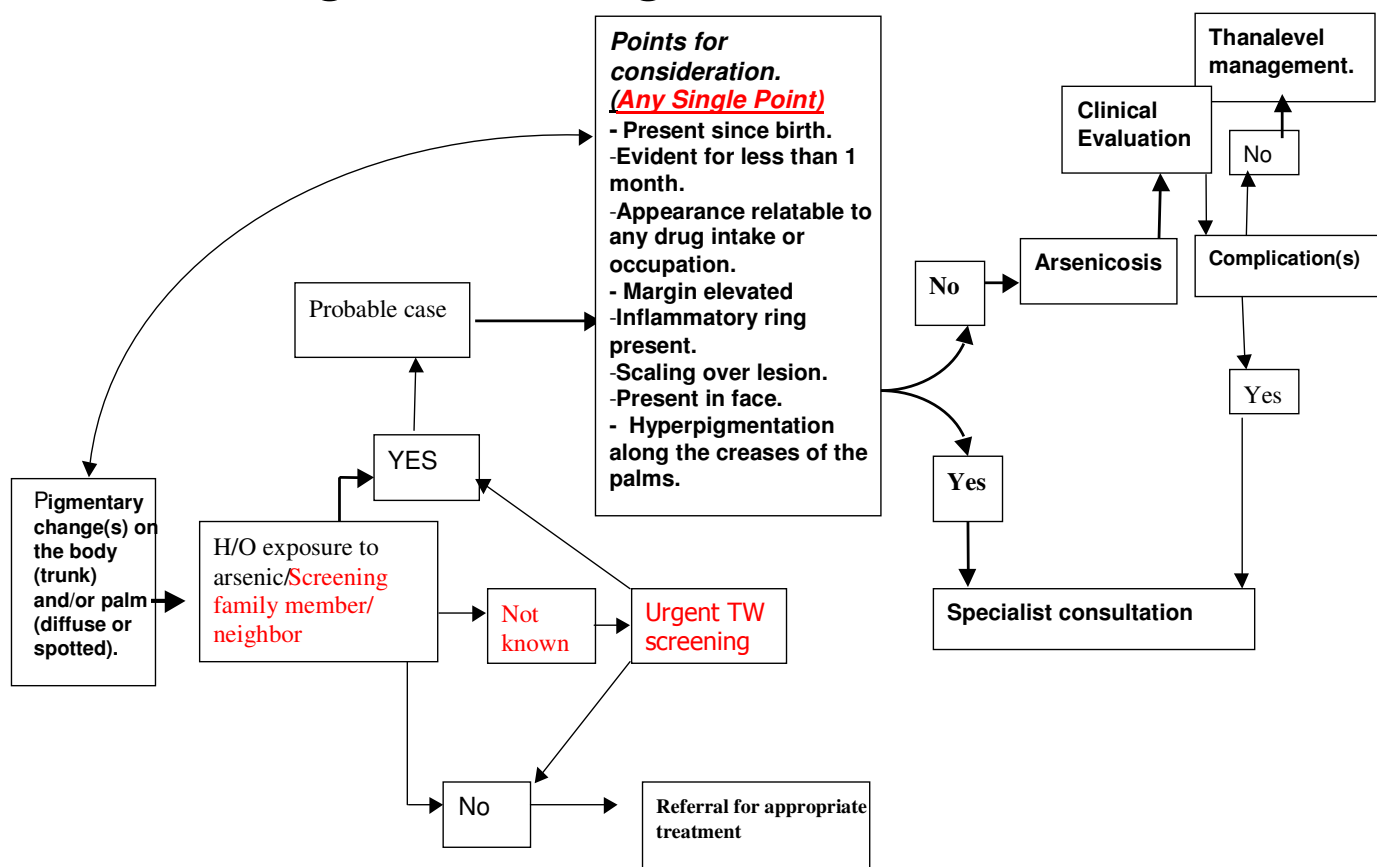
Approach: Subsidy is given to construct only the gutter for collection of rainwater. No subsidy is given to construct any container. The people will collect the water with their own container and by or construct any container according to their need. No storage is being advocated, as the strategy of the pilot project is to accustom the people to rain water as a source of drinking water.

For **Technology Validation**, BCSIR has been assigned to validate different technology for arsenic removal. BCSIR has already called for submission of different arsenic removal technologies for validation. This project is funded by CIDA and assisted by OCETA.

C. Health Issue:

The diagnostic protocol which was prepared in January international workshop 2002, has been approved by the '**Secretariat Committee**' and it is decided to illustrate in an easily understandable form for field use.

Flow diagram for diagnosis of arsenicosis



ANNEX: 02**Constitution of the National Expert Committee****Secretary, Local Government Division****Convener****On the basis of expertise:**

1. Professor S.Z.Haider	Member
2.Mr. C.K.M.Abdullah	Member
3.Professor Kazi Kamruzzaman	Member
4. Professor Muhammad Masihuzzaman	Member
5. Professor Ainun Nishat	Member
6. Professor Firoz Ahmad	Member

On the Basis of Head of the respective Institute

1. Director General, Health Department	Member
2. Chairman, Bangladesh Atomic Energy Commission	Member
3. Executive Chairman, Bangladesh Agricultural Research Council	Member
4. Director General, Environment Department	Member
5. Director General, Bangladesh Geological Survey Department	Member
6. Director General, Bangladesh Water Development Board	Member
7. Chief Engineer, Public Health Engineering Department	Member
8. Head of the Department, Department of Civil Engineering Bangladesh University of Engineering & Technology	Member
9. Head of the Department, Dermatology Bangabandhu Shiek Mujib Medical University	Member
10. Chairman, Bangladesh Agricultural Development Corporation	Member
11. Director General, Water Resources Planning Organization	Member
12. Director General, Agricultural Extension Department	Member
13. Coordinator, Dhaka Community Hospital	Member
14. Project Director, Bangladesh Arsenic Mitigation Water Supply Project	Member

ANNEX: 03**Arsenic Related Research and Publications of Dr. K M Ahmed, Department of Geology, Dhaka University:****Publications:**

1. A. van Geen, H. Ahsan, A. Horneman, R.. K. Dhar, Y. Zheng, A. Z. M. I. Hussain, **K. M. Ahmed**, A. Gelman³, M. Stute^{1,6}, H. J. Simpson¹, S. Wallace¹, C. Small¹, M. F. Parvez², V. Slavkovich², N. J. Lolacono², M. Becker⁴, Z. Cheng¹, H. Momotaj⁷, M. Shahnewaz⁸, A. A. Seddique⁸, and J. Graziano². Promotion of well-switching to mitigate the arsenic crisis in Bangladesh, *Bulletin of the World Health Organization (in press)*.
2. Khan, A A, S H Akhter, M A Hasan & **K M Ahmed**, 2002. VES Signatures in Soft Rock Groundwater Exploration vis-à-vis Geoenvironmental Implications. In Sherif et al., Eds. *Groundwater Hydrology Volume 2* (Proceedings of the International Conference on Water Resources Management in the Arid Regions (WaRMAR), Kuwait), pp. 179-193, March 2002.
3. W G Burgess, M Burren, J Perrin & **K M Ahmed**, 2002. Constraints on sustainable development of arsenic-bearing aquifers in southern Bangladesh. Part 1: A conceptual model of arsenic in the aquifer. In Hiscock, K M, M O Rivett & R M Dovson (eds) *Sustainable Groundwater Development*, Geological Society Special Publications No. 193, pp. 145-163, Geological Society Publishing House, Bath.
4. M Shahnewaz, **K M Ahmed** & A I Kazi, 2001. Occurrence and distribution of arsenic in groundwater of Singair Thana, Manikganj District, Bangladesh. *Dhaka Univ. J. Sci.*, **49(1)**: 37-45.
4. G Jacks, P Bhattacharya, **K M Ahmed**, & D Chatterjee, 2000. Arsenic in groundwater and redox conditions in the Bengal delta - possible in situ remediation. ICIWRM-2000, Proceedings of International Conference on Integrated Water Resources Management for Sustainable Development, **Vol. I**, pp. 413-418, 19-21 December 2000, New Delhi, India.
5. W G Burgess, M Burren, M O Cuthbert, S E Mather, J Perrin, M K Hasan, **K M Ahmed**, P Ravenscroft & M Rahman, 2000. Field relationships and models of arsenic in aquifers of southern Bangladesh. In *Groundwater: Past Achievements and Future Challenges*, Sillo et al., (eds.), pp. 707-712, A A Balkema.
6. **K M Ahmed** & P Ravenscroft, 2000. Extensive Arsenic Contamination of Bangladesh Groundwater: Curse of Unmanaged Development? Proceedings of the 4th International Symposium on Environmental Geotechnology and Global Sustainable Development (Eds. H I Inyang & V O Ogunro), CEEST, University of Massachusetts, **Volume I**, pp. 105-114.
7. R T Nickson, J M McArthur, P Ravenscroft, W G Burgess & **K M Ahmed**, 2000. Mechanism of arsenic release to groundwater, Bangladesh and West Bengal. *Applied Geochemistry*, **15(4)**: 403-413.
8. R Nickson, J McArthur, W Burgess, **K M Ahmed**, P Ravenscroft, M Rahman, 1998 (September). Arsenic Poisoning of Groundwater in Bangladesh. *Nature*, Vol. 395, p 338.

Student Research:

1. Geology and Geochemistry of Arsenic Occurrence in Groundwater of Singair Thana, Manikganj District. M.Sc. Thesis (M Shahnewaz), Department of Geology, University of Dhaka, ongoing - Supervisor.
2. A Comparative Study of Arsenic Contaminated (Iswardi, Pabna) and Non-Contaminated (Thakurgaon Sadar) Aquifers, NW Bangladesh. M.Sc. Thesis (S Shamima Parveen), Department of Geology, University of Dhaka, 1999 - Supervisor.
3. Physico-Chemical Status of Arsenic Contaminated Aquifers in Nawabganj Sadar and its Surroundings, Nawabganj District. M.Sc. Thesis (S M M Alam), Department of Geology, University of Dhaka, 1999 - Co-supervisor.
4. Geostatistical and Hydrogeological Evaluation of Arsenic Field Testing Data from Jhikargachha Upazila, Jessore, SW Bangladesh. M.Sc. (Sabiqunnahar), 2001 – Supervisor.
5. Investigation of the Deeper Aquifer as a Source of Arsenic Free Water in Kachua Municipality, Chandpur, SE Bangladesh. M.Sc. (M Zubaer Ahmed), 2001 – Co-supervisor.

Overseas Student Research:

1. Origin and distribution of arsenic in central Bangladesh. M. Sc. Thesis (Ross Nickson), Department of Geological Sciences, University College London, UK, 1997 - Co-supervisor.
2. Arsenic in groundwater at Meherpur, Bangladesh-a vertical pore water profile and rock/water interactions. M. Sc. Thesis (J Perrin), Department of Geological Sciences, University College London, UK, 1998 - Local supervisor.
3. Arsenic in groundwater at Meherpur, Bangladesh-spatial variations and hydrogeological controls. M. Sc. Thesis (M Burren), Department of Geological Sciences, University College London, UK, 1998 - Local supervisor.
4. The vertical and spatial variability of arsenic in the groundwater of Chaumohani, Southesat Bangladesh. M.Sc. Thesis (S Mather), Department of Geological Sciences, University College London, UK, 1999 - Local supervisor.
5. Modelling the transport of arsenic to hand pumped tube-wells in the Holocene alluvial aquifer of Bangladesh. M.Sc. Thesis (M Curthbert), Department of Geological Sciences, University College London, UK, 1999 - Local supervisor.
6. The spatial variations of arsenic in Groundwater at Magura, Western Bangladesh. M.Sc. Thesis (J Cobbing), Department of Geological Sciences, University College London, UK, 2000 - Local supervisor.
7. Helen M.Sc. Thesis (J Cobbing), Department of Geological Sciences, University College London, UK, 2000 - Local supervisor.
8. Alison M.Sc. Thesis (J Cobbing), Department of Geological Sciences, University College London, UK, 2000 - Local supervisor.
9. Groundwater arsenic contamination in Bnagladesh: Hydrogeochemical studies at Tala Thana in Satkhira District, Southwestern Bangladesh. M.Sc. Thessis (M L Mazumdar), Dept. of Civil & Environmental Engineering, Royal Institute of Technology, Stockholm, Sweden, 2000 – Local Supervisor.
10. Field investigations of arsenic-rich groundwater in the Bengal Delta Plains, Bangladesh – An interbasinal comparison of mechanisms of arsenic translocation and test of low-cost removal technology. Master of Science Thesis, Division of Land and Water Resources, Dept. of Civil and Environmental Engineering, Royal Institute of Technology, Stockholm, Sweden, 2001 – Local Supervisor.
11. McCarthy, E.M. 2002. Spatial and depth distribution of arsenic in groundwater in the Begal Basin. Hydrogeology M.Sc. thesis (UCL). Unpublished, Department of Geological Sciences, University College London, UK, 2001 - Local supervisor.

Other Research:

1. Sedimentological and Mineralogical Studies on Arsenic Contaminated Aquifers within Bangladesh. Funded by Ground Water Circle, Bangladesh Water Development Board. (1997, 98, 99, 00, 01).
2. High Arsenic Groundwater in the Alluvial Aquifers of Bengal Delta Plains in Bangladesh: Genesis and low-cost Remediation. Joint Research Project with KTH, Sweden funded by SIDA-SAREC – Local Collaborator (1999-2001).
3. Arsenic mobilization in Bangladesh ground water. Jointly with Lamont-Doherty Earth Observatory, Columbia University, New York Funded by ASF – Local Collaborator (2000-2005).

ANNEX-04**Research Studies and Publications on Arsenic Contamination by the Department of Occupational & Environmental Health, NIPSOM.****International Journal:**

1. *Ahmad SA, Sayed MHSU, Barua S, Faruquee MH, Khan MH, Jalil MA Hadi SA, Arsenic in Drinking Water and Pregnancy Outcomes. Environ Health Perspect 2001; 109(6): 629-631.*
2. *Ahmad SA, Muyeen-us-Safa AKM, Sayed MHSU, Khan MH, Faruquee MH, Jalil MA Bhuiyan MSA, Barbhuiya MAK and Elias M. Arsenic in Drinking Water and Urinary Level of Arsenic. Environ Sci 2001; 8 (5) : 417-423.*
3. *Ahmad SA, Sayed MHSU, Hadi SA, Faruquee MH, Khan MH, Jalil MA, Ahmed R, Khan A Arsenicosis in a village in Bangladesh. Inter J Environ Health Res.1999; 9:187-195.*
4. *Ahmad SA, Bandarnayake D, Khan AW, Hadi SA, Uddin G, Halim MA. Arsenic in ground water and arsenicosis in Bangladesh. Inter J Environ Health Res. 1997; 7(4): 271-276.*

National Journal:

5. *Ahmad SA, Sayed MHSU, Faruquee MH, Khan MH, Jalil MA, Ahmed R, Razzaque MA, Safa MU. Arsenicosis: Sex Differentials. JOPSOM 1999; 18(1): 35-40.*
6. *Ahmad SA, Sayed MHSU, Khan MH, Faruquee MH, Jalil MA, Ahmed R, Arsenicosis: Neoplastic Manifestations of Skin. JOPSOM 1998; 17(2): 110-115.*
7. *Ahmad SA, Faruquee MH, Sayed MHSU, Khan MH, Jalil MA, Ahmed R, Hadi SA. Chronic Arsenicosis: Management by Vitamin A,E,C Regimen. JOPSOM 1998; 17(1):19-26.*
8. *Ahmad SA, Sayed MHSU, Hadi SA, Khan AW, Modified Arsenic Field Test Kit: A cheap and easy device for detection of arsenic in water. JOPSOM 1997; 16(2):143-150.*
9. *Khan AW, Ahmad SA, Sayed MHSU, Hadi SA, Khan MH, Jalil MA, Ahmed R, Faruquee MH. Arsenic contamination in ground water and its effects on human health with particular reference to Bangladesh. JOPSOM 1997; 16(1): 65-73.*
10. *Khan AW, Ahmad SA, Sayed MHSU, Hadi SA, Faruquee MH and Khan MH. Arsenic: silent catastrophe. Environment on Health Bulletin 1997; 1:1-3.*

ABSTRACTS & PROCEEDINGS:

1. *Ground Water Arsenic Contamination and its Effect on Human Health in Bangladesh. 8th ASCON, ICDDR, B, Dhaka, Bangladesh; February 1999.*
2. *Medical examination in Samta- Internal and Neurological Findings. Proceedings of Symposium 'Forum on the Arsenic Contamination of Ground Water in Asia: Cause, Situation and Measures' Miyazaki University, Miyazaki, JAPAN, November 22-23,1998.*
3. *Health Effects Due to Arsenic Toxicity in Bangladesh. Proceedings of Symposium 'Forum on the Arsenic Contamination of Ground Water in Asia: Cause, Situation and Measures' Miyazaki University, Miyazaki, JAPAN, November 22-23,1998.*
4. *Arsenic Contamination in Ground Water and its effect on human health with particular reference to Bangladesh. Proceedings of International Conference on Arsenic Pollution of Ground Water in Bangladesh: Causes, Effects and Remedies, Dhaka, Bangladesh, 8-12 February, 1998.*

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5. Ahmad SA et al. Health Effects due to Arsenic Toxicity in Bangladesh. Proceedings of Symposium 'Forum on the Arsenic Contamination of Ground Water in Asia: Cause, Situation and Measures, Organised at Miyazaki University. Japan, November, 1998.
6. Ahmad SA. Arsenic: Water Contamination & Health Hazard (Monograph-in Bengali), Dhaka. Feb" .2000.
7. Khan AW, Ahmad SA. Arsenic in Drinking Water, Health Effects and Management. Training Manual, Department of Occupational and Environmental Health, NIPSOM, Dhaka, 1997.
8. Khan AW, Ahmad SA, Hadi SA. Survey on Health Hazards Due to Arsenic Toxicity. Research report

Thesis/Dissertations (Completed & Ongoing)

1. Arsenic Contamination of Ground Water in the Village Rajarampur under Nawabganj District of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 1996. .
2. Health Effects among the Arsenic Exposed People in a Village of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 1996.
3. Knowledge and Awareness on Arsenicosis among People in the Selected Affected and Non-Affected Areas of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 1997.
4. Knowledge of Doctors and Health Assistants on Arsenicosis in Selected Affected and Non-Affected Upazila of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 1997.
5. Socio-Demographic Characteristics of the Cases with Arsenicosis among the People of the Affected Area of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 1997.
6. Pattern of Water Intake by Arsenicosis Patients. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM),1999.
7. Menstrual Pattern in Chronic Arsenic Exposed Patients. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM),1999.
8. Effects of Chronic Arsenic Exposure on Nutritional Status of Children (6-12 Years) in a Selected Area of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 2000.
9. Knowledge and Practice of Water Use in Selected Arsenic affected Villages. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 2000.
10. Knowledge of Physicians on Arsenicosis and Disease Profile in Different Health Complexes of Arsenic Affected and Non-Affected Districts. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 2000.
11. Knowledge and Practice of Water Use in an Arsenic Affected Village where Alternative Water Intervention has been given. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 2000.
12. A Cohort Study on Health Aspects among the Villagers of an Arsenic Affected Village of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 2001.

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13. Blood Glucose Level among the Arsenic Exposed and Non-Exposed Persons in some Selected Areas of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 2001.
14. Nutrition Status among the Arsenic Exposed and Non-Exposed Persons in some Selected Areas of Bangladesh. Deptt. of Occupational and Environmental Health, National Institute of Preventive & Social Medicine (NIPSOM), 2001

ANNEX: 05 A

MAGC/Alcan Enhanced Activated Alumina Filter

Technology	Enhanced Activated Alumina Filter
Process	Adsorption to enhanced activated alumina (AAFS-50)
Chemical controls	Semi-reversible adsorption to Al ₂ O ₃
Physical controls	Formulae to calculate bed-volumes to exhaustion (for 0.1mg/l AsO ₄ , 15000 bed volumes). Periodic back wash required.
Operating procedure	Main unit placed under well head and pump directly into the filter. For household unit, contaminated water is collected from tubewell and poured into filter for processing.
Flow rate - low turbidity - high turbidity	Main unit:>300 litres per hour Household unit:> 100 litres/hr Main unit:>300 litres per hour Household unit:> 100 litres/hr
Time for 20 litres to pass	Main unit: 3-5 minutes Household unit: 7-10 minutes
Litres in 12 hours	Main unit: >3600 litres Household unit: > 1,000 litres
Batches before deterioration - low turbidity - high turbidity	No deterioration No deterioration
Claims on effectiveness (Results and references)	Studies by Department of Chemistry, Dhaka University, and BRAC (Sonargaon) show a removal rate of 100%. Validation under Rapid Assessment of Arsenic Removal Technologies under BAMWSP/DFID/WATERAid confirmed the same fact and adjudged as top technology in Bangladesh in all respect.
Costs	Main unit: Unit cost US\$170 (5 year warranty, expected life 20 years) Lower cost main unit \$50 (no warranty, expected life 5 years). Same filter material costs. : Filter material costs US\$220 for 1 st 80,000 litres of processed water : Replacement cost of filter material US\$ 220 for further 80,000 litres Household unit: Initial cost US\$ 34 (unit plus filter material) for 11,000 litres of processed water : Replacement cost of filter material \$ 14 for further 11,000 litres. Costs expected to fall further.
Contact Details	M. Saber Afzal, MAGC Technologies Ltd, House 15, Road 5 Dhanmondi, Dhaka-1205. Tel: 861 5279, 989 3747 Fax: 861 5279 E-mail: magc@bdmail.net Website: www.magctech.com

ANNEX: 05 B**BUET Activated Alumina Filter**

Technology	BUET Activated Alumina Filter
Process	Oxidation, sedimentation, filtration, active alumina
Chemical controls	Semi-reversible adsorption to Al ₂ O ₃ Arsenite removal occurs (through oxidative step)
Physical controls	Formulae to calculate bed-volumes to exhaustion (for 0.1 mg/l AsO ₄ , 15000 bed volumes) Potentially prone to clogging by FeOH
Operating procedure	Fill top bucket and add chemicals as directed. Stir vigorously and leave for one hour. Turn tap to allow water into the activated alumina column. Retrieve water from bottom of column
Flow rate - low turbidity - high turbidity	Approx. 8 litres per hour Approx. 8 litres per hour
Time for 20 litres to pass	Approx. 2.5 hours
Litres in 12 hours	Approx. 96 litres
Batches before deterioration - low turbidity - high turbidity	Steady gentle deterioration (<10% over 15 batches) Steady gentle deterioration (<10% over 15 batches)
Claims on effectiveness (Results and references)	
Costs	Tk. 1000/
Contact Details	Dr. M.A. Jalil, Department of Civil Engineering, BUET, E:mail: majalil@ce.buet.edu

ANNEX: 05 C

Sono 3- Kolshi Filter

Technology	SONO 3-KOLSHI FILTER
Process	Filtration
Chemical controls	Relies on passive coagulation with Fe and/or adsorption to sand matrix PO ₄ > ASO ₄ >> SiO ₄ >F High HCO ₃ has -ve impact High Ca/Mg has +ve impact
Physical controls	Sand/iron filings/charcoal packing in filter Distribution of water over filter Sand grain size and clays Sand Fe and Organic C content Character and rate of flow through filter
Operating procedure	Pour water into top kolshi. Use water from the bottom kolshi
Flow rate - low turbidity - high turbidity	Approx. 5 litres per hour Approx. 5 litres per hour
Time for 20 litres to pass	Approx. 4 hours
Litres in 12 hours	Approx. 60 litres
Batches before deterioration - low turbidity - high turbidity	15 batches with no major deterioration 15 batches with no major deterioration
Claims on effectiveness (Results and references)	As (III) from 800ppb to less than 50ppb (2ppb) As (total) from 1100ppb to less than 50ppb (10ppb) A.H.Khan et al, 'Appraisal of a Simple Arsenic Removal Method for Groundwater of Bangladesh', Journal of Environmental Science and Health, A35(7), 1021-1041 (2000)
Costs	Tk. 325/- (See note below)
Contact Details	Professor A.H. Khan, Department of Chemistry, University of Dhaka, Dhaka-1000, E-mail: ahkhan@udhaka.net Dr. A.K.M. Munir, Director, SDC-Environment Initiative, College More, Courtpara, Kushtia 7000 Ph: 07153144

The total cost of the three kolshi unit is Tk 250 to 300 (US\$ 5 to 6), of which about 50% is the cost of the metal stand. BRAC have experimented with bamboo and wooden stands, but found that these were even more expensive to produce than the metal stand. The cost of a replacement kolshi, including iron filings and coarse sand, is about Tk 55 (US\$ 1.10).

ANNEX: 05 D

Stevens Institute Technology

Technology	Stevens Institute Technology
Process	Coagulation/filtration
Chemical controls	Relies on enhanced coagulation and co-precipitation (ferrous sulphate) Less dependent upon groundwater Fe Chemical oxidant (chlorine-based) enhances arsenite removal PO ₄ > ASO ₄ >> SiO ₄ >F High HCO ₃ has -ve impact High Ca/Mg has +ve impact
Physical controls	Sand cleaning and packing in filter Distribution of water over filter Sand grain size and clays Sand Fe and Organic C content Character and rate of flow through filter
Operating procedure	Collect 20 l in a bucket, add chemicals and stir rapidly for a minute. Pour into filter (bucket with holes on top of sand in larger bucket) and wait for water
Flow rate - low turbidity - high turbidity	18 litres per hour 18 litres per hour
Time for 20 litres to pass	Just over 1 hour
Litres in 12 hours	Approx. 240 litres
Batches before deterioration - low turbidity - high turbidity	Steady decline to 50% initial flow after 10 batches Steady decline to 50% initial flow after 10 batches
Claims on effectiveness (Results and references)	Kachua - less than 50ppb As in treated water (max. 25ppb) from initial As concentrations of 300-800ppb). BAMWSP testing programme Kishoreganj and Munshiganj – max. As was 19ppb from initial untreated concentrations of 280-468ppb. Xiaoguang Meang and George P. Korfiatis, 'Removal of Arsenic from Bangladesh Well Water by the Stevens Technology for Arsenic Removal (STAR)'. Occasional Paper.
Costs	Installation Cost: Tk. 2000 Chemical Cost : Tk. 200
Contact Details	Professor Meng, Center for Environmental Engineering, Stevens Institute of Technology, Hoboken, NJ 07030. E-mail: xmeng@stevens-tech.edu Ms. Nasrine R. Karim, Director General, Earth Identity Project, F 6/1 House 2, Road 17, Block - C, Banani, Dhaka-1213. Tel: 8812049-53

ANNEX: 05 E

DPHE/DANIDA Bucket Treatment Unit

Technology	DPHE/DANIDA Bucket Treatment Unit
Process	Oxidation/coagulation/filtration
Chemical controls	Relies on enhanced coagulation Less dependent upon groundwater Fe Chemical oxidant enhances arsenite removal PO ₄ > ASO ₄ >> SiO ₄ >F High HCO ₃ has –ve impact High Ca/Mg has +ve impact Ideal pH 6.5 to 8 for optima functioning of alum Possible residual Mn
Physical controls	Agitation and duration of coagulation Sand packing in filter Distribution of water over filter Sand grain size and clays Sand Fe and Organic C content Character and rate of flow through filter
Operating procedure	Pour water into the top bucket. Add mixture of aluminium sulphate and potassium permanganate and stir vigorously 20 times. Leave to settle for 2 hours. Turn tap to send water to lower bucket where it passes through a sand filter. Turn tap in bottom bucket to get drinking water.
Flow rate - low turbidity - high turbidity	70 litres per hour (but 23 l/hr including 2 hours preparation) 50 litres per hour (but 17 l/hr including 2 hours preparation)
Time for 20 litres to pass	Approx 3 hours (1 hour settling + 1 hour filtration)
Litres in 12 hours	60 litres
Batches before deterioration - low turbidity - high turbidity	17 batches – no deterioration 40% fall in flow after 6 batches, then constant to 15 batches
Examples of claims on effectiveness (Results and references)	Noakhali – 100% As below 50ppb after treatment (initial levels 120-1000ppb.) DPHE/Danida Arsenic Mitigation Pilot Project Information leaflet 'Arsenic Removal at Household Level' Sitakunda and Gomastapur – 100% As below 50ppb after treatment (initial levels 116-201 ppb) Water Aid, March 2000. Household Level Arsenic Removal Methodologies, Preliminary Research Report.
Costs (capital and recurrent)	Tk. 300-350 depending on the production cost of the flat cover for the lower bucket.
Contact details	DPHE-Danida Water Supply and Sanitation Components, Arsenic Mitigation Component, 2888, Central Road, Harinarayanpur, Maijdee Court, Noakhali. Ph. 0321 5582

Households buy the reagent from project staff at Tk 10 (US\$ 0.10) for a 250g pot that lasts an average household about one month.

ANNEX: 05 F

Tetra Hedron

Technology	TETRAHEDRON, INC
Process	Ion Exchange
Principle	Ion Exchange is a reversible physical chemical process in which ionic species (As^{+3} , As^{+5}) in aqueous solution are exchanged with ions attached to the exchange media. After exhaustion a simple regeneration by 25L of 10% brine solution (NaCl) can refresh the system.
Oxidizing Agent	Chlorine that acts as a disinfectant also
Capacity	Capacity depends upon water quality. A one year long pilot study at 150 sites under the supervision of BAMWSP revealed that whatever might be the arsenic concentration (1ppb to 1500 ppb), a half cubic feet Tetrahedron's resin can treat minimum 30000 L to maximum 120000 L of water before regeneration. After regeneration the system is as effective as a new one.
Other water quality	Iron is removed by back wash. Bacteria free, and other parameter is within Bangladesh standard.
Flow Rate	2.5 L/minute or 150 L/hr
Liters in 12 hr	1800 L
Batch or continuous?	Continuous process
Bacterial Performances	Very good
Cost	Tk. 12500.00 (imported) and Tk. 8000.00 (Local)
Regeneration Cost	Tk. 30.00 to 40.00
Waste Disposal	Procedure developed with the help of Chemical Engineering Dept. BUET
Contact Details	US: Dr. Waqi Alam, tetrahedron@prodigy.net Bangladesh: Wazir Alam or Md. Masud Rana 9882770, 601852, 017171376

ANNEX: 05 G

Emergency Home-made Garnet Filter

Technology	Emergency GARNET FILTER
Process	Filtration
Chemical controls	Relies on passive coagulation with Fe and/or adsorption to sand matrix $PO_4 > ASO_4 \gg SiO_4 > F$ More or less treats arsenic up to 0.4 mg/l concentration without adding any chemical. Treatment capacity (with arsenic greater than 0.4 to 1 mg/l) increases and performance improves by adding approximately 0.25 tea spoon bleaching powder solution in 10 liters of influent water. The flow rate can be also increased up to about 2 liter per hour by adding the bleaching powder solution. ((High HCO_3 has -ve impact High Ca/Mg has +ve impact ?))
Physical controls	Brick chips, sand and synthetic cloth packing in filter More or less even distribution of water over filter Brick chip and sand grain size. Maintenance status and rate of flow through filter
Operating procedure	ii). Water poured in the first bucket as and when the level goes down. Flow rate controlled in both buckets separately using a I_V flow control meter, a clean cloth string or any other devise at the rate of about 180-200 ml per minute or one tea spoon per minute. iii). Exchange of the bucket position required once in 3-4 weeks interval iii). Cleaning of the materials required once in about 3- 4 weeks interval after the exchange of position. . iv). This option can be made with local materials at household level. Instead of bucket, chari (as in original design) or any other container can be used. But flow rate is critical. v) Suitable for emergency purposes.
Flow rate - low turbidity - high turbidity	0.7 - 1.2 litre per hour 0.4 – 0.6 litres per hour
Time for 20 litres to pass	Approx. 18- 30 hours
Litres in 12 hours	Approx. 7- 15 litres
Claims on effectiveness (Results and references)	Removal efficiencies of 60-100% cited in GARNET's and Rapid Assessment (by DFID and MAWSP) literatures. The Rapid assessment Assessment document has referred to it as an interesting option and suggested further research and development. It is being further studied by EPRC.
Costs	Tk.250-600 based on material for stand and containers
Contact Details	Tofayel Ahmed/Sufia Khanam, GARNET-SA. C/o Environment and Population Research Center (EPRC). 1/7, Block-E, Lalmatia, Dhaka-1207, Tel: 88-2- 8115376

ANNEX- 05 H

Passive Sedimentation

TECHNOLOGY	PASSIVE SEDIMENTATION
Process	Sedimentation – co-precipitation with iron on oxidation
Chemical controls	Relies on passive coagulation with iron Main control is iron in the water PO ₄ > ASO ₄ >> SiO ₄ >F High HCO ₃ has –ve impact High Ca/Mg has +ve impact
Physical controls	Duration of settling Final water could be contaminated by stirring Bacteriological contamination could be an issue
Operating procedure	Fill kolshi and leave to settle for over 12 hours. Pour top 2/3rds for use and discard lower 1/3rd.
Flow rate - low turbidity - high turbidity	N/A N/A
Time for 20 litres to pass	12 hours (depends on size of kolshi – 12 hrs = 30l kolshi)
Litres in 12 hours	20 litres (depends on size of kolshi – 20 litres = 30l kolshi)
Batches before deterioration - low turbidity - high turbidity	N/A N/A
Claims on effectiveness (Results and references)	Only 2 out of 17 wells tested took As below 50ppb. Greatest influence seen was negative correlation between As removal and Electrical Conductivity. Water Aid, March 2000. Household Level Arsenic Removal Methodologies, Preliminary Research Report.
Costs (capital and recurrent)	20 litre aluminium kolhsi – approx. Tk. 200/-
Contact Details	

ANNEX: 05 I**Adarsha Filter**

Technology	Adarsha
Process	Filtration
Chemical controls	Unknown
Physical controls	Character and flow rate through filter
Operating procedure	Pour water into tray within bucket. Use tap to get treated water from bottom of bucket
Flow rate	1.1 litre per hour
- low turbidity	1.1 litre per hour
- high turbidity	
Time for 20 litres to pass	19 hours
Litres in 12 hours	13 litres
Batches before deterioration	
- low turbidity	No deterioration in 15 batches
- high turbidity	No deterioration in 15 batches
Claims on effectiveness (Results and references)	DPHE R& D (Ishtishamul Hoque) have done some assessment and think it reduces As below 50ppb. Not sure why
Costs	Tk. 550
Contact Details	Mr. Sounir Mojumdar, CRS-Ardasha Filter Industries, Chagalnaya Bazar, Chagalnaya, Feni

ANNEX- 05 J

Shapla Arsenic Removal Filter

Technology	Shapla Arsenic Filter
Process	Absorption, filtration
Chemical controls	Relies on As absorption to Fe ₂ O ₃ through brick sand matrix PO ₄ > AsO ₄ > SiO ₄ (order of competing ions)
Physical controls	Fe ₂ O ₃ impregnated brick sand in filter container Brick sand grain size (+/- 2mm) Time exposure to treated media
Operating procedure	Disperse As contaminated water throughout filter media and use water from the bottom tap
Flow rate - low turbidity - high turbidity	Approx. 2-3 litres per hour Approx. 2-3 litres per hour
Time for 20 litres to pass Litres in 12 hours	Approx 7 hours Approx. 30 liters
Batches before deterioration - low turbidity - high turbidity	3000 liters at As level 300 ppb per media charge No deterioration No deterioration
Claims on effectiveness (Results and references)	2 years lab testing: Conducted by Professor Fakhrul Islam, Department of Applied Chemistry & Chemical Technology, Rajshahi University Input water (857 ppb As) reduced to 9.5 ppb = 98.9% As removal rate Input water (257 ppb) reduced to 6.8 ppb = 97.4% As removal rate Household level field tests: Field tested in UNICEF working areas in Sonargaon & Kachua, Danida working area in Noakhali and SDC WATSAN-WPP working area in Rajshahi, test results show arsenic removal rate 98%
Cost (Capital and current) per unit	350-400 taka including media 20 kg of replacement media 100 taka
Contact details	David B. Nunley International Development Enterprises (IDE-B) House # 15, Road # 7, Dhanmondi, PO Box 5055 New Market, Dhaka-1205 Tel (880) 2-861 4485, 861-9258 Fax 861-3506 Email: dbnunley@agni.com

Shapla Arsenic Removal Filter (continued)

International Development Enterprises (IDE), in collaboration with Dr. Fakhrul Islam, Professor of Applied Chemistry and Chemical Technology, Rajshahi University, has developed an inexpensive filter media (iron salt solution bonded to crushed brick particles) that has been proven to be effective in the lab and field reality. Twenty kgs of this media has proven to filter arsenic from 3,000 to 4,000 liters of contaminated water containing levels of 0.1 to 0.5 ppm As. Test results show that arsenic concentrations were removed

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completely and/or reduced to well below the Bangladesh acceptable level of 0.05 ppm As and supplies an average family with 20 to 30 liters of safe drinking water per day. The filter also removes iron, phosphate and turbidity and enhances taste of water. The filter can produce about 50-60 liters of water in 12 hours but the effective life the media will be reduced significantly. For the economic standpoint of the rural poor, the filter is being promoted for daily production of 20-30 liters of water per 12 hours.

Shapla is an extremely environment friendly filter which does not produce any hazard to environment or health. The used filter media is non-toxic and can be disposed of safely without danger to the environment or human health. The Filter is also extremely user-friendly and requires almost no operation and maintenance challenges. The users simply pour arsenic contaminated water in the filter and collect arsenic free water through the faucet.

The Shapla arsenic filter is becoming rapidly accepted as the most affordable, simple, and effective filter for the removal of arsenic in Bangladesh. The cost of a family sized Shapla filter in rural Bangladesh is about Taka 450. The cost of 20kg media (which runs approximately about 3-4 months on an average depending on the water parameters and water output) costs about Taka 150.

Tests of the Shapla filter have been undertaken in Bangladesh by IDE in conjunction with UNICEF, Danida and WorldVision as well as BRAC and Grameen.

ANNEX: 06

Detail on Community Level Arsenic Removal Technologies

ARSENIC / IRON REMOVAL PLANTS

A number of organisations working in geographical areas with the problem of high iron concentrations in drinking water have designed and constructed community level iron removal plants. In areas that are also effected by high arsenic concentrations the arsenic removal rates of these iron removal plants have been monitored.

Organisations that have piloted this arsenic removal methodology include:

18 District Towns Project
Rotary International / UNICEF

DPHE / DANIDA
NGO Forum for safe drinking water and sanitation

SIDCO

AdsorpAs® is an Adsorbent developed by M/S HARBAUER GmbH, Berlin in co-operation with the Technical University of Berlin, Germany.

SIDCO claim that studies on the adsorption of both arsenic forms (AsIII & AsV) on different adsorbents have determined that granular activated ferric Hydroxide with high specific surface has 5 to 10 times higher efficiency for adsorption of Arsenic from water than other adsorbents.

The main application of AdsorpAs® is the adsorptive removal of arsenate and arsenic. Arsenic binds on the surface of AdsorpAs® by chemisorption process forming a stable surface complex with ferric hydroxide. AdsorpAs® does not require chemical regeneration and does not produce any regenerate sludge. The residual mass of the spent AdsorpAs® is small.

The adsorption technique with Granular Ferric Hydroxide in fixed bed reactor is simple, safe and effective method for elimination of arsenic from contaminated groundwater. Depending on the concentration of arsenic in raw water 50,000 to 70,000 bed volumes can be treated with Granular ferric Hydroxide. SIDCO claim that the system is cost-effective. The running/operating cost of the AdsorpAs® system for removal of arsenic from drinking water having a 250 ppb Arsenic concentration is less than 1.0 paisa (US\$0.02) per liter of guaranteed arsenic below the WHO (10ppb) recommendation level in water. All adsorption plants (SIDCO, Alcan, BUET, Apyron, Shapla etc.) are influenced in their efficiency by competing ions in the water (as well as by things such as pH). Phosphate (PO₄) is an effective competitor for adsorption, and can significantly reduce run-lengths before media needs to be replaced. This is relevant to Bangladesh, since there are various areas with high Phosphate in the water.

The DPHE Pabna & PROSHIKA mobilized the community to organize themselves for running the plant smoothly. They are doing all the regular maintenance and collecting monthly contribution from beneficiaries regularly. From that fund they are paying salary for the caretaker and electric bill to REB. They also generating fund so that they can purchase Granular Ferric Hydroxide in future where required.

Our principal M/S Harbauer GmbH Germany can supply for municipal water supply system of any capacity as per customer requirement. We can also install Arsenic Removal Plant in the existing municipal water supply system.

Contact: Mir Moaidul Huq, General Manager, Sidko Limited
Paragon House (7th Floor), 5, Mohakhali c/A., Dhaka-1212
Phone: 880-2-9881794 / 8827122
Fax: 880-2-9883400
E-Mail: sidko@neksus.com

ALCAN Activated Alumina Filter

A process of sedimentation, filtration and active alumina with the system usually attached to well head and pumped directly into the filter. Approximate flow rates of >300 litres per hour. Approximate capital cost US\$170 (5 year warranty, expected life 20 years). Annual filter material costs US\$220 (assuming 80,000 litres of treated water). Studies have been carried out by Department of Chemistry, Dhaka University, and BRAC (Sonargaon). Within a 12hour timespan >3600 litres can be treated.

Contact: M. Saber Afzal, MAGC Technologies Ltd, House 15, Road 5 Dhanmondi, Dhaka-1205. Tel: 861 5279, 989 3747 Fax: 861 5279 E-mail: magc@bdmail.net Website: www.magctech.com

Arsen-X System

Arsen-X adsorbent is an inorganic matrix which selectively adsorbs and binds targeted compounds. The media will bind arsenic, chromium, selenium and ferric cyanide. Arsen-X is claimed to be suitable for either dose or flow through systems. Arsen-X also claims to produce a very low sludge volume. The pH value of the treated water will increase slightly when Arsen-X is working enabling a monitoring systems other than testing for arsenic concentrations to be put in place.

Contact: Ostertech Inc. 37 North Forge Drive, Phoenixville, Pennsylvania 19460, USA

Phone / fax: +610 935 066

Email: lewo@att.net

Community Base Surface Water Treatment Plant - Nirapad

'Nirapad' is a kind of surface water treatment plant, the production of which has been pioneered by PROSHIKA in Bangladesh, using a simple process of chlorinating with calcium hypochloride tablets, filtration through sand layers of different granulometries and dechlorination with active carbon. It can supply drinking water to 2000 consumers of rural communities with production capacity of around 1200 litters per hour of instantly drinkable water. This is a joint venture project of PROSHIKA with a Belgium firm, 'Altech'. The cost of this plant is 8,00,000 Tk.

In Tungipara Upazilla under Gopalganj district one such plant was experimentally set up last year. Later, one plant in Monla, two in Manikgonj and one plant in Pirojpur have been installed. Preparatory work to establish five more plants has already been completed during the reporting period. Construction of the plants will start very soon in Rampal, Mathbaria, Gopalganj and Horirampur.

ANNEX: 07**Upazilla wise Arsenic Mitigation Activities by Different Organizations**

Who is Doing What on Arsenic: Upazila Coverage Area (up to June 2001)

BAMWSP

BAMWSP: Phase 1 (6 Upazila)

Status: Screening- Completed, Mitigation – Ongoing

Sl #	Division	District	Upazila
1.	BARISAL	BARISAL	Uzirpur
2.	CHITTAGONG	CHANDPUR	Hajiganj
3.	DHAKA	GOPALGANJ	Gopalganj
4.	KHULNA	KUSHTIA	Bheramara
5.	RAJSHAHI	PABNA	Ishwardi
6.	SYLHET	SYLHET	Golapganj

BAMWSP: Phase 2 (25 Upazila)

Status: Screening – Completed

Sl #	Division	District	Upazila
1.	BARISAL	BARISAL	Banaripara
2.	BARISAL	BARISAL	Gournadi
3.	BARISAL	BARISAL	Agailjhara
4.	BARISAL	JHALAKATI	Jhalakati
5.	BARISAL	PIROJPUR	Bhandaria
6.	CHITTAGONG	BRAHMANBARIA	sarail
7.	CHITTAGONG	CHANDPUR	matlab
8.	CHITTAGONG	CHANDPUR	faridganj
9.	CHITTAGONG	COMILLA	daudkandi
10.	CHITTAGONG	COMILLA	laksham
11.	CHITTAGONG	LAKSMIPUR	raipur
12.	DHAKA	GOPALGANJ	kotalipara
13.	DHAKA	GOPALGANJ	tungipara
14.	DHAKA	KISHOREGANJ	Bhairab
15.	DHAKA	MANIKGANJ	Harirampur
16.	DHAKA	MUNSHIGANJ	Gozaria
17.	DHAKA	NETRAKONA	Kendua
18.	KHULNA	SATKHIRA	Debhata
19.	RAJSHAHI	CHAPAINAWBGANJ	Nawabganj
20.	RAJSHAHI	KURIGRAM	Rajarhat
21.	RAJSHAHI	NATOR	Lalpur
22.	RAJSHAHI	PABNA	Sujanagar
23.	RAJSHAHI	RAJSHAHI	Charghat
24.	RAJSHAHI	RANGPUR	Pirgachha
25.	SYLHET	MOULVIBAZAR	Kulaura

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Status: Screening – Completed

Sl #	Division	District	Upazila
1.	DHAKA	DHAKA	Dohar
2.	DHAKA	NARSINGDI	Belabo
3.	DHAKA	SHERPUR	Nalitabari
4.	KHULNA	CHUADANGA	Alamdanga
5.	KHULNA	KHULNA	Dighalia
6.	KHULNA	SATKHIRA	Kalaroa
7.	RAJSHAHI	KURIGRAM	Ulipur
8.	RAJSHAHI	NAOGAON	Porsha
9.	RAJSHAHI	NATOR	Bagatipara
10.	RAJSHAHI	SIRAJGANJ	Raiganj

Screening Program of BAMWSPBAMWSP: Phase 3 (147 Upazila)

Status: Screening – Future plan

Sl #	DIVISION	DISTRICT	Upazila
1	BARISAL	BARISAL	Mehediganj
2	BARISAL	BARISAL	Muladi
3	BARISAL	BHOLA	Bhola
4	BARISAL	BHOLA	Lalmohan
5	BARISAL	JHALAKATI	Nalchiti
6	BARISAL	PIROJPUR	Mathbaria
7	BARISAL	PIROJPUR	Nazirpur
8	BARISAL	PIROJPUR	Nesarabad
9	CHITTAGONG	BRAHMANBARIA	Akhaura
10	CHITTAGONG	BRAHMANBARIA	Brahmanbaria
11	CHITTAGONG	BRAHMANBARIA	Kasba
12	CHITTAGONG	BRAHMANBARIA	Nasirnagar
13	CHITTAGONG	CHANDPUR	Chandpur
14	CHITTAGONG	CHITTAGONG	Mirsharai
15	CHITTAGONG	CHITTAGONG	Sitakunda
16	CHITTAGONG	COMILLA	Brahmanpara
17	CHITTAGONG	COMILLA	Burichang
18	CHITTAGONG	COMILLA	Chandina
19	CHITTAGONG	COMILLA	Chauddagram
20	CHITTAGONG	COMILLA	Debiduar
21	CHITTAGONG	COMILLA	Nangalkot
22	CHITTAGONG	COMILLA	Meghna
23	CHITTAGONG	COX'S BAZAR	Ukhia
24	CHITTAGONG	FENI	Daganbhuiya
25	CHITTAGONG	FENI	Feni
26	CHITTAGONG	LAKSMIPUR	Ramganj
27	CHITTAGONG	NOAKHALI	Chatkhil
28	CHITTAGONG	NOAKHALI	Companiganj
29	CHITTAGONG	NOAKHALI	Senbag
30	DHAKA	DHAKA	Nawabganj
31	DHAKA	FARIDPUR	Alfadanga
32	DHAKA	FARIDPUR	Boalmari
33	DHAKA	FARIDPUR	Char Bhadrasan
34	DHAKA	FARIDPUR	Madhukhali
35	DHAKA	FARIDPUR	Nagarkanda
36	DHAKA	FARIDPUR	Sadarpur
37	DHAKA	GAJIPUR	Kaliganj
38	DHAKA	GOPALGANJ	Kasiani

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Sl #	DIVISION	DISTRICT	Upazila
39	DHAKA	JAMALPUR	Sarishabari
40	DHAKA	KISHOREGANJ	Bajitpur
41	DHAKA	KISHOREGANJ	Hossainpur
42	DHAKA	KISHOREGANJ	Karimganj
43	DHAKA	KISHOREGANJ	Kishoreganj
44	DHAKA	KISHOREGANJ	Kuliarchar
45	DHAKA	KISHOREGANJ	Pakundia
46	DHAKA	MADARIPUR	Kalkini
47	DHAKA	MADARIPUR	Madaripur
48	DHAKA	MUNSHIGANJ	Lohajang
49	DHAKA	MUNSHIGANJ	Srinagar
50	DHAKA	MUNSHIGANJ	Tongibari
51	DHAKA	MYMENSINGH	Dhobaura
52	DHAKA	NARAYANGANJ	Araihasar
53	DHAKA	NARSINGDI	Narsingdi
54	DHAKA	NARSINGDI	Raipur
55	DHAKA	NETRAKONA	Atpara
56	DHAKA	NETRAKONA	Khaliajuri
57	DHAKA	NETRAKONA	Madan
58	DHAKA	NETRAKONA	Mohanganj
59	DHAKA	RAJBARI	Goalanda
60	DHAKA	RAJBARI	Pangsha
61	DHAKA	RAJBARI	Rajbari
62	DHAKA	SHARIATPUR	Bhedarganj
63	DHAKA	SHARIATPUR	Damudya
64	DHAKA	SHARIATPUR	Goshairhat
65	DHAKA	SHARIATPUR	Janjira
66	DHAKA	SHARIATPUR	Naria
67	DHAKA	SHARIATPUR	Shariatpur
68	DHAKA	SHERPUR	Sribardi
69	DHAKA	TANGAIL	Delduar
70	DHAKA	TANGAIL	Nagarpur
71	KHULNA	BAGERHAT	Bagerhat
72	KHULNA	BAGERHAT	Chitalmari
73	KHULNA	BAGERHAT	Fakirhat
74	KHULNA	BAGERHAT	Kachua
75	KHULNA	BAGERHAT	Mollahat
76	KHULNA	BAGERHAT	Morelganj
77	KHULNA	BAGERHAT	Rampal
78	KHULNA	BAGERHAT	Sarankhola
79	KHULNA	CHUADANGA	Chuadanga
80	KHULNA	CHUADANGA	Jibnnagar
81	KHULNA	JESSORE	Abhoynagar
82	KHULNA	JESSORE	Bgherpara
83	KHULNA	JESSORE	Chaugachha
84	KHULNA	JESSORE	Keshabpur
85	KHULNA	JHENAIDAH	Harinakundu
86	KHULNA	JHENAIDAH	Jhenaidah
87	KHULNA	JHENAIDAH	Kotchandpur
88	KHULNA	JHENAIDAH	Maheshpur
89	KHULNA	JHENAIDAH	Sailkupa
90	KHULNA	KHULNA	Batiaghata
91	KHULNA	KHULNA	Dumuria
92	KHULNA	KHULNA	Paikgachha
93	KHULNA	KHULNA	Phultala
94	KHULNA	KHULNA	Rupsha
95	KHULNA	KHULNA	Terakhada

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SI #	DIVISION	DISTRICT	Upazila
96	KHULNA	KUSHTIA	Daulatpur
97	KHULNA	KUSHTIA	Kumarkhali
98	KHULNA	KUSHTIA	Kushtia
99	KHULNA	KUSHTIA	Mirpur
100	KHULNA	MAGURA	Magura
101	KHULNA	MAGURA	Mohammadpur
102	KHULNA	MAGURA	Salikha
103	KHULNA	MEHERPUR	Gangni
104	KHULNA	MEHERPUR	Meherpur
105	KHULNA	NARAIL	Lohagara
106	KHULNA	NARAIL	Narail
107	KHULNA	SATKHIRA	Asasuni
108	KHULNA	SATKHIRA	Kaliganj
109	KHULNA	SATKHIRA	Shyamnagar
110	KHULNA	SATKHIRA	Tala
111	RAJSHAHI	BOGRA	Dhunot
112	RAJSHAHI	BOGRA	Gabtali
113	RAJSHAHI	BOGRA	Shibganj
114	RAJSHAHI	DINAJPUR	Birganj
115	RAJSHAHI	GAIBANDHA	Gabindaganj
116	RAJSHAHI	GAIBANDHA	Palashbari
117	RAJSHAHI	GAIBANDHA	Sadullapur
118	RAJSHAHI	GAIBANDHA	Sundarganj
119	RAJSHAHI	KURIGRAM	Nageshwari
120	RAJSHAHI	KURIGRAM	Ruhumari
121	RAJSHAHI	NAOGAON	Manda
122	RAJSHAHI	PABNA	Santhia
123	RAJSHAHI	SIRAJGANJ	Balkuchi
124	RAJSHAHI	SIRAJGANJ	Kamarkhanda
125	RAJSHAHI	SIRAJGANJ	Kazipur
126	RAJSHAHI	SIRAJGANJ	Shahzadpur
127	RAJSHAHI	SIRAJGANJ	Sirajganj
128	SYLHET	HABIGANJ	Ajmiriganj
129	SYLHET	HABIGANJ	Baniyachang
130	SYLHET	MOULVI BAZAR	Kamalganj
131	SYLHET	MOULVI BAZAR	Moulvi Bazar
132	SYLHET	MOULVI BAZAR	Rajnagar
133	SYLHET	SUNAMGANJ	Bishambarpur
134	SYLHET	SUNAMGANJ	Chhatak
135	SYLHET	SUNAMGANJ	Derai
136	SYLHET	SUNAMGANJ	Dharmapasha
137	SYLHET	SUNAMGANJ	Dwarabazar
138	SYLHET	SUNAMGANJ	Jamalganj
139	SYLHET	SUNAMGANJ	Sulla
140	SYLHET	SUNAMGANJ	Sunamganj
141	SYLHET	SYLHET	Balaganj
142	SYLHET	SYLHET	Beani Bazar
143	SYLHET	SYLHET	Bishwanath
144	SYLHET	SYLHET	Companiganj
145	SYLHET	SYLHET	Gowainghat
146	SYLHET	SYLHET	Kanaighat
147	SYLHET	SYLHET	Zakigani

List of Upazilas covered by different non governmental Stakeholders

UNICEF : Phase 1 (5 Upazila)

Status : Screening – Completed

Sl #	DIVISION	DISTRICT	Upazila
1.	CHITTAGONG	CHANDPUR	Kachua
2.	DHAKA	MANIKGANJ	Manikganj
3.	DHAKA	NARAYANGANJ	Sonargaon
4.	KHULNA	JESSORE	Jhikargachha
5.	RAJSHAHI	PABNA	Bera

UNICEF : Phase 2 (15 Upazila)

Status : Screening – Completed, Mitigation ongoing

Sl #	DIVISION	DISTRICT	Upazila
1.	BARISAL	BARISAL	Babuganj
2.	CHITTAGONG	BRAHMANBARIA	Nabinagar
3.	CHITTAGONG	BRAHMANBARIA	Banchharampur
4.	CHITTAGONG	CHANDPUR	Haimchar
5.	CHITTAGONG	CHANDPUR	Shahrasti
6.	CHITTAGONG	COMILLA	Barua
7.	CHITTAGONG	COMILLA	Homna
8.	CHITTAGONG	COMILLA	Muradnagar
9.	DHAKA	FARIDPUR	Bhanga
10.	DHAKA	MADARIPUR	Sibchar
11.	DHAKA	MADARIPUR	Rajoir
12.	DHAKA	MUNSHIGANJ	Serajdikhan
13.	KHULNA	CHUADANGA	Damurhuda
14.	KHULNA	JESSORE	Manirampur
15.	KHULNA	NARAIL	Kalia

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UNICEF : Phase 3 (25 Upazila)

Status : Ongoing Screening – Program

Sl #	DIVISION	DISTRICT	Upazila
1.	DHAKA	DHAKA	Dhamrai
2.	DHAKA	DHAKA	Keraniganj
3.	DHAKA	JAMALPUR	Bakshiganj
4.	DHAKA	JAMALPUR	Jamalpur
5.	DHAKA	KISHOREGANJ	Ashtagram
6.	DHAKA	KISHOREGANJ	Itna
7.	DHAKA	KISHOREGANJ	Nikli
8.	DHAKA	MANIKGANJ	Ghior
9.	DHAKA	MANIKGANJ	Saturia
10.	DHAKA	MUNSHIGANJ	Munshiganj
11.	DHAKA	MYMENSINGH	Gouripur
12.	DHAKA	MYMENSINGH	Muktagachha
13.	DHAKA	MYMENSINGH	Mymensingh
14.	DHAKA	MYMENSINGH	Nandail
15.	DHAKA	NARSINGDI	Manohardi
16.	DHAKA	NARSINGDI	Palas
17.	DHAKA	NARSINGDI	Sibpur
18.	DHAKA	SHERPUR	Nakla
19.	DHAKA	SHERPUR	Sherpur
20.	DHAKA	TANGAIL	Basail
21.	DHAKA	TANGAIL	Mirzapur
22.	DHAKA	TANGAIL	Tangail
23.	KHULNA	JESSORE	Jessore
24.	KHULNA	JESSORE	Sarsa
25.	KHULNA	JHENAIDAH	Kaliganj

WATSAN Partnership Project (WPP)

WPP: Phase 1 (8Upazila)

Status: Screening- Ongoing/Completed in 640 Village

Sl #	DIVISION	DISTRICT	Upazila
1.	RAJSHAHI	CHAPAINAWABGANJ	Shibganj
2.	RAJSHAHI	CHAPAINAWABGANJ	Nachol
3.	RAJSHAHI	RAJSHAHI	Bagha
4.	RAJSHAHI	RAJSHAHI	Godagari
5.	RAJSHAHI	RAJSHAHI	Tanor
6.	RAJSHAHI	RAJSHAHI	Bagmara
7.	RAJSHAHI	RAJSHAHI	Mohanpur
8.	RAJSHAHI	RAJSHAHI	Paba

WPP: Phase 2 (5Upazila)

Status: Screening – Plan for Next Phase

Sl #	DIVISION	DISTRICT	Upazila
1.	RAJSHAHI	CHAPAINAWABGANJ	Bholahat
2.	RAJSHAHI	CHAPAINAWABGANJ	Gomastapur
3.	RAJSHAHI	RAJSHAHI	Boalia
4.	RAJSHAHI	RAJSHAHI	Durgapur
5.	RAJSHAHI	RAJSHAHI	Puthia

DPHE- DANIDA – Arsenic Mitigation Component

DPHE – DANIDA: Phase 1 (8 Upazila)

Status: Screening – Ongoing/ Completed

Sl #	DIVISION	DISTRICT	Upazila
1.	BARISAL	BARISAL	Bakerganj
2.	BARISAL	BARISAL	Barisal
3.	BARISAL	PIROJPUR	Pirojpur
4.	CHITTAGONG	FENI	Sonagazi
5.	CHITTAGONG	LAKSMIPUR	Laksmipur
6.	CHITTAGONG	LAKSMIPUR	Ramgati
7.	CHITTAGONG	NOAKHALI	Begumganj
8.	CHITTAGONG	NOAKHALI	Noakhali

World Vision International – Arsenic Mitigation Program**WVI: Phase 1 (14 Upazila)**

Status: Screening – Plan

Sl #	DIVISION	DISTRICT	Upazila
1.	CHITTAGONG	BANDARBAN	Bandarban
2.	DHAKA	FARIDPUR	Faridpur
3.	DHAKA	GOPALGANJ	Muksudpur
4.	DHAKA	MYMENSINGH	Haluaghat
5.	DHAKA	MYMENSINGH	Phulpur
6.	DHAKA	NETRAKONA	Durgapur
7.	DHAKA	NETRAKONA	Kalmakanda
8.	KHULNA	BAGERHAT	Mongla
9.	KHULNA	KHULNA	Dacope
10.	KHULNA	SATKHIRA	Satkhira
11.	RAJSHAHI	BOGRA	Shariakandi
12.	RAJSHAHI	JOYPURHAT	Joypurhat
13.	RAJSHAHI	SIRAJGANJ	Tarash
14.	SYLHET	SUNAMGANJ	Tahirpur

ANNEX: 08

Summary Result Of The Screened Upazila (BAMWSP: 42, UNICEF: 20)

SL. #	Upazila	# of Union	# of Village	# of Ward	Tubewell Surveyed				Total Population Surveyed	Arsenicosis Patient Identified
					Total Operative TW	Arsenic Safe TW	Arsenic Conta. TW	% of Arsenic Conta. TW		
1	Bheramara	9	76	81	14221	10399	3822	26.88%	184280	189
2	Golapganj	11	237	99	16470	14720	1750	10.63%	344099	13
3	Gopalganj (S)	23	199	207	14603	915	13688	93.73%	375843	181
4	Hajiganj	12	134	108	13387	234	13153	98.25%	332829	552
5	Ishwardi	10	83	90	15390	13757	1633	10.61%	196608	88
6	Uzirpur	9	109	81	6297	1604	4693	74.53%	264751	116
7	Agailjhara	5	86	45	4382	833	3549	80.99%	162348	64
8	Bagatipara	6	139	54	10831	9986	845	7.80%	124970	98
9	Banaripara	8	77	72	3251	1252	1999	61.49%	167467	110
10	Bhairab	6	67	54	11763	8348	3415	29.03%	172716	371
11	Bhandaria	7	33	63	4408	2819	1589	36.05%	154096	15
12	Charghat	6	73	54	12292	11124	1168	9.50%	210858	137
13	Daudkandi	23	388	207	26133	3326	22807	87.27%	490568	421
14	Debhata	5	102	45	8541	2002	6539	76.56%	132878	74
15	Dighulia	6	48	54	7181	4997	2184	30.41%	151557	260
16	Faridganj	16	156	144	25236	372	24864	98.53%	475165	370
17	Gazaria	7	98	63	7815	1521	6294	80.54%	132258	218
18	Gournadi	7	101	63	4406	1635	2771	62.89%	166642	62
19	Harirampur	13	242	117	13275	4915	8360	62.98%	172413	199
20	Jhalokathi (S)	9	174	81	4473	2545	1928	43.10%	153999	72
21	Kotalipara	12	179	108	6889	1663	5226	75.86%	239722	129
22	Lalpur	10	196	90	18852	17007	1845	9.79%	232070	226
23	Matlab	19	315	171	22151	3211	18940	85.50%	475879	462
24	Nawabganj (S)	14	131	126	19046	13572	5474	28.74%	346263	498
25	Pirgachha	9	185	81	34624	31145	3479	10.05%	409375	298
26	Raiganj	9	252	81	26274	20541	5733	21.82%	314026	226
27	Raipur	10	51	90	10712	1454	9258	86.43%	270903	607
28	Rajarhat	7	142	63	22745	18198	4547	19.99%	180941	159
29	Sarail	10	137	90	14223	6437	7786	54.74%	335796	231
30	Sujanagar	10	172	90	19872	16107	3765	18.95%	281309	258
31	Tungipara	5	59	45	2877	523	2354	81.82%	98768	133
32	Ulipur	13	175	117	34924	25138	9786	28.02%	347752	209
33	Kendua	13	252	117	19561	13418	6143	31.40%	323020	122
34	Belabo	7	92	63	22878	20264	2614	11.43%	190946	266
35	Porsha	6	225	54	2811	2795	16	0.57%	127814	0
36	Nalitabari	12	132	108	19692	13039	6653	33.79%	240794	392

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SL. #	Upazila	# of Union	# of Village	# of Ward	Tubewell Surveyed				Total Population Surveyed	Arsenicosis Patient Identified
					Total Operative TW	Arsenic Safe TW	Arsenic Conta. TW	% of Arsenic Conta. TW		
37	Kolaroa	12	136	108	17003	889	16114	94.77%	212815	669
38	Laksham	22	535	198	40170	8266	31904	79.42%	661866	1791
39	Dohar	7	87	63	13705	2702	11003	80.28%	156819	94
40	Kulaura	17	492	153	22234	18889	3345	15.04%	355390	43
41	Alamdanga	14	241	126	34133	19434	14699	43.06%	398727	400
42	Singair	11	142	99	20557	11499	9058	44.06%	257470	13
43	Kachua	12	238	108	17897	385	17512	97.85%	352420	240
44	Manikganj	13	308	117	21300	14846	6454	30.30%	285325	58
45	Sonargaon	11	473	99	24430	9112	15318	62.70%	314257	250
46	Jhikorgachha	11	179	99	26637	13825	12812	48.10%	283058	311
47	Bera	10	157	90	14360	6975	7385	51.43%	250676	120
48	Homna	10	207	90	15605	4800	10805	69.24%	253876	-
49	Bancharampur	13	118	117	17628	5164	12464	70.71%	310045	68
50	Damurhuda	10	102	90	25263	18428	6835	27.06%	255949	199
51	Monirampur	17	249	153	35170	17216	17954	51.05%	391312	22
52	Bhanga	12	227	108	21147	1975	19172	90.66%	257642	282
53	Haimchar	6	64	54	3665	565	3100	84.58%	135967	100
54	Barura	15	332	135	25986	7504	18482	71.12%	372934	28
55	Rajoir	10	177	90	13022	3129	9893	75.97%	245227	85
56	Shibchar	18	467	162	31964	17463	14501	45.37%	367298	120
57	Muradnagar	21	301	189	30199	1965	28234	93.49%	500645	287
58	Shahrasti	9	176	81	16380	159	16221	99.03%	216772	-
59	Nabinagar	19	198	171	30122	3941	26181	86.92%	454247	173
60	Babuganj	6	87	54	5956	1969	3987	66.94%	163086	106
61	Serajdikhan	14	177	126	15058	8462	6623	43.98%	274902	134
62	Kalia	15	184	135	11307	3106	8201	72.53%	236096	40
Total (62 Upazila)		699	11371	6291	1073384	504484	568927	53.00%	16946544	13459

*Data From SL # 1 to 42 are Collected from the Screening Result of BAMWSP

*Data From SL # 43 to 62 are Collected from the Screening Result of UNICEF

Source: NAMIC

ANNEX: 09

Summary of project activities by Dhaka Community Hospital

1. Arsenic Problem, Causes and Remedies in Bangladesh

Executing Agency : Dhaka Community Hospital & SOES, JU, Calcutta, India
Funding agency :1. Dhaka Community Hospital
2. SOES, Jadavpur University, Calcutta. India
Project Duration : July 1996 – continue

Major Activities of the Project:

1. Water samples (randomly) test of HTWs and DWTs all over Bangladesh by AAS method
2. Patient identification and biological samples test (Urine, Blood, Nail, Hair and skin)
3. Patient management and flow-up
4. Awareness building
5. Knowledge dissemination on arsenic mitigation
6. Preparation database on arsenic contamination and arsenicosis
7. National of National Map on Arsenic

2. Community Based Arsenic Mitigation Project

Project Area:

1. 182 (all) village of Sirajdikhan Upazila of Munshiganj district

Duration: June 2001 to May 2003

2. 171 Village of Bera Upazila of Pabna District

Duration: July 1999 to continue (2 years funding by UNNICEF-DCH, Now DCH is continuing with its own funding)

Support: UNICEF-DPHE-DCH

Objective:

1. Assessment of Arsenic contamination
2. Development of alternative safe drinking water sources
3. Awareness building

Major Activities:

1. Test and mark of arsenic contamination of all tubewell of the project by field kit
2. Identification and management of arsenic patient
3. Provide alternative safe water
4. Awareness creation
5. Community mobilization and empowerment
6. Ensuring of local participation

3. Emergency Arsenic Screening project

Project Area:

1. 558 (all) village of Laksham Upazila of Comilla district

Duration: November 2000 to continue (BAMWSP provided fund for 6 month, DCH is continuing its activities by own fund)

Funding: BAMWSP and DCH

Objective:

2. Assessment of Arsenic contamination
3. Development of alternative safe drinking water sources
4. Awareness building
5. Local resource mobilization and capacity building

Major Activities:

6. Test and mark of arsenic contamination of all tubewell of the project by field kit
7. Identification and management of arsenic patient
8. Provide alternative safe water
9. Awareness creation
10. Community mobilization and empowerment
11. Ensuring of local participation

4. Assessment of arsenic contamination in Hand pump project

Project Areas:

1. 225 village of 11 Upazilas
2. 4 district town of 4 District

Duration: October 2001 June 2002

Funding: CARE- Bangladesh

Objective:

1. Assessment of Arsenic contamination
2. Awareness building

Major Activities:

- Test and mark of arsenic contamination of all tube well of the project areas by field kit
- Awareness creation
- Community mobilization and empowerment
- Ensuring of local participation

Arsenic Patient identification and Management in 14 Upazila

Project Areas: all the villages of 14 Upazila

Implementation:

1. DCH along in 7 Upazila
2. DCH and DGHS jointly in 7 Upazila

Funding: UNICEF and DCH

Objective:

1. Development of patient management protocol
2. Capacity building of local health facilities
3. Awareness building

Major Activities:

1. Patient identification and management
2. Prepare patients baseline
3. Awareness building
4. Provide alternative safe water
5. Information dissemination

6. Patient Identification and Management

Project area: 25 Areas of 21 Upazilas

Duration: 1998 to continue

Funding: DCH

Objective:

1. Continuous arsenic patient identification and management
2. Patient rehabilitation (Physical, social and economical)
3. Community awareness
4. Information dissemination

Major Activities:

1. Continuous patient identification (new patient)
2. Provide treatment
3. Social awareness creation
4. Patient follow-up
5. Patient data base
6. Provide alternative safe water to the patient families

7. Arsenic Patient Management at Hospital

Project area: Serious Arsenic patient of Bangladesh

Funding: DCH

Duration: 1996 to Continue

Objective:

1. Better treatment of serious arsenic patient
2. Development of patient data based

Activities:

1. Patient treatment at out door (all the days)
2. Investigation (pathological and others) support
3. Admission and treatment including operation
4. Food and medicine support
5. Long term follow-up
6. Physical rehabilitation

8. Establishment of Bangladesh-Australia Arsenic Mitigation Resource Centre

Project area: 30 village of Bangladesh

Funding: AusAid

Duration: 2002 to 2003 (2 years)

Objective:

1. Establish a resource Centre for Arsenic mitigation
2. Development of safe water source based on surface water
3. Prevention of arsenic exposure through food.
4. Development of community education system

Major activities

1. Set-up laboratory and resource library
2. Provide alternative safe water
3. Collection and analysis of food, soil, water, human samples
4. Community mobilization and training for arsenic patient

9. Molecular Epidemiology of Arsenic exposure and Skin Lesions in Bangladesh

Sample size: 1600 case and control

Duration: 2001 to 2003 (3 years)

Funding: Harvard University (USA) and DCH

Major Activities:

1. **Patient identification, management and long term follow-up (at least 3 years)**
2. **Testing of samples for 3 years (human and water)**
3. **Provide alternative safe water**
4. **Awareness building**

10. Pilot study on Community Based Arsenic Mitigation

Project Area: 2 village

Duration: August 2000 to July 2001 (DCH is continuing the project by its own)

Funding: UNDP and DCH

Objective

1. **Developed community based sustainable mitigation model**

2. Development of community financing

Major Activities:

1. **Testing all tubewells**
2. **Identification, management and follow-up of all patients**
3. **Provide safe water sources**
4. **Community mobilization and empowerment**
5. **Awareness building**

11. Assessment of arsenic contamination of Town water

Project area: **All the districts**

Duration: **2000 to continue**

Funding: **DCH**

Objective:

1. **Assess the contamination of town water**
2. **Find out the possible alternative safe water sources**

Major Activities:

1. **Testing of drinking water**
2. **Identify and manage arsenic patient**
3. **Awareness building**
4. **Inform community about alternative safe water sources**

12. National Screening of Arsenic Contamination

Project Area: **31 Upazila**

Duration: **September 2002 to December 2002**

Funding: **BAMWSP**

Major Activities

1. **Testing and marking all the tubewell of the Upazilas**
2. **Awareness building**
3. **Community mobilization and empowerment**
4. **Training to field workers**
5. **Provide safe water (2nd phase)**

ANNEX 10

Water Quality Fact Sheet:



Arsenic



WHO guideline value (recommended limit): $10 \mu\text{g l}^{-1}$

National standard in most countries: $50 \mu\text{g l}^{-1}$

Typical range in groundwater: usually $< 10 \mu\text{g l}^{-1}$ (up to around $3000 \mu\text{g l}^{-1}$)

This is one of a series of information sheets prepared for a limited number of inorganic constituents of significant health concern that are commonly found in groundwater. The sheets aim to explain the nature of the health risk, the origin and occurrence of the constituent in groundwater, the means of testing and available methods of mitigation. The purpose of the sheets is to provide guidance to WaterAid Country Office staff on targeting efforts for water-quality testing and to encourage further thinking within the organisation on water-quality issues.

Health effects

Arsenic is a ubiquitous element found in the atmosphere, soils and rocks, natural waters and organisms. It is mobilised in the environment through a combination of natural processes such as weathering reactions, biological activity and volcanic emissions as well as through a range of human activities, including mining, industry and agricultural use of arsenical pesticides. Of the various sources of arsenic in the environment, drinking water probably process the greatest threat to human health.

Arsenic has long been recognised as a toxin and carcinogen. Long-term ingestion of high concentrations from drinking water can potentially give rise to a number of health problems, particularly skin disorders, of which the most common are pigmentation changes (dark/light skin spots) and keratosis (warty nodules, usually on the palms and feet). Additional symptoms include other more serious dermatological problems (e.g. skin cancer and Bowen's disease), cardio-vascular (blackfoot disease, Raynaud's syndrome, hypertension, gangrene), neurological, respiratory and hepatic diseases as well as diabetes mellitus. Such symptoms have been well-documented in areas of known groundwater contamination such as Bangladesh, West Bengal, Taiwan, northern China, Mexico, Chile and Argentina.

A number of internal cancers have also been linked with As in drinking water, particularly lung, bladder, liver, prostate and kidney cancer (e.g. Smith et al., 1992 - 1998). Much research is being carried out to assess the risks of such cancers at the levels of the drinking-water standards. Clinical symptoms of As poisoning and their relative prevalence seem to vary between affected regions and there is no clear agreement on the definition of As poisoning.

Some studies have shown a clear relationship between arsenic dose from drinking water and the development of cancer and other diseases. However, the relationship may be complicated by other factors such as nutritional and general health status (hepatitis B may exacerbate the problems) and water chemistry (e.g. aqueous arsenic chemistry, dissolved iron concentration). Debate also remains over whether a threshold as concentration exists below which the element is effectively safe (e.g. Smith et al., 1999).

Latency periods of several years for the development of arsenic-related health problems have been noted in several investigations a factor which in part explains why many of the problems in developing countries have only recently emerged despite several years of groundwater use.

Many of the advanced and most serious clinical symptoms are incurable, others can be treated and symptoms can go into remission provided a supply of low-As drinking water is provided a relatively early stage. Early detection of arsenic in drinking water and provision of low arsenic alternatives is therefore critical and the element warrants special monitoring in potentially vulnerable groundwaters.

Following the accumulation of evidence for the chronic toxicological effects of As in drinking water, recommended and regulatory limits of many authorities are being reduced. The WHO guideline value for As in drinking water was provisionally reduced in 1993 from $50 \mu\text{g l}^{-1}$ to $10 \mu\text{g l}^{-1}$. The new recommended value is based largely on analytical capability. Standards based on risk alone would likely be lower still. At present, most countries, and indeed all developing countries, continue to use the $50 \mu\text{g l}^{-1}$ limit as the national standard because of limited analytical capability.

Occurrence in groundwater

Arsenic concentrations in natural waters vary significantly, potentially spanning more than four orders of magnitude. Groundwaters are generally more vulnerable to accumulation of high arsenic concentrations than surface waters because of increased opportunity for chemical reactions between water and host rocks and the high ratios of solid to solution compared to surface waters. Exceptions can occur locally where surface waters (as well as groundwaters) are contaminated by point sources (mining, geothermal, industrial) or where river waters have a high component of baseflow (groundwater). Groundwaters are where the greatest number of, as yet unidentified, high-arsenic sources are likely to be found.

Observed arsenic concentrations in groundwater are themselves highly variable. Most groundwaters tend to have concentrations $< 10 \mu\text{g l}^{-1}$ but may range up to and in excess of $3000 \mu\text{g l}^{-1}$ in some conditions. Arsenic and fluoride together are now recognised as the greatest problems of all inorganic constituents in groundwater.

Most cases of arsenic contamination in groundwater are naturally-derived, either due to the occurrence of favourable oxidation/reduction and pH conditions in the aquifers (see below) or due to inputs from local geothermal sources. Arsenic problems may also be exacerbated in areas affected by mining activity (coal and metals associated with sulphide minerals). Both mining effluent and geothermal waters often have arsenic concentrations in the milligram-per-litre range and can cause major increases in concentrations of surface waters and groundwaters. Unlike affected major aquifers, these tend to be relatively localised to the contaminant source and are usually easily identified. Contamination from industrial sources may also be severe locally, but such cases are comparatively rare.

Unlike many other toxic trace elements, arsenic is potentially highly mobile in water given the appropriate environmental conditions. It forms anionic (negatively charged) species in water and hence unlike cations can be stable in soluble form at the neutral to alkaline pHs (6.5-8.5) characteristic of most groundwaters. However, arsenic is strongly adsorbed (adhered) onto sediments and soils, particularly iron oxides, as well as aluminium and manganese oxides and clays. These are common constituents of aquifers and are the reason why most groundwaters have low arsenic concentrations.

Arsenic occurs in two oxidation states in water. In reduced (anaerobic) conditions, it is dominated by the reduced form: arsenite and in oxidising conditions by the oxidised form: arsenate. Adsorption (and hence restricted mobility in water) is particularly strong for arsenate.

High arsenic concentrations in groundwater are mainly found in cases where adsorption is restricted. These are found naturally under two main types of conditions:

- ii) strongly reducing (anaerobic, low-Eh) groundwaters where arsenite dominates and hence sorption to oxides is less favourable. Iron oxides themselves may also dissolve in such conditions, which may release further arsenic;
- iii) oxidising (aerobic) aquifers with high groundwater-pH values (> 8), typically restricted to arid or semi-arid environments. Such groundwaters commonly also have high concentrations of other potentially toxic elements such as fluoride, boron, uranium, vanadium, nitrate and selenium.

Although the precise mechanisms of arsenic release in groundwater are not yet fully understood, there appear to be two further criteria necessary for the development of high arsenic concentrations in groundwaters from these two environments. Naturally-contaminated aquifers recognised so far tend to be:

- i) geologically young (ie. sediments deposited in the last few thousand years) and;
- ii) groundwaters characterised by slow flow conditions, either because of low hydraulic gradients low-lying areas such as flat alluvial basins and the lower parts of deltas) or lack of active rainfall and recharge (arid areas, closed basins).

Examples of anaerobic aquifers affected by arsenic include the alluvial and deltaic aquifers of Bangladesh and West Bengal (formed by erosion of the Himalaya in the last few thousand years), and alluvial and lake sediment aquifers of Inner Mongolia, southern Taiwan and the Danube Basin, Hungary. Examples of oxidising aquifers with arsenic problems include the loess aquifers of central Argentina and Chile (formed over the last few thousand years largely by wind erosion of Andean rocks) and alluvial aquifers of northern Mexico and parts of south-west USA (Figure 1; Smedley and Kinniburgh, 2000).

Arsenic problems in mining and mineralised areas occur because of the oxidation of sulphide minerals (especially pyrite and arsenopyrite) which can contain very high concentrations of arsenic and which oxidise by aeration, particularly by the disturbances created by the mining activities. Arsenic problems have been recorded in sulphide-mining areas in many parts of the world, but are particularly well documented in parts of Thailand, Ghana, the USA and Canada (Figure 1). Recent health problems from mining-

related arsenic contamination have also been recognised in part of Madhya Pradesh, India.

Areas where potential future arsenic problems may be identified therefore include:

- i) large low-lying present-day alluvial and deltaic basins composed of young sediment where groundwater flow is slow or stagnant and where anaerobic conditions prevail (possibilities include the lower reaches of the Indus Valley, Pakistan, the Mekong and Red River deltas of Vietnam and possibly the lower reaches of the Niger Delta, Nigeria);
- ii) inland basins with young sediments in arid and semi-arid areas (such as parts of northern China);
- iii) sulphide mining and mineralised areas (occurring in basement aquifers in for example parts of Africa, including Ghana, South Africa, Zimbabwe and India);
- iv) geothermal areas (possibilities include the East African Rift of Tanzania, Uganda and Kenya, although no arsenic data are known for the region).

DOCUMENTED ARSENIC PROBLEMS IN GROUNDWATER AND THE ENVIRONMENT

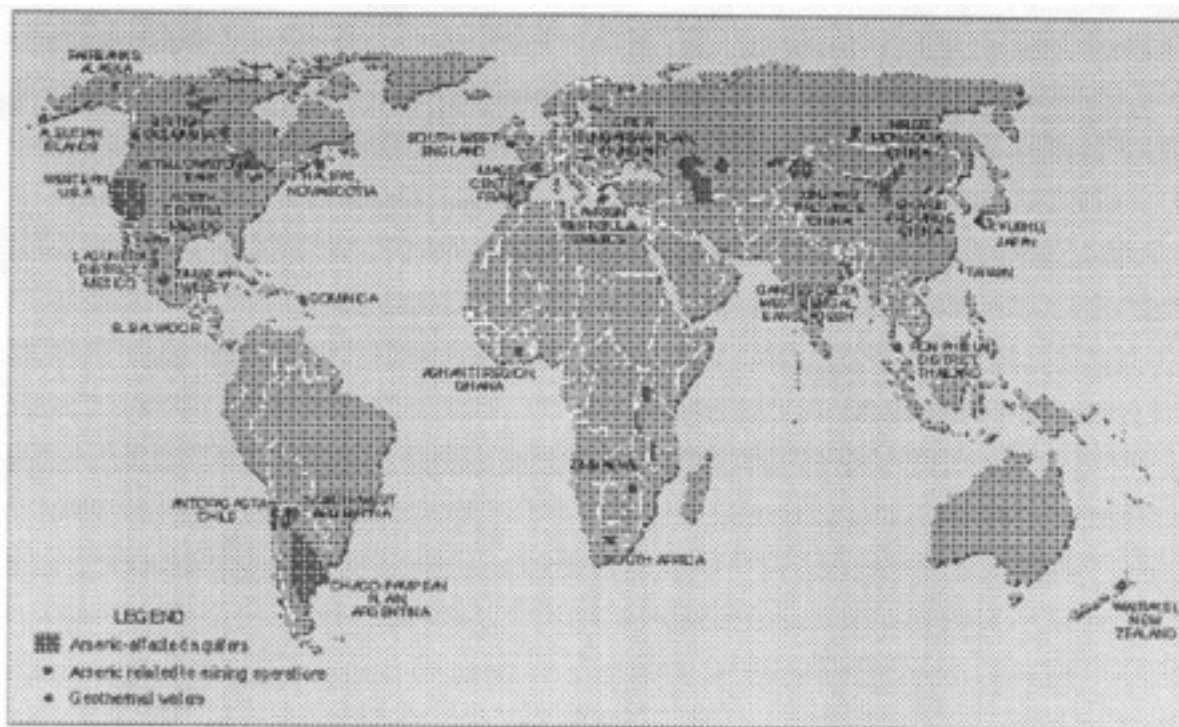


Figure 1. Documented arsenic problems in groundwater and the environment. Includes known occurrences of geothermal and mining-related arsenic problems

abandoned completely without further evaluation. In Bangladesh, a British Geological Survey study has shown that of some 3500 groundwaters collected nationally, 25% were above $50 \mu\text{g l}^{-1}$ and 35% above $10 \mu\text{g l}^{-1}$ (Kinniburgh and Smedley, 2000). There is also the possibility of selective use of contaminated sources (for washing etc). However, in some areas, a high percentage of tubewells may be contaminated and alternatives therefore need to be found.

Groundwater treatment

The most commonly used methods of treatment of high-arsenic waters at community and municipal level are by the addition of coagulants such as alum or potassium permanganate. Alum is readily available in most countries but has the drawback of leaving residual aluminium and sulphate in treated waters and is not very efficient for waters above pH 7.5. Alum is being promoted for domestic use in Bangladesh using a two-bucket (alum and sand) system. Potassium permanganate is also added to reducing groundwaters to oxidise arsenite to arsenate and thereby facilitate its removal. Adsorption of arsenic to the manganese oxide produced also occurs. Ferric chloride is also used, but more so in western countries because of cost. The efficacy of the various treatments depends on a number of factors, including the original arsenic concentrations and the overall water chemistry. Activated alumina is also used in some areas to remove arsenic by adsorption, though this is also expensive and not so suitable for developing countries. Both alum and activated alumina are also commonly used to remove fluoride (see Fluoride Fact Sheet).

For anaerobic groundwaters, there may be some benefit from simple natural flocculation of iron present in the water which precipitates as iron oxide upon aeration. This may be done by simply leaving water for a period (overnight) to allow aeration and settling. Where arsenic concentrations are high and/ or arsenic:iron ratios are high, this will be less effective but while the method may not remove the arsenic completely, it will certainly help. This method is not effective for aerobic groundwaters because iron concentrations are usually low.

Treatment of affected groundwater in Bangladesh and West Bengal is also being tried at household level using pots with various adsorption media (e.g. sand, gravel, clay) with varying success.

In oxidising aquifers with high pHs, arsenic is often not the only water-quality problem. Water treatment may also require salinity reduction alongside removal of other problem elements such as fluoride, boron, uranium, vanadium and selenium. Where possible, reverse osmosis is

commonly carried out to remove these constituents, but the method is expensive and not suitable for village-level treatment in poor communities.

Alternative tubewell siting

In Bangladesh and West Bengal, older aquifers at greater depth ($> 150 \text{ m}$) have mainly low arsenic concentrations and have in places been developed for drinking-water supply. The great spatial variability in arsenic concentrations also offers some possibilities for alternative siting. Potential for alternative tubewell siting, either spatially or with depth therefore arises in some vulnerable aquifers. However, spatial and depth variations in arsenic concentrations are not universally predictable in different aquifers. For example, the occurrence of low-arsenic groundwaters at depth in parts of Bangladesh and West Bengal is specific to the region and cannot be used as a rule of thumb elsewhere. This approach requires a detailed knowledge of the hydrogeological and geochemical conditions of the local aquifers. Provision of deeper tubewells involves significant extra cost. The current extent of understanding of spatial variations on a local scale probably does not allow accurate prediction of the locations of low-arsenic groundwater sources spatially.

Use of hand-dug wells in reducing aquifers

In reducing (anaerobic) aquifers, it has often been found that shallow open hand-dug wells have low arsenic concentrations whilst tubewells only a few metres deeper have much higher concentrations. The difference is probably due to maintenance of aerobic conditions in the open well and also to regular flushing of the shallowest parts of the aquifer, close to the water table, by inputs of recent rainwater. Low arsenic concentrations are typical of hand-dug wells in Bangladesh and West Bengal as well as in Ghana. The problem arises with bacteriological quality of open dug wells, as they are more vulnerable to pollution from the surface. Such sources require bacterial disinfection for potable use. UNICEF (India) has developed a sanitary well system with a well cover, hand pump and chlorination pot for this purpose.

Rainwater harvesting

In areas with sufficient rainfall, collection and storage of rainwater for potable use may be possible, at least seasonally. The method involves collection of rainwater either from roofs or with sheets of plastic and storage in large cement tanks. Once in the tank, rainwater can be stored safely without bacterial contamination for several months. Rainwater harvesting has been practised for a long time in many coastal areas, island

communities and other areas where aquifers are saline. It is now also being tried in arsenic-affected areas, for example parts of Bangladesh.

Treated surface water

Surface water usually has low arsenic concentrations (generally much less than $10 \mu\text{g l}^{-1}$) but may suffer from serious bacterial contamination and can cause severe health problems if not treated. Use of pond sand filters is being tried to remove bacteria in some areas. These usually involve filtration of surface water through a sand- and gravel-filled tank. Such filters are being installed for example by UNICEF in parts of Bangladesh. The filters are generally effective, provided they are periodically cleaned.

On a larger scale, urban piped-water supplies distributing treated river water are being installed in some arsenic-affected areas (e.g. West Bengal). This is however expensive and not suitable immediately for many large, dispersed and rural communities.

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