COMBATING A DEADLY MENACE

Early Experiences With A Community-Based Arsenic Mitigation Project in Bangladesh

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August 2000
Research Monograph Series No.16

BRAC
Research and Evaluation Division
75 Mohakhali, Dhaka 1212
Bangladesh

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Research team
A. M. R. Chowdhury (Project Director)
Md. Zabed Hossain
Ross Nickson
Mizanur Rahman
Md. Jakariya
Md. Shamimuddin

Editor
Hasan Shareef Ahmed

Cover design
Golam Hafiz Masud

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Publisher
BRAC
BRAC Centre
75 Mohakhali
Dhaka 1212, Bangladesh

E-mail : bracamr@bdmail.net mushtaq@bdmail.net
Fax : 880-2-8823542, 8823614
Telephones : 9881265, 8824051, 8824180-87
Website : www.brac.net

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Dedicated to

Kaiser Ali (of Goalbakpur village of Jhikargachha upazila) and others who died due to arsenic poisoning.

Let our efforts gear up to prevent such untimely deaths

CONTENTS

EXECUTIVE SUMMARY

Bangladesh is facing the problem of arsenic poisoning in drinking water. Around 27% of the tubewells, which supply drinking water to most of the population, have arsenic concentrations above the government of Bangladesh limit of 50 µg per litre. This means that a quarter of the country's population is exposed to arsenic poisoning which is alarming and unprecedented in history.

BRAC, a non-governmental organisation, in conjunction with the Department of Public Health Engineering (DPHE) of the government of Bangladesh and UNICEF, has implemented a project titled, **'Action Research into Community-Based Arsenic Mitigation'** in two upazilas of Bangladesh - from June 1999 to June 2000. The aim of the project was to assess the technical viability as well as the effectiveness of different alternative safe water options and to figure out the community acceptance of such options. The activities included the determination of the extent of arsenic contamination in water of all the tubewells of the project area; involvement of community members in choosing, implementing and maintaining alternative sources for safe drinking water, determination of the viability and effectiveness of different mitigation options and assess their relative acceptance by villagers; identification of arsenic-affected patients and providing treatment; and make the community people aware of arsenic poisoning. This report presents the experiences of the initial course of project implementation. A summary of the experiences is given below.

Results of tubewell testing

Testing of tubewells for arsenic was carried out on a 'census' basis by BRAC-trained Village Health Workers (VHW) using the field test kit produced by Merck of Germany. Test results were verified twice by field supervisors and in the laboratory. In Sonargaon upazila 62% of the wells contain arsenic above 100 ppb[1] and in Jhikargachha it was 48%. All these wells were painted 'red'. The percentage of 'safe' well (arsenic concentration in water of 0 ppb) in Sonargaon and Jhikargachha is 35% and 41% respectively, and all their spouts were painted 'green'. Wells that lie in the range of above 0 but below 100 ppb have been painted with a 'red cross' to indicate uncertainty. The proportion of these wells is 3%

[1] Both ppb (parts per billion) and micrograms per litre have been used interchangeably as the unit of measurement for arsenic. In some cases, ppm (parts per million) and milligram per litre (mg/L) have also been used.

in Sonargaon and 11% in Jhikargachha. A total of 51,685 tubewells were tested in the two upazilas.

Validation of tubewell testing

To check the accuracy of testing by VHWs, 2,266 tubewells (5% of total 'red' and 'green' marked tubewells in both the upazilas) were re-tested by BRAC field supervisors using the same kit. The results showed that VHWs did very well in testing the tubewells. The percentage of correctly tested tubewells (green-green and red-red) was 90% of the tubewells tested in Sonargaon and 85% of the tubewells tested in Jhikargachha. The percentage of false negatives (red tubewells painted green - a dangerous identification) was 12.5% of the green tubewells tested in Sonargaon and 5% of the green tubewells tested in Jhikargachha. The percentage of false positives (a tubewell painted red when it should have been green- a wasted well) was 4% of the red tubewells tested in Sonargaon and 7% of the red tubewells tested in Jhikargachha.

Monitoring of tubewell testing over time

Tubewells tested 'green' in September 1999 using Merck kit were again re-tested in June 2000 with the kit and Atomic Absorption Spectrophotometry (AAS). In Sonargaon upazila, 95.8% of the tubewells continued to mark green implying that they remained unchanged for over 9 months; only 3.3% and 0.9% green marked tubewells changed to 'red' and 'cross' respectively during this period. In Jhikargachha only 2.8% of the tubewells changed into 'red'.

Twenty-five tubewells had tested 'green' and 'cross' using the Merck kit in September 1999 in Jhikargachha. In June 2000 when these were re-tested using AAS, only one was found to have become 'red' (0.06 mg/L). In Sonargaon, 64 'green' and 'cross' marked tubewells were re-tested using AAS in June 2000, and only one of the 'cross' marked tubewells changed to 'red'. Based on these results, it can be said that no change in concentration of arsenic in tubewell waters occurred in these two upazilas over a nine-month period.

Arsenicosis patients, their treatment and support

VHWs initially identified 348 arsenicosis patients who were later confirmed by physicians. The number of patients increased over time, and by June 2000 this rose to 403. All these patients were provided with safe drinking water. Of them, 269 received *Carocet* tablets with vitamin A, C, and E, and salicylic acid as ointment. They are being monitored on a regular basis.

Installation and assessment of safe water options

Installation and assessment of safe water options was a major activity. The main options promoted were: treatment of surface water with Pond Sand Filter (PSF) and home-based filters; collection of rainwater in Rain Water Harvesters (RWH); treatment of arsenic contaminated groundwater with home-based three-pitcher filters, Safi filters, and arsenic removal plants; and use of shallow groundwater through dugwells. It may be noted that there was little previous experience to draw lessons from.

These options have been assessed on several criteria: initial and running costs; ease of implementation, running and maintenance; continuity and flow of supply; arsenic removal capacity; susceptibility to bacteriological contamination; and acceptability to the community.

All options have their own strengths and limitations and none are as easy as fetching tubewell water directly. At present the home-based filters are proving most popular due to their low cost, ease of use, and cultural acceptability. Three-pitcher filters have proved to be the most popular and feasible in the short-run due to their low cost, ease of operation, availability, and low running cost. Among the community-based options the pond-sand filters initially created good interests among people. But it was found later that people were more interested in using the PSF treated water for cooking than drinking. People in general were found less enthusiastic in using rain water although people in Sonargaon used this option more than in Jhikargachha. Dugwells have good potentials in the arsenic-affected areas if the shallow aquifer is free of arsenic contamination; people's interest to use this option was found to be marked. The newly introduced community-based activated alumina filter also seems promising but it requires further monitoring. The tubewell-sand-filter also has good potentials. The bacteriological quality of all these need continuous monitoring.

BRAC has been able to provide 'safe' water to nearly a quarter of the households exposed to arsenic contamination in all severely affected villages of the two upazilas.

Community involvement in project implementation

The people of the project areas were involved in implementing the project. In a village multiple meetings were held at different stages of the project to inform and involve the community. At these meetings the potential safe water options were discussed. Taking into account the opinion of the villagers, BRAC proceeded with the demonstration of different alternative safe water options with no cost to the community. The villagers decided where the community-based systems would be best located and then committed to maintaining the system.

Awareness development

A combination of approaches such as meetings, workshops, distribution of posters and leaflets, and the print and electronic media were used in raising awareness about arsenic contamination and the consequences of drinking arsenic contaminated water.

Village meetings, school meetings, and meetings with the local elected bodies were conducted to inform people about the arsenic issues. To design a communication campaign workshops were conducted in the two upazilas where representatives of different stakeholders participated. Research carried out found that BRAC was the primary source of knowledge about arsenic and its mitigation options in the project villages although health workers of other organisations and the media played a role. As a result of the project activities, the awareness level of the community increased significantly.

Collaboration with other organisations

The BRAC arsenic mitigation project maintained a close relationship with the local DPHE and elected bodies like the Union Parishad (UP). Monthly field co-ordination meetings were conducted with the Sub-Assistant Engineer (SAE) of DPHE, Jhikargachha and UNICEF Regional Co-ordinator to inform them of the progress of the project activities. The DPHE officials of Jhikargachha upazila were involved in selecting sites for construction and distribution of options.

The UP chairmen and ward members of both the upazilas were involved in implementing the project activities. They contributed in site selection for construction of options and distribution of filters.

Summary conclusions

1. The existence of arsenic contamination in drinking water has been confirmed in the two upazilas. A blanket testing reveals that 62% of the tubewells in Sonargaon and 48% in Jhikargachha are contaminated with arsenic above the government of Bangladesh limit. There are many villages where no arsenic-free tubewells are available.

2. With some training it is possible for semi- or illiterate female village volunteers to test the tubewell water for arsenic. The technology for testing at the field level, however, needs further improvement.

3. Community mobilisation and involvement are essential for the process of arsenic mitigation.

4. Among the home-based options the three-pitcher filters were most popular due to their low cost and ease of construction. Tubewell-sand-filter, dugwells, and activated alumina filters so far monitored, seemed promising to fulfil the demand of the community. Eleven different options were tested under this project.

5. There should be a system of continuous monitoring of water quality for arsenic treated by any device. Most of these devices have potentials in removing arsenic for a certain period of time. The water also needs to be monitored regularly for bacteriological contamination.

6. There was a lack of consistency in the results of laboratory tests, particularly for coliform bacteria, much of which remained unexplained. In future, more attention needs to be given on proper testing of the water.

7. The usage of the different 'safe' water options by the community also needs to be monitored to understand the use dynamics.

8. It is likely that multiple options will need to be promoted in Bangladesh to tackle the arsenic crisis based on local situations.

9. NGOs with their base at the grassroots level and wide network throughout the country are capable of scaling up the arsenic mitigation activities rapidly; however, co-ordination of various agencies involved in the process is very important. In the two upazilas BRAC has so far been able to provide 'safe' water to a quarter of households exposed to arsenic contamination in the severely affected villages.

10. Finally, this action research project has provided some important learning about the potential sources of arsenic-free water. Community mobilisation and motivation will be essential in providing a sustainable solution to the problem. In the longer term, the country must consider piped water supply to its rural and urban populations. In the short term, however, the options tested in this and other similar projects will need to be considered as emergency measures for the arsenic affected villages.

ACKNOWLEDGEMENT

The financial assistance for this project provided by UNICEF Bangladesh is gratefully acknowledged. BRAC is also grateful to the Department of Public Health Engineering (DPHE) of the government of Bangladesh and to other partners for their constant support. The many visitors to the project sites were a source of encouragement and BRAC acknowledges with thanks their encouragement and suggestions. The contribution of field staff based in the two upazilas is also acknowledged.

Last but not the least, BRAC is indebted to the people of the project areas who provided all cooperation in carrying out this action research project.

ABBREVIATIONS

AAN	Asia Arsenic Network
AAS	Atomic Absorption Spectrophotometer
Al	Aluminium
As	Arsenic
BAMWSP	Bangladesh Arsenic Mitigation and Water Supply Project
BDL	Below Detection Level
BGS	British Geological Survey
BRAC	Formerly Bangladesh Rural Advancement Committee
cfu	Coliform unit
DANIDA	Danish International Development Agency
DCH	Dhaka Community Hospital
DFID	Department for International Development (UK)
DPHE	Department of Public Health Engineering
Fe	Iron
GoB	Government of the People's Republic of Bangladesh
ICDDR,B	International Centre for Diarrhoeal Disease Research, Bangladesh
µg/L	Microgram per litre
mg/L	Milligram per litre
Mn	Manganese
NGO	Non-governmental Organisation
NIPSOM	National Institute of Preventive and Social Medicine
ppb	Parts per billion
ppm	Parts per million
PSF	Pond Sand Filter
RED	Research and Evaluation Division (BRAC)
RWH	Rain Water Harvester
SAE	Sub-Assistant Engineer (DPHE)
TAG	Technical Advisory Group (BAMWSP)
TSF	Tubewell Sand Filter
TW	Tubewell
UNICEF	United Nations Children's Fund
UP	Union Parishad
VHW	Village Health Worker
VO	Village organization
WHO	World Health Organization

Chapter 1

INTRODUCTION

1.1 The arsenic problem

Bangladesh faces multi-faceted problems in relation to its development. Now there is also a new threat - arsenic contamination in ground water. It is estimated that 95% of the population relies on groundwater for drinking purposes and over a quarter of Bangladesh is affected by this new problem (DPHE/BGS/DFID, 2000). This means that about 30 million people are potentially at risk of arsenic poisoning. Map in Figure 1.1 shows the distribution of arsenic contamination in the groundwater of Bangladesh, as revealed by a recent study.

The degree of toxicity of arsenic depends on its chemical form and specification. Arsenic may be organic or inorganic. Humans are exposed to arsenic mainly through ingestion and inhalation. The World Health Organisation (WHO) has recently revised its original guideline value for arsenic in drinking water 0.05 mg/L (WHO, 1984) to a provisional guideline value 0.01 mg/L (WHO, 1993). The level recommended by the Bangladesh government is 0.05 mg/L (DoE, 1991). Water with high levels of arsenic leads to health problems including melanosis, leuko-melanosis, hyperkeratosis, black foot disease, cardiovascular disease, hepatomegaly, neuropathy and cancer. Arsenic accumulates in the liver, kidney, heart, and lungs. It is also deposited in bones, teeth and hair (Khan, 1997). The toxicity and health impact of arsenic depends on the chemical and physical forms of the compound, the route by which it enters the body, the dose and the duration of exposure, dietary compositions of interacting elements and the age and sex of the exposed individuals.

For manifestation in a person's body the symptoms of arsenic toxicity may take several years after the starting date of drinking arsenic contaminated water. This period differs from person to person, depending on the quantity and volume of arsenic ingested, nutritional status of the person, immunity level of the individual and the total time of arsenic ingestion. Malnutrition and poor socioeconomic conditions aggravate the hazard of arsenic toxicity. Although arsenicosis is not an infectious, contagious or hereditary disease, arsenic toxicity creates many social problems for the victims and their families (Khan & Ahmad, 1997).

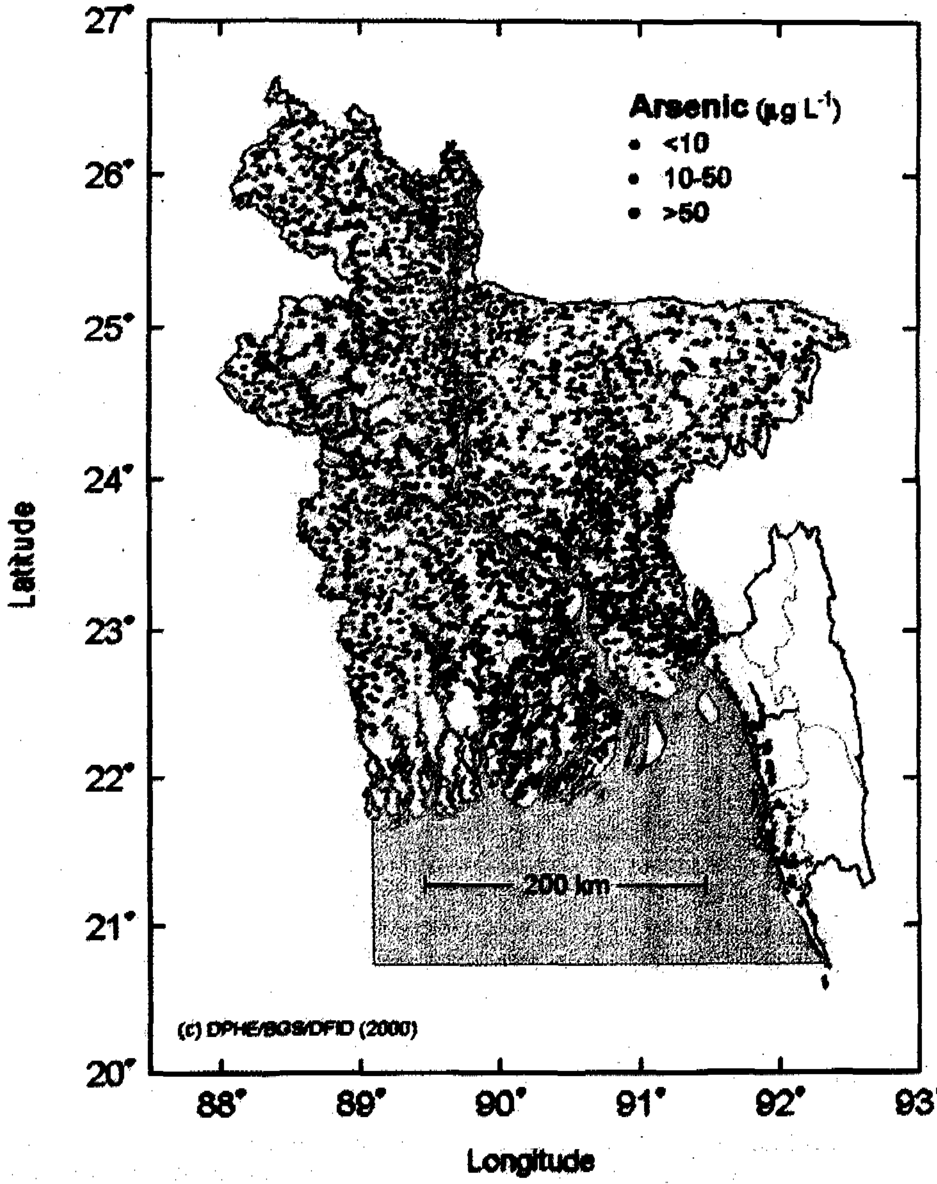


Figure 1.1: Map of Bangladesh showing the distribution of arsenic contamination in groundwater (courtesy: DPHE/BGS/DFID 2000).

Origin of arsenic poisoning in groundwater of Bangladesh

There are two principal hypotheses on the origin of arsenic poisoning in groundwater of the vast tract of alluvial aquifers in Bengal Delta Plains of West Bengal in India and Bangladesh.

Oxidation hypothesis: According to this hypothesis arsenic is derived from the oxidation of arsenic-rich pyrite in the shallow aquifer as a result of lowering water table due to over abstraction of groundwater for irrigation. Shallow aquifers in Bangladesh and West Bengal are highly arsenic contaminated. So, as per this hypothesis the arsenic problem in this region is man-made.

Reduction hypothesis: According to this hypothesis the source of arsenic in drinking water is geological. Arsenic was naturally occurring in the sediments of Bangladesh bound to amorphous iron oxyhydroxide. Due to the strongly reducing nature of Bangladesh groundwater this compound has broken down and arsenic has been released to groundwater (Nickson R, et al, 1998). Arsenic contamination has been detected mainly in groundwater from the shallow aquifer (less than 50 meters deep) (DPHE/BGS/DFID, 2000).

Now the main challenge is how to provide arsenic-free drinking water to the millions of people at risk. Many organisations have taken up different arsenic-related programmes; most of which, however, are focused on testing tubewell water for arsenic. The World Bank is providing support for an integrated response to the arsenic crisis by the Government of Bangladesh through the Bangladesh Arsenic Mitigation-Water Supply Project (BAMWSP). A key component of the BAMWSP will be the use of community-based, demand-driven projects, in which community members play an active role in choosing and implementing solutions to the site-specific problems of arsenic contamination. BRAC has also been involved in arsenic-related activities since 1997.

1.2 BRAC activities on arsenic

BRAC, one of the largest national non-governmental organisations, has a proven capacity for field-level programme implementation, socioeconomic research, a strong institutional network and experience in training of community members in testing tubewell water for arsenic. It initiated arsenic mitigation activities through testing all the 802 tubewells in its field offices.

The situation in Hajiganj upazila was found to be very alarming; of all of 11,954 tubewells tested in this upazila 93% showed the presence of arsenic. When the results of field testing by VHWs were compared with laboratory results, 93% matched, showing the quality of the field kits and the capability of VHWs in effectively conducting the testing. The cost of testing each water sample was minimal and the testing programme in Hajiganj upazila was completed in just over a month indicating that the methodology used by BRAC is both cost and time effective (Chowdhury and Jakariya, 1999).

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

In 1999 BRAC, in collaboration with UNICEF and DPHE, initiated a pilot project on community-based arsenic mitigation in one union of Sonargaon upazila under Narayanganj district. This study aimed to find out the success and constraints in implementing such a project completely new in the country.

1.3 Development of the project and purpose of the report

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

Once tubewells have been tested for arsenic the next logical step is to 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 upazilas. 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.

This is the phase-ending report for the **'Action Research on Community-Based Arsenic Mitigation'** project for the period June 1999 - June 2000. It covers results of testing, resource mapping and village meetings, treatment of arsenic-affected patients, and the installation, monitoring and evaluation of safe water options in the two upazilas.

1.4 Project objectives

The objectives of the action research project were:

1. to determine the extent and level of arsenic contamination in all tubewell water of the project areas by -

- giving training to community members to test all tubewells using field kits, and marking all tested tubewells red if arsenic detected above the acceptable level and green otherwise.

2. to determine the technical viability and effectiveness of different mitigation options and to assess their relative acceptance by villagers by -

- conducting a participatory rural appraisal (PRA) to map resources in each of the project villages;
- involving community members in selection and implementation of a source of arsenic-free drinking water;
- installing and/or supplying demonstration units of different alternative safe-water options in the project areas;
- monitoring and maintenance of alternative drinking water systems and continued promotion of safe water use in the community;
- monitoring quality of water supplied from various alternative sources for arsenic, coliform and other pollutants;
- interaction with the community and evaluation of their acceptance of different mitigation strategies.

3. to identify arsenic-affected patients in the project area and provide basic health information and medical support.

4. to create awareness among the people of the project areas about the arsenic problem.

1.5 Project areas

Sonargaon upazila of Narayanganj district and Jhikargachha upazila of Jessore district were selected for this action research study (Figure 1.2). Although both the upazilas are within the zone of severe arsenic contamination, substantial variation in physiography and manifestation of arsenicosis exist.

Sonargaon is a low-lying area and is flooded every year. On the other hand, Jhikargachha is flood free area and is an area of relatively low rainfall.

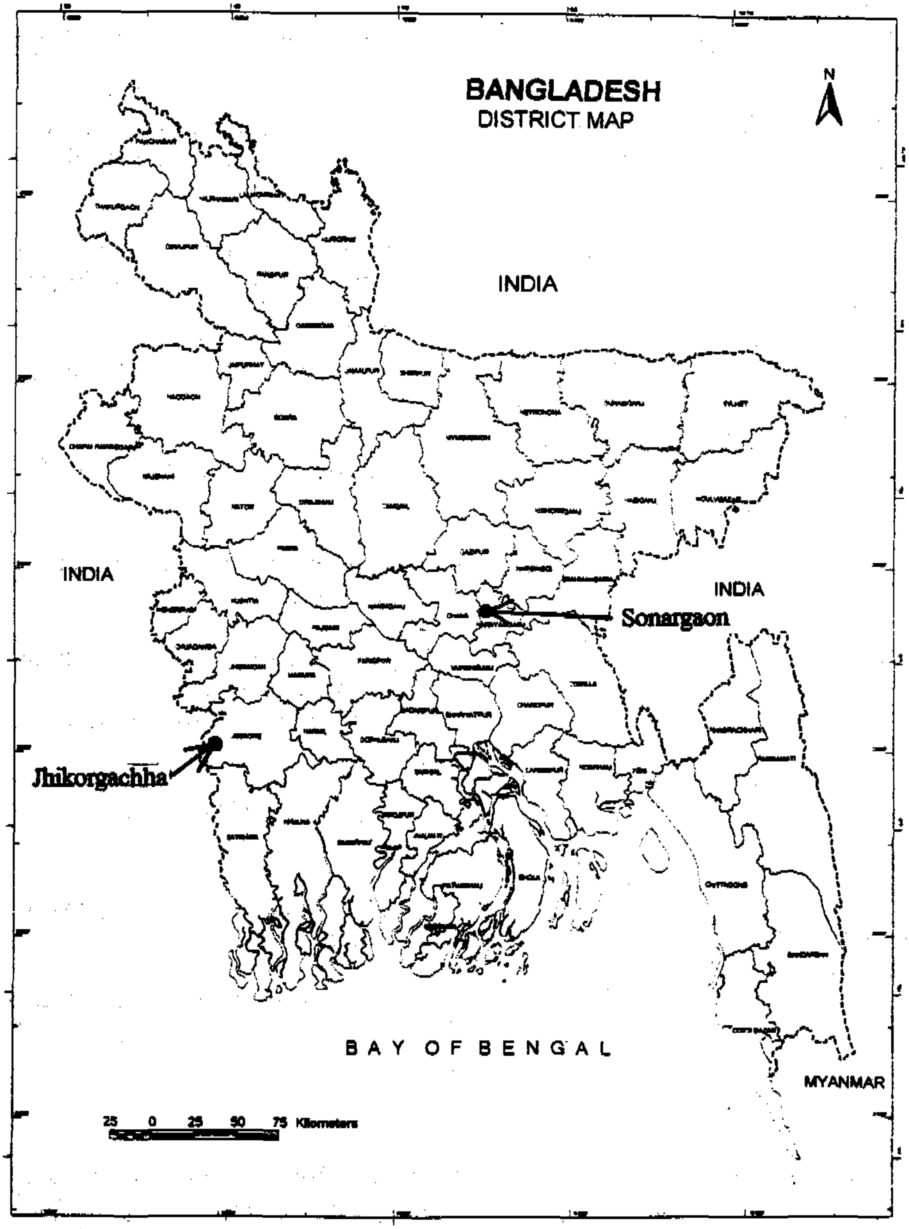


Figure 1.2: Map of Bangladesh showing the two upazilas (sub-districts) where the action research was carried out.

1.6 Overall strategy of the project

BRAC's action research on community based arsenic mitigation includes some major components shown in the following flowchart:

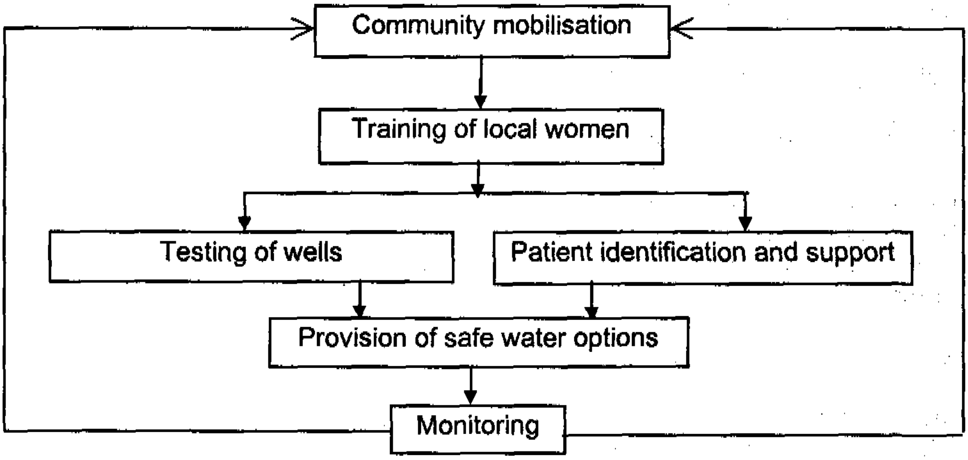


Figure 1.3: Flowchart of the BRAC arsenic mitigation programme.

1.6.1 Optimum use of local resources

The optimum use of the local resources in implementing the project was the driving force. First of all local village women with limited educational background were selected to test tubewells across the upazila. They were also trained in arsenic patient identification, developing local awareness, different safe water options and monitoring the use of options in the two target regions. During the course of project implementation, people of different walks of life were encouraged to voice their views on the arsenic issues, and how they believed they could contribute to mitigate this problem which is completely new to the village. Peoples' own evaluation was used to assess the different safe water options in the community. Local masons were trained in the construction and manufacture of different options so that their expertise can be used to a maximum extent.

1.6.2 Community-based approach

Throughout the duration of the project, emphasis was placed on ensuring that the community was involved as an integral part of the implementing force. Preference was given to community-based options to allow for a greater role for local participation and decision-making and make use of local knowledge.

1.6.3 Ensuring quality of testing for arsenic in tubewell water

To ensure the quality of testing arsenic in tubewell water conducted by the Village Health Workers (VHW) the tubewells were re-tested by field supervisors. Water of some selected tubewells were again tested at the laboratory using Atomic Absorption Spectrophotometry (AAS).

1.6.4 Collaboration with local government bodies

During the course of project implementation, local DPHE was involved at different stages. The Sub-Assistant Engineer of Jhikargachha upazila was particularly helpful in the construction of safe water options. Among the local elected bodies the Union Parishad chairmen and the members were also involved to site selection for construction and distribution of different options.

1.6.5 Priority for worst affected villages and the poor

Arsenic contamination varied among villages in the two upazilas. In some villages more than 90% of the groundwater was found contaminated, while in others less than 50% was found contaminated. Although the construction and distribution of different safe water options were at first concentrated in the villages where more than 50% of the tubewells were contaminated, within a village, priority was given to the poor households. However, the first to receive the options were the households where arsenicosis patients were identified.

1.6.6 Arsenicosis patient care

From the very beginning of project implementation, patient-care was taken up seriously. Arsenicosis patients were screened and confirmed as early as possible and were supplied with safe drinking water. Then they were given different medicines such as *spirulina*, vitamins A, C, E, and salicylic acid as ointment. All the patients were under regular follow-up and visited weekly by field supervisors. In one instance, a seriously affected patient was sent to Dhaka Community Hospital for treatment. Unfortunately he died after returning home (see Box 3.1)

1.6.7 Ensuring safe drinking water supply

The monitoring of water quality treated by different technologies introduced in the pilot project received utmost attention. A large number of tests on different water quality parameters were done in different laboratories including the Atomic Energy Commission, ICDDR,B, Intronics Technologies Centre, Environmental Quality Laboratory (Equal), and DPHE Zonal laboratories.

1.6.8 Increased awareness on arsenic issues

The arsenic problem is new in Bangladesh. Awareness and motivation on arsenic issues were done in two ways. First, to make people believe that arsenic is a poison and health hazard and secondly people should procure safe water at their own effort and cost. Monitoring work was also done on the option use by the community because it was found that although people were provided with safe drinking water sources free-of-cost many of them did not use those.

1.6.9 Environment-friendly activities

Sludge produced in the treatment units contains arsenic of higher concentration which was a major environmental concern. Proper management of this sludge was given utmost importance during the project period. To this end, the users of all treatment units were asked to deposit the sludge into their nearest BRAC offices.

Chapter 2

TESTING OF TUBEWELL WATER FOR ARSENIC

2.1 Testing methods used

In Bangladesh laboratory-based methods to test arsenic are available only in a few institutions and the cost is prohibitive. Besides, several field-kit techniques are in use to detect arsenic in water. Field kit techniques are low cost and give rapid results. It provides qualitative result (yes or no) and is used for screening. If carefully controlled, the field kit procedure is a fairly reliable method.

The field kit of Asian Arsenic Network (AAN) is one of such type. The National Institute of Preventive and Social Medicine (NIPSOM) in Dhaka further modified the AAN kit to make it easily available in Bangladesh, inexpensive, more effective and simple to operate even by a non-technical person. BRAC used the NIPSOM kit to detect arsenic in water in its earlier testing (Chowdhury and Jakariya, 1999).

At the beginning of the project the field kit produced by a local pharmaceutical company was used for arsenic testing but was later discarded because of its low reliability. Later, to comply with the guidelines of the Technical Advisory Group (TAG) of the BAMWSP project, it was decided to use Merck field test kit (produced in Germany). One Merck kit costs Tk. 2,500 (around US $ 50) through which about 80 tests can be conducted (Tk. 31 or US $ 0.63 per test).

The Merck kit uses a semi-quantitative colourometric method. Addition of chemicals to the water sample converts the arsenic present in water to arsine gas, which then reacts with a mercury bromide impregnated test paper. The colour change on the paper indicates the amount of arsenic present in the water sample. This test kit, however, does not provide reliable reading for the arsenic concentration between 0.01 to 0.1 mg/L.

If the test paper showed no stain the wells are considered 'safe' and were marked 'green'. If it showed a stain equal to or greater than 0.1 mg/L they are considered 'dangerous' and were marked 'red'. If it showed some stain (i.e. greater than 0 but less than 0.1 mg/L) the wells were are considered 'potentially dangerous' and marked with a red cross. Table 2.1 shows the definition of arsenic contamination and their qualitative and field specification.

Table 2.1: Qualitative and field specification of different levels of arsenic contamination

Level of arsenic mg/L	Qualitative specification	Spout of TW painted
0	Safe	Green
>0-<0.1	Potentially dangerous	Red cross
0.1+	Dangerous	Red

2.2 Training

The village health workers (VHW) are selected from among the village women with limited or no literacy. They are then trained by BRAC to treat some selected common illnesses in the village (Chowdhury et al. 1997). A total of 157 such VHWs, 80 from Sonargaon and 77 from Jhikargachha, were given two days training on arsenic at local BRAC

Figure 2.1: A Village Health Worker testing water for arsenic contamination.

offices. These training were conducted by the staff of BRAC's Research and Evaluation Division and Dhaka Community Hospital (DCH). The DCH training concentrated on how to identify arsenicosis patients and how to provide treatment and referrals.

On the first day the BRAC trainers provided them details about the origin and extent of arsenic poisoning in the groundwater of Bangladesh, health aspects of arsenicosis, and identification of the patients. On the second day the VHWs learned about the technique of testing of arsenic in water by using field kit. They learned about arsenicosis both theoretically and practically by observing patients of different stages in the field.

During the field level testing of tubewell water, refresher training were conducted for the VHWs every week. This also produced feedback from the field work. Any problem in arsenic testing faced by the VHWs were discussed and resolved.

2.3 Results of tubewell testing

A total of 25,048 tubewells were tested by VHWs in Sonargaon upazila and 26,637 in Jhikargachha upazila. The work in the two upazilas were done simultaneously and it took about 50 days to complete the testing and painting of the tubewell spouts.

Summary results of the arsenic testing are given in Figure 2.2. Complete union wise breakdown of results is shown in Tables 2.2 and 2.3 and Figures 2.3 and 2.4. It shows that 62% of the wells in Sonargaon and 48% in Jhikargachha are contaminated with arsenic. Tables 2.3 shows that in 15% of the villages of Sonargaon and 2% in Jhikargachha, all the wells are contaminated; it also shows that in 74% villages of Sonargaon and 52% villages of Jhikargachha over half of the wells are contaminated.

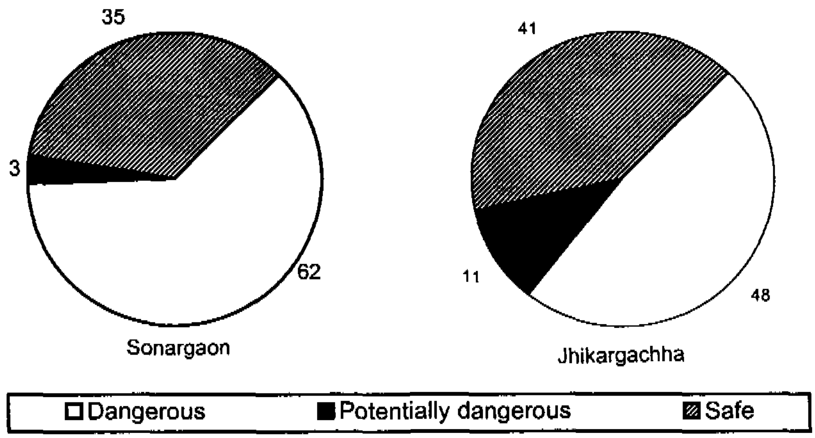


Figure 2.2: Results of tubewell testing in Sonargaon and Jhikargachha upazilas.

Table 2.2: Unionwise details of arsenic contamination in Sonargaon upazila

Union	Number of tubewells tested			
	Dangerous	Safe	Potentially dangerous	Total
Kachpur	70 (4)	1565 (94)	30 (2)	1665
Sadipur	26 (1)	3178 (99)	18 (0.56)	3222
Jampur	1566 (57)	1131 (41)	72 (3)	2769
Noagaon	1044 (81)	155 (12)	86 (7)	1285
Sanmandi	2563 (86)	347 (12)	69 (2)	2979
Baradi	1372 (83)	185 (11)	89 (5)	1646
Mugrapara	2353 (80)	503 (17)	69 (2)	2925
Aminpur	1570 (64)	846 (34)	54 (2)	2470
Baidyer Bazar	1470 (75)	430 (22)	53 (3)	1953
Shambhupara	1483 (88)	137 (8)	65 (4)	1685
Pirojpur	1972 (81)	400 (16)	77 (3)	2449
Total	15,489 (62)	8,877 (35)	682 (3)	25,048 (100)

Note: Figures within parentheses indicate percentages.

Table 2.3: Unionwise details of arsenic contamination in Jhikargachha upazila

Union	Number of tubewells			
	Dangerous	Safe	Potentially dangerous	Total
Ganganandpur	1150 (54)	862 (40)	121 (6)	2133
Magura	1399 (65)	574 (27)	195 (9)	2168
Simulia	899 (46)	897 (46)	167 (9)	1963
Gadkhali	1217 (46)	979 (37)	465 (17)	2661
Jhikargachha	1410 (30)	2962 (64)	295 (6)	4667
Navaron	1119 (37)	1495 (49)	424 (14)	3038
Panisara	1043 (40)	1041 (40)	497 (19)	2581
Nirbashkhola	879 (45)	861 (44)	232 (12)	1972
Hazaribag	827 (46)	783(43)	191 (11)	1801
Shankarpur	1295 (76)	279 (16)	128 (8)	1702
Bankra	1570 (80)	246 (13)	135 (7)	1951
Total	12,808 (48)	10,979 (41)	2,850 (11)	26,637 (100)

Note: Figures within parentheses indicate percentages.

Table 2.4: Scale of arsenic contamination in Sonargaon and Jhikargachha upazilas

Upazila	Number of villages	Total TW tested	Number of villages with		
			50%+ Dangerous tubewell	80%+ Dangerous tubewell	100% Dangerous tubewell
Sonargaon	368	25,048	272 (74%)	64 (17%)	54 (15%)
Jhikargachha	163	26,637	96 (54%)	34 (21%)	3 (2%)

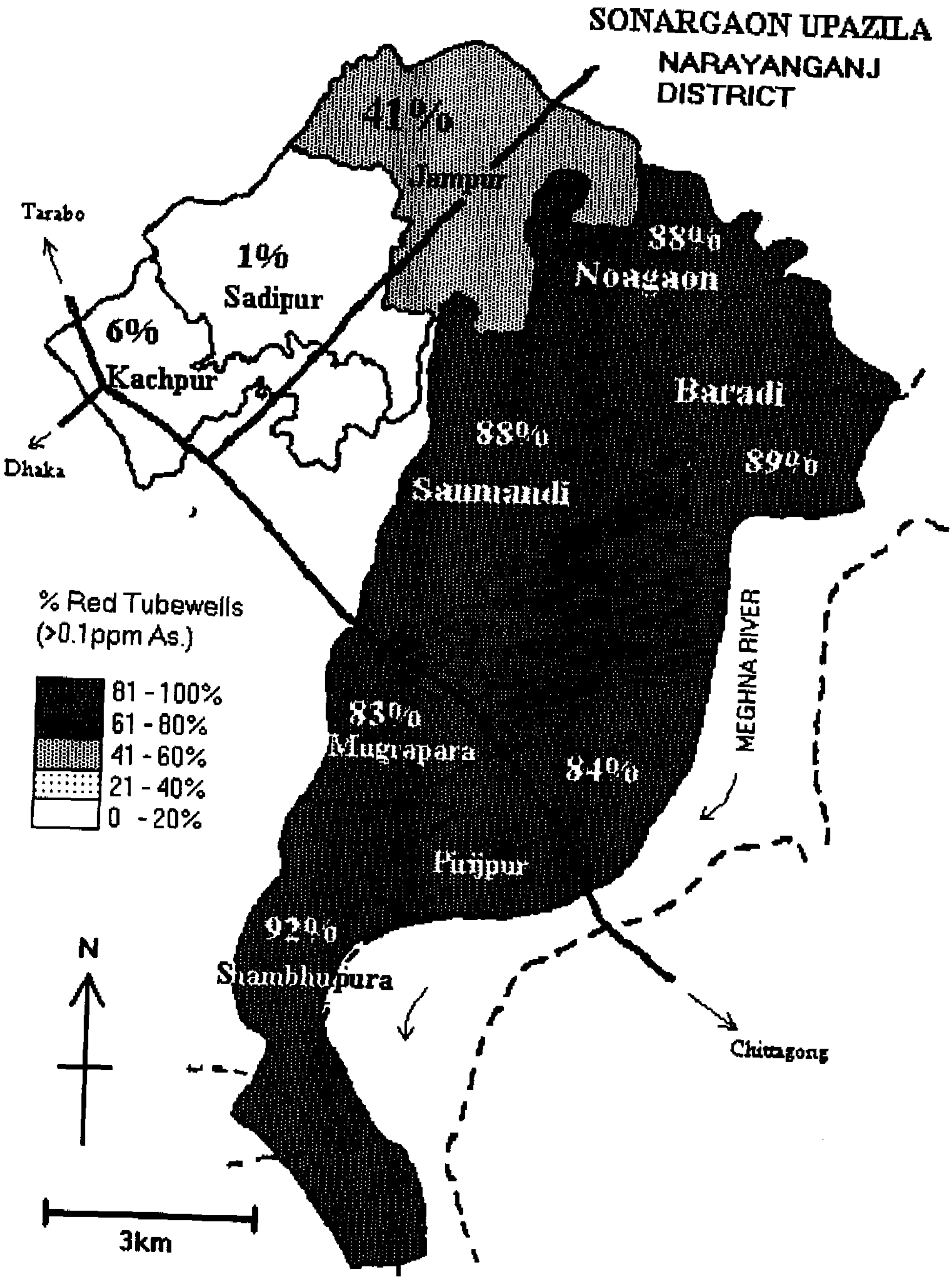


Figure 2.3: Map of Sonargaon upazila showing percentage of contaminated tubewells in different unions.

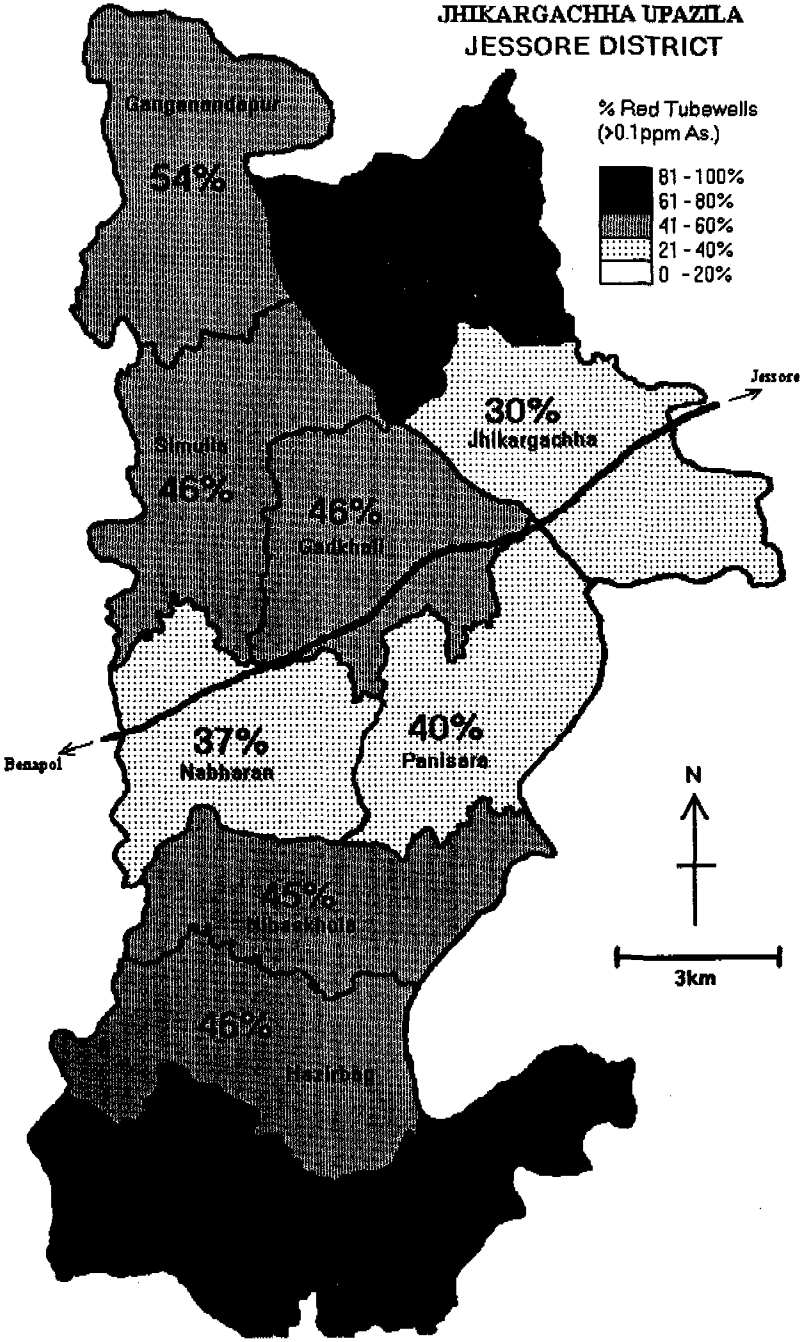


Figure 2.4: Map of Jhikargachha showing percentage of contaminated tubewells in different unions.

The above-mentioned Tables highlight the intra-upazila variation in arsenic contamination. Figure 2.3 shows that Shambhupara Union in Sonargaon upazila has the highest percentage of contaminated tubewells (88%) while Sadipur Union has the lowest (1%). This large difference is due to geological variations within the upazila. The Plio-Pleistocene terrace (Madhupur Tract) which underlies the northern part of the upazila (Kachpur, Sadipur and part of Jampur). This geological formation contains oxidised groundwater which does not contain arsenic. The southern part of the upazila is underlain by Holocene-Recent floodplain sediments from the Meghna river and the groundwater abstracted from these sediments is strongly reducing and is likely to contain high levels of arsenic.

In Jhikargachha upazila the highest percentage is in Bankra Union (80%) and the lowest is in Jhikargachha Union (30%) (Table 2.3). Compared to Sonargaon, the contamination is much more evenly spread across Jhikargachha upazila.

The variation in contamination of groundwater of Sonargaon and Jhikargachha may be explained by considering the geomorphology and geology of the two areas. Jhikargachha is rarely flooded and is geomorphologically more stable than Sonargaon, which is mainly underlain by active Meghna floodplain. It is likely that Jhikargachha will be underlain by the full range of fluvial sediments (gravels, sands, silts and clays) related to different relict features of fluvial systems such as infilled oxbow lakes, floodplain, meander belts, levees etc. In contrast, the sediments underlying the southern part of Sonargaon are more likely to be dominated by the finer grain sizes (silts and clays) which are associated with floodplains. As finer grained sediments (silts and clays) are more likely to contain arsenic (Mok and Wai, 1994) this geomorphological variation between the two unions may explain why more arsenic-contaminated tubewells are found in Sonargaon than in Jhikargachha.

2.4 Validation of field testing

2.4.1 Field validation by BRAC supervisors

To check the accuracy of arsenic testing by VHWs 1,216 tubewells in Sonargaon and 1,050 tubewells in Jhikargachha (5% of total red and green marked tubewells of both the upazilas) were re-tested by BRAC field supervisors using the Merck field test kit.

Tables 2.5 and 2.6 show that VHWs did reasonably well in testing the tubewells. The percentage of correctly tested tubewells (green-green and red-red) was 90% of the total tubewells tested in Sonargaon and 85% of the total tubewells tested in Jhikargachha (not shown in tables). The false negatives (red tubewells painted green - a dangerous identification) were 12.5% of the green tubewells tested in Sonargaon and 5% of the green tubewells tested in Jhikargachha. The false positives (a tubewell painted red when it should have been green - a wasted well) was 4% of the red tubewells tested in Sonargaon and 7% of the red tubewells tested in Jhikargachha.

Table 2.5: Validity of tubewell testing by VHWs, Sonargaon

Tested by VHWs	Re-tested by supervisors			Total
	Red	Green	Cross	
Red	695 (92%)	32 (4%)	27 (4%)	754 (100%)
Green	58 (12.5%)	400 (86.5%)	4 (1%)	462 (100%)

Table 2.6: Validity of tubewell testing by VHWs, Jhikargachha

Tested by VHWs	Re-tested by supervisors			Total
	Red	Green	Cross	
Red	465 (83%)	40 (7%)	51 (9%)	556 (100%)
Green	25 (5%)	427 (86%)	42 (9%)	494 (100%)

2.4.2 Results of laboratory testing of 'green' tubewells

To validate the effectiveness of the Merck test kit in correctly identifying 'green' tubewells 43 samples were collected in the field, acidified with the relevant amount of Hydrochloric Acid and sent to Dhaka. These were then tested using the Atomic Absorption Spectrophotometry (AAS). Table 2.7 shows that all these were below the Bangladesh standards signifying that the VHWs correctly identified the 'safe' tubewells with the help of field kit.

Table 2.7: Summary results of laboratory testing of 'green' tubewells (0 ppb As.)

Range of arsenic concentrations (ppb)	Samples tested by AAS
0-10	15 (35 %)
11-20	14 (32 %)
21-30	9 (21 %)
31-40	5 (12 %)
>40	0 (0 %)
Total (0-40)	43 (100 %)

The results also indicate that where the field kit gives a result of 0 ppb it is unlikely that this will be false negative (i.e. the actual result will be greater than 50 ppb).

2.5 Results of laboratory testing of 'cross' tubewells (>0-<100 ppb As)

In August 1999, a study was conducted to compare the results produced by the Merck 'doubling method' (reagents are used in double the amount recommended in the original procedure) and the field kit manufactured by the Asia Arsenic Network (AAN). This involved laboratory testing of 245 water samples from tubewells marked 'cross' (tested by VHWs as 0-100 ppb). The results were then compared with the "doubling method" and the AAN field kit to determine whether either or both of these were capable of measuring arsenic in water between 1-100 ppb. The overall result was that neither of these methods was effective in determining arsenic in water where concentration was above 0 and below 100 ppb. The results of this study are available in a separate BRAC report (Nickson R, et al., 1999).

However, as these samples were taken from wells originally tested by VHWs as between 0-100 ppb with the field test kit they also provide a check on the quality of the original testing. If the testing by the VHWs is of good quality the majority of the laboratory results for these samples should lie above 0 and below 100 ppb. Table 2.8 shows that this was indeed the case as 89% were within this range.

Table 2.8: Summary results of laboratory testing of 'cross' tubewells

Range of arsenic concentrations (ppb)	Number samples	% of samples within range
1-100	218	89.0
101-200	16	7.0
201-300	6	2.0
301-400	1	0.4
401-500	4	1.6
Total	245	100.0

2.6 Monitoring of 'green' and 'cross' tubewells over time

An attempt was made to see whether any change occurred in the concentration of arsenic in tubewell water over time. To do this experiment, tubewells tested in September 1999 using the Merck kit were again re-tested by both Merck kit and Atomic Absorption Spectrophotometry (AAS) in June 2000. The results of such tests are shown in Tables 2.9 and 2.10.

Table 2.9: Monitoring results of tests for arsenic in tubewell water using Merck kit

Upazila	Tubewells tested in September 1999		Tubewells tested in June 2000 using Merck kit		
			Green	Red	Cross
Sonargaon	Green	576	552 (95.8%)	19 (3.3%)	5 (0.9%)
	Cross	65	7 (10.8%)	37 (56.9%)	21 (35.6%)
Jhikargachha	Green	459	403 (87.8%)	13 (2.8%)	43 (9.4%)
	Cross	124	51 (41.1%)	20 (16.1%)	53 (42.4%)

Table 2.10: Monitoring results of tests for arsenic in tubewell water using AAS

Upazila	Tubewells tested in September 1999 using Merck kit.		Tubewells tested in June 2000 using AAS.	
			<0.05mg/L	>0.05mg/L
Sonargaon	Green	49	49	0
	Cross	15	14	1
Jhikargachha	Green	12	12	0
	Cross	62	61	1

Table 2.9 shows that in Sonargaon upazila, 95.8% of the tubewells marked green in September 1999 using Merck kit remained unchanged for over 9 months. Only 3.3% and 0.9% 'green' marked tubewells changed to 'red' and 'cross' respectively during this period. In Jhikargachha, only 2.8% tubewells changed from 'green' into 'red'.

Table 2.10 shows that in Sonargaon 49 and 15 'green' and 'cross' tubewells respectively were re-tested using AAS in June 2000 and only one 'cross' marked tubewell changed to 'red'. Out of total 74 tubewells tested 'green' and 'cross' in September 1999 in Jhikargachha only one showed to contain 0.06 mg/L arsenic in water in June 2000.

Based on the above results it can be said that over a nine-month period no change in concentration of arsenic of tubewell water occurred in these two upazilas.

Chapter 3

PATIENT IDENTIFICATION AND SUPPORT

3.1 Identification of arsenicosis patients

Arsenicosis patients were primarily identified by the VHWs when they went door to door to test arsenic contamination in tubewell water. After finishing testing they described the visual symptoms of arsenicosis and asked the villagers whether they knew of anybody showing these symptoms. They took details of the patients if found and were later checked by the field supervisors. A total of 252 patients in Sonargaon upazila and 151 in Jhikargachha Upazila were identified by VHWs and finally confirmed by a physician.

3.2 Symptoms of arsenicosis

The following describes the symptoms observed in the three stages of arsenicosis as described by Khan and Ahmad, (1997):

1st stage: Melanosis (spotted, diffuse)
Keratosis (spotted, diffuse)
Conjunctivitis
Bronchitis
Gastroentiritis

2nd stage: Depigmentation (Leucomelanosis - rain drop pigmentation)
Hyperkeratosis
Oedema of legs (non-pitting)
Peripheral Neuropathy
Nephropathy (early stage)
Hepatopathy (early stage)

3rd Stage: Nephropathy (late stage)
Hepatopathy (late stage)
Gangrene
Cancer (skin, bladder and lung)

Figures 3.1, 3.2, and 3.3 show symptoms of arsenicosis found on patients in Jhikargachha.

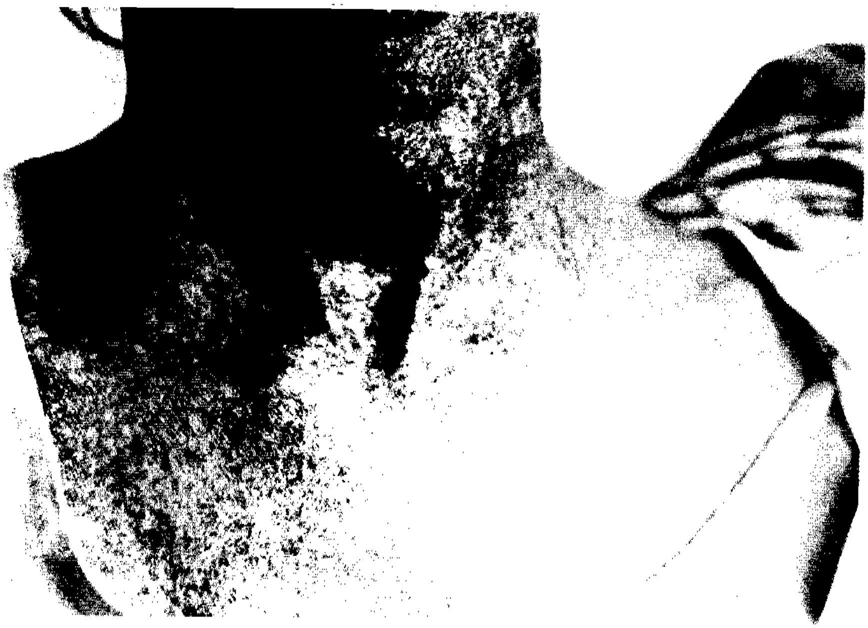


Figure 3.1: Melanosis on the chest of a patient from Jhikargachha.

Figure 3.2: Keratosis on the palms of the hands of a patient from Jhikargachha upazila.

Figure 3.3: Cancer on the leg of Kaiser Ali, the most severely affected patient in Jhikargachha upazila (see also Box 3.1).

3.3 The arsenicosis patients

A total of 252 patients have been identified in Sonargaon upazila and 151 in Jhikargachha upazila. Some details about these patients are given in Tables 3.1 and 3.2 below.

Table 3.1: Details of arsenicosis patients in Sonargaon Upazila, identified by VHWs

Union	Number of patients				% female affected	Average age	No. of families affected	No. of villages affected	% Red TW
	1st stage	2nd stage	3rd stage	Total					
Kachpur	-	-	-	0	-	-	-	-	4
Sadipur	-	-	-	0	-	-	-	-	1
Jampur	2	4	0	6	16.7	20	2	1	57
Noagaon	0	1	0	1	100	-	1	1	81
Sanmandi	98	38	3	135	36.3	30	88	15	86
Baradi	2	1	0	3	66.7	36	3	3	83
Mugrapara	3	10	1	14	21.4	41	13	4	80
Aminpur	25	16	0	41	50	33	30	9	64
Baidyer Bazar	20	4	1	25	48	32	17	5	75
Shambhupura	16	3	0	19	42.1	32	17	5	88
Pirojpur	4	0	0	4	75	41	4	2	81
Total/Average	170	77	5	252	39.7	36	175	45	62

Table 3.2: Details of arsenicosis patients in Jhikargachha upazila, identified by VHWs

Union	Number of patients				Average age	% female affec -ted	No. of families affected	No. of villages affected	% of red TW
	1st stage	2nd stage	3rd stage	Total					
Ganganandapur	19	2	1	22	36	45.5	14	3	54
Magura	-	-	-	0	-	-	-	-	65
Simulia	11	1	0	12	34	25	5	1	46
Gadkhali	72	36	0	108	30	40.7	24	3	46
Jhikargachha	4	1	0	5	50	40	4	4	30
Nabharon	-	-	-	0	-	-	-	-	37
Panisara	-	-	-	0	-	-	-	-	40
Nirbashkhola	-	-	-	0	-	-	-	-	45
Hazirbag	-	-	-	0	-	-	-	-	46
Shankarpur	-	-	-	0	-	-	-	-	76
Bankra	1	3	0	4	32	0	1	2	80
Total/Average	107	43	1	151	30	39.5	48	13	48

3.4 Pattern of arsenic contamination and distribution of arsenicosis

No correlation was evident between the number of patients and the arsenic contamination in the unions (Tables 3.1 and 3.2). However, the number of patients could be correlated to the arsenic content of individual tubewells, this was not investigated.

The majority of the affected patients were found to be in the first stage of arsenicosis (70%). This indicates that the problem is still to become fully apparent for the people to drink arsenic-free water. Only a few patients were identified to be in third stage of arsenicosis. One of them was Kaiser Ali of Jhikargachha (see Box 3.1)

The patients are found in cluster form, not evenly distributed across the affected areas. In Sonargaon upazila 252 patients were found from 175 families in 45 villages. In Jhikargachha 151 patients were found in 48 families from 13 villages. Several members of the same family and only certain villages are often affected. This indicates that there are other factors which influence the effects of arsenic on the body. The clustered distribution of patients may be due to differences in nutritional status, diet or other social factors which influence the severity of arsenicosis.

It appears that more men are affected than women (60% men). It is not clear yet whether this is the actual situation or whether the higher identification of male patients is a cultural phenomenon (i.e., men are more likely to come forward to report).

The average age of the arsenicosis patients in Sonargaon and Jhikargachha is 36 and 30 years respectively. Although the range was high (7-65 in Sonargaon and 5-60 years in Jhikargachha), the majority of patients were in the most active age group, between 15 and 45 (around 80% in Jhikargachha).

The number of estimated people drinking arsenic contaminated water in Sonargaon and Jhikargachha upazilas were 165,000 and 115,000, whereas the prevalence rates were 0.15% and 0.13% in Sonargaon and Jhikargachha respectively.

3.5 Treatment of arsenicosis patients

The arsenicosis patients were diagnosed and categorised for treatments. The first step was to ensure arsenic-free water to all patients.

The patients were also provided with medicines. Twelve patients of Kamarpara village in Jhikargachha upazila were given Spirulina tablets for six consecutive months starting July 1999. They were advised to take 4 tablets daily, 2 in the morning and 2 in the evening and were kept under close follow-up of the project staff. The stages of external manifestation of the affected parts of the patients, their feeling and the weight of the patients were monitored. The manifestation did not actually change significantly. A mixed result was found when patients were asked how did they feel after the treatment had started.

During February-April 2000, 252 patients from Sonargaon and 117 from Jhikargachha were provided with vitamins A, C, and E. Afterwards these patients were provided with *Carocet* tablets (a combination of vitamin A, C, and E). Salicylic acid, an ointment, was provided to some selected patients to soften the hardening of the affected parts of the palms and the footsoles of the patients. All these patients are kept under close monitoring.

Kaiser Ali - The story of a victim

Kaiser Ali (45), of Goalbakpur village, was the most severely affected patient identified so far in Jhikargachha. BRAC's physician diagnosed him with cancer from arsenic poisoning in February 2000.

He was a widower with three young children. He said, "I have tried many things, even been to India for treatment, but have found no relief from this poisoning. I know that I will die soon - who will care for my children?"

He was sent by BRAC to Dhaka Community Hospital where the physicians suggested a surgical operation on his foot where the cancer lesion was prominent. But Kaiser Ali himself and his relatives refused to go for any surgical operation. After suffering for a prolonged period he breathed his last in July 2000.

Box 3.1: Kaiser Ali of Jhikargachha upazila who died of cancer from arsenic poisoning.

3.6 Need for patient support and further research

Chronic arsenic poisoning may involve many organs and systems in the body, e.g. skin (Tondel et al., 1999), heart and vessels (Abernathy et al., 1999), kidneys (Kurttio et al., 1999) and lead to cancer development (Furreccio et al., 1998) or have consequences for pregnancy outcome (Golub, Macintosh, and Baumrind, 1998). Clinical reports and some scattered studies indicate that a wide variety of suspected manifestations of chronic arsenic poisoning are starting to appear in Bangladesh (Biswas et al., 1999). In spite of vast number of studies from Taiwan, Chile, the United States and other countries, controversies still exist on the relationships between arsenic in drinking water and various health effects. Similarly, there is little consensus on the possible variation in risks by age, sex, and nutritional status, and on the possible reversibility of some of the health effects. Epidemiological information of this type is much needed for proper planning of countrywide interventions in Bangladesh.

It is clear that in the absence of any known effective treatment regime, continued support and follow-up of all patients are necessary. The health consequences of this exposure may soon develop into epidemic proportions, if judged from the scattered studies performed in Bangladesh (Biswas et al., 1999). There is an urgent need for patient support and further research in the country.

There are still many questions regarding the incidence of arsenicosis. A well-planned research programme is necessary to determine the factors behind the scattered and clustered distribution of arsenicosis patients in Bangladesh. If this research can determine the reasons why some are affected while others being in the similar situation are not, why males are more affected than females, it may provide a better understanding of the problem.

Chapter 4

COMMUNITY INVOLVEMENT IN THE PROJECT

Sustainable development cannot be achieved without involving the local community in planning and development processes. To this end, the people of the project area were involved in implementing the arsenic mitigation project.

4.1 Village meetings

Village meetings were held in the villages where contamination level was found to be high. Multiple village meetings were held at different stages of the project to inform and involve community people.

1. The first meeting was held to tell the villagers about arsenic problem and to inform them of the ensuing testing of tubewells.

2. The next meeting was held, just after completing the tubewell testing to share the test results with the villagers.

   At this meeting the potential safe water options were also discussed. The following topics were covered: different alternative safe water options and their relative merits, approximate costs of different options; methods of operation and maintenance of the safe-water options; and possible demonstration sites for the chosen alternative safe-water options.

   Taking into account the opinion of the villagers, BRAC proceeded with the demonstration of different alternative safe water options with no cost to the community. The community decided where the system would be best located and then committed to maintaining the system.

3. The third meeting was organised at the time of construction or distribution of the alternative safe water options to motivate the villagers to use the option and encourage community participation in the process of obtaining safe water.

4. The final meeting was after construction or distribution of the alternative safe water options to inform about the monitoring, operation and maintenance and again to raise awareness level of the villagers about their alternative safe water options.

Figure 4.1: A village meeting.

4.2 Resource mapping

Making a resource map of a village is an important tool for development projects. In this project the resource map was drawn jointly by the villagers and BRAC workers. In the map water sources like wells, different types of ponds like perennial, non-perennial, used or not used for commercial fish culture, etc. were shown. This resource map gives an idea of the resources available in the village and their locations. In particular this is helpful in receiving an idea of the existence of water for alternative safe water options. Example of a resource map can be seen in Annex 1.

Chapter 5

SAFE WATER OPTIONS

5.1 Introduction to safe water options

The basic purpose of this project was to provide people with arsenic-free drinking water. It introduced people to different safe water options, some of which were known and some were completely new to the area. Potential sources of arsenic-free drinking water that were identified are:

- Treated pond and river water,
- Rain water, and
- Treated groundwater.

One of the major objectives of this action research project was to provide people with safe drinking water and test their short-and long-term safety. This job of providing safe drinking water was not easy as very little was known about the different technologies. Therefore, we needed first to assess the technical effectiveness, applicability and community acceptance of different alternative safe water options.

Table 5.1: Different safe water options initially selected for this project

Option	Water source	Location	No. of families served
Pond Sand Filter (PSF)	surface water	community	40-60 families
Rain Water Harvester (RWH)	rainwater	family	1 family
Two Chamber Treatment Unit	surface water	community	6-10 families
DPHE-DANIDA Filter	groundwater	family	1 family
Safi Filter	groundwater	family	1 family

The two-chamber treatment units and DPHE-DANIDA filters were later excluded from the project due to concerns about residual aluminium in the treated water. During the course of the project several new options were introduced including the following:

Table 5.3 details the total number of safe water options constructed or supplied until the end of August 2000.

Table 5.2: Safe water options introduced during the course of project implementation

Option	Water Source	Location	No. of families served
Three Pitcher or Three Kolshi-Filter	groundwater	family	1 family
Home Based Surface Water Filter	surface water	family	1 family
Arsenic Removal Plant (SIDKO plant)	groundwater	community	50-75 families
Tubewell Sand Filter (TSF)	groundwater	community	20 families
Activated Alumina Filter	groundwater	community	30 families
Motka (large size clay pitcher)	rain water	family	1 family

Table 5.3: Number of options proposed under the project and the number actually constructed/supplied in the two upazilas

Option	Jhikargachha		Sonargaon		Total
	Proposed	Constructed/ Distributed	Proposed	Constructed/ Distributed	constructed
Pond Sand Filter (PSF)	11	33	11	4	37
Rain Water Harvester (RWH)	110	20	110	70	90
Two chamber treatment unit	55	0	55	0	0
DPHE-DANIDA Filter	110	0	110	0	0
Safi filter	360	104/40*	360	160/80*	264/120*
Stevens I.T. Buckets	250	0	250	0	0
Three Kolshi Filter	0	4,000	0	6,000	10.000
Home-based Surface Water Filter	0	3	0	4	7
Dug Well	0	10	0	36	46
Arsenic Removal Plant (SIDKO plant)	0	1	0	0	1
Tin filter (Modification of three kolshi)	0	25	0	21	46
Motka (Rain water harvesting)	0	0	0	103	103
Tubewell Sand Filter (TSF)	0	2	0	9	11
Activated Alumina Filter	0	0	0	2	2

* Because of technical problems these were removed from the field and replaced with three-pitcher filters.

5.2 Training on construction of options

For the construction of selected options (i.e. PSF, RWH, TSF, Dugwells), a two-day training on construction procedures for each of these alternative safe water options was organised for local masons. This training was conducted by DPHE masons with extensive experience in constructing these type of structures. The other intention of involving local masons in the training and construction process, as mentioned earlier, to build local capacity so that villagers can use their skills to continue construction of safe water options in future. The whole construction process was guided and overseen by the technical advisor of the project and BRAC engineers. At the time of implementation of the alternative safe water options the experiences of DPHE and UNICEF were used.

5.3 Pond Sand Filter (PSF)

5.3.1 Design of the system

Filtration is the process by which water is purified by passing it through a porous media. In slow sand filtration a bed of fine sand is used through which the water slowly percolates downward. The suspended matter present in the raw water is largely retained in the upper 0.5-2 cm of the filter bed. This allows the filter to be cleaned by scraping away the top layer of sand. The filter cleaning operation need not take more than one day, but after cleaning one or two more days are required for the filter bed to again become fully effective.

In the coastal belt of Bangladesh where much of the groundwater is salted, the local population is dependent on surface water from dug ponds. Since the untreated water from these ponds is unpotable DPHE with funding from UNICEF have installed slow sand filtration units into which pond water is fed using a handpump. These units are called Pond Sand Filters (PSF). The use of PSF technology to filter surface water is also considered appropriate for areas where groundwater is contaminated with arsenic. One pond sand filter can supply the daily requirement of drinking and cooking water for about 40-60 families.

BRAC constructed a number of PSFs in both Sonargaon and Jhikargachha Upazilas. Ponds were selected based on the following criteria:

- Pond will not be used for fish culture;
- Pond should be protected in all respects, e.g., free from agricultural and domestic runoff, latrine discharges, etc.;

- Pond will not be used for washing livestock or other domestic purposes;
- Pond should be perennial; and
- Finally, community pledge for involvement in operation and maintenance of the pond and PSF.

A water management committee composed of potential users of the PSF was formed for each of the constructed PSFs and were given training on their operation and maintenance. Their activities were monitored frequently by the project supervisors.

5.3.2 Technical details

The original design of the PSF consists of a tank containing the bed of filter material and a storage chamber. Water is pumped into the PSF using a tubewell head connected to a pipe which intakes water from the pond. It then flows vertically through the sand bed. At the bottom of the tank an underdrain system (the 'filter bottom') is placed to support the filter bed. The bed is composed of fine sand, usually free from clay and loam and other organic matter. The filter bed normally is 1.0-1.5 m thick, and the water to be treated stands to a depth of 0.3-0.5 m above the filter bed. From the base of the filter bed the water is discharged into a storage chamber. The design in use is based on the DPHE/UNICEF 'Large Pond Sand Filter', (drawing no. PSF-01/1, December 1988) (DPHE and UNICEF, 1988-93).

It was found that due to high initial load of bacteria in the pond water the PSFs were not performing satisfactorily. It was then necessary to add a roughing filter as a form of pre-treatment before the PSF sand bed. A chamber was added onto the side of the PSF containing brick chips. The pond water flows horizontally through the brick chips, over a weir and into the main PSF chamber.

In a PSF constructed in Sonargaon, addition of alum followed by coagulation and settling was tested as a pre-treatment alternative to the roughing filter. Small pieces of solid alum and brick chips were placed in a funnel under the tubewell spout. The water flowed through this funnel then flows into a sedimentation basin constructed on the side of the PSF where coagulation and settling occurs. It then flows into the normal PSF sand bed.

To construct a PSF with a roughing filter or sedimentation chamber costs about Tk. 40,000* and takes 11-12 days to complete. Smaller versions of PSF was also constructed keeping all the necessary structures

* US$ 1=Taka 53 (August 2000)

functional which brought down the construction cost to Tk 25,000. This modified PSF could fulfil the daily water requirement of the locality, almost as like as the larger ones. In Jhikargachha; 20 such smaller PSFs were constructed. Some constructed PSFs can be seen in Figures 5.1 and 5.2.

Figure 5.1: A pond sand filter in Jhikargachha upazila.

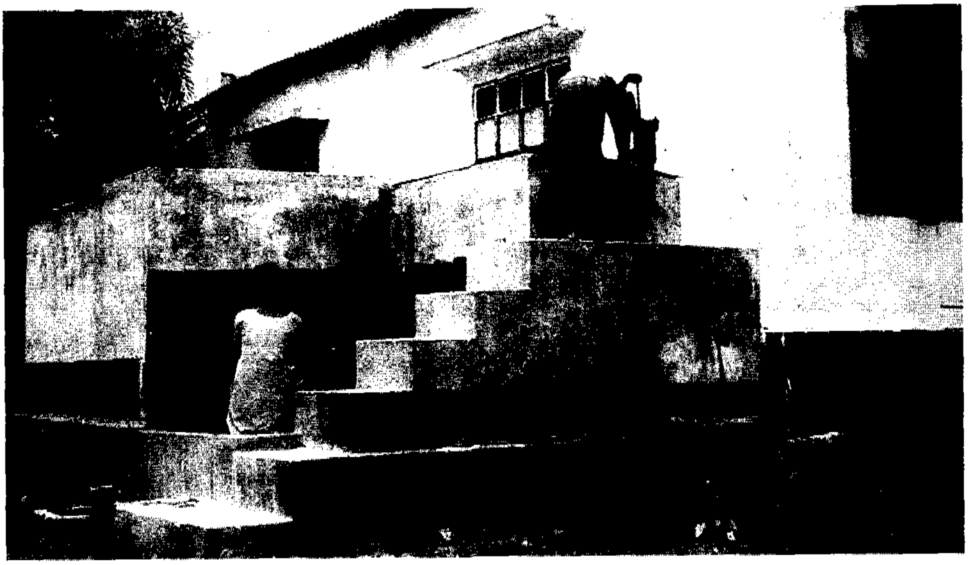


Figure 5.2: A pond sand filter in Sonargaon upazila.

5.3.3 Monitoring

To estimate the load of total coliform and faecal coliform bacteria, water samples were collected frequently of pond water and treated water from all PSFs. Figures 5.3, 5.4, and 5.5 show the performance of several PSFs. The complete results are given in Annex 5. Generally it appears that the level of faecal and total coliform bacteria in the pond water can be reduced by two orders of magnitude following treatment with the PSF. Despite the generally high rate of removal the results still exceed the WHO recommended standards. The treated water was saved in containers used for storage of drinking water in rural households. The Technical Advisory Group of the BAMWSP is currently in the process of defining what is the acceptable level of coliform bacteria in rural water supply for Bangladesh.

Amples were tested from the PSF in which alum was added followed by coagulation and settling as a pre-treatment before filtration by the sand bed. In one PSF (PSF 1 in Nakatibhanga of Sonargaon), alum was added in the first chamber of the horizontal roughing filter to reduce coliform bacteria. The results for aluminium and coliform bacteria in the pond and in different stages of filtration are shown in Table 5.4.

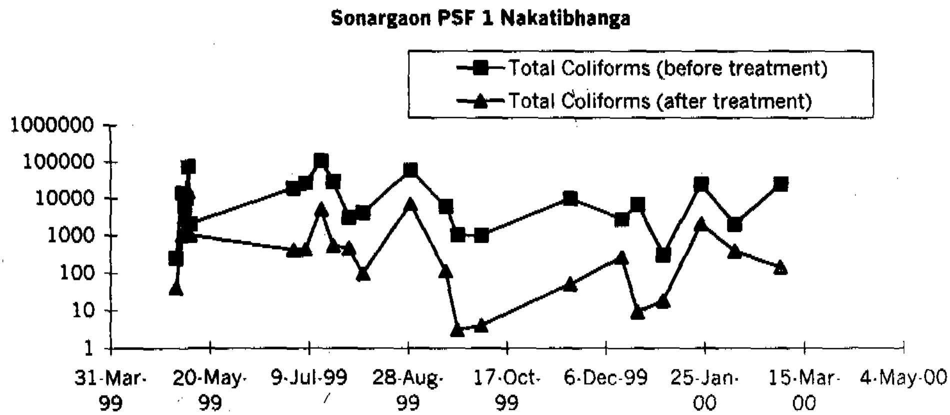


Figure 5.3: Total coliform bacteria in pond water before and after treated in a PSF (Nakatibhanga village, Sonargaon upazila).

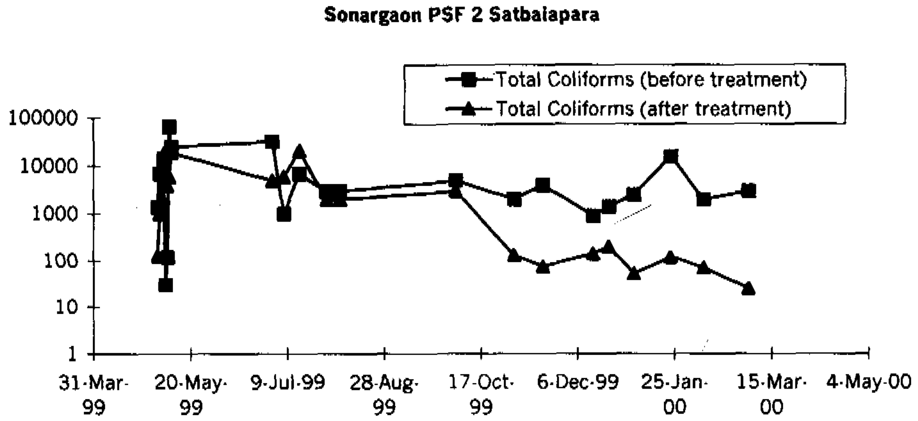


Figure 5.4: Total coliform bacteria in pond water before and after treatment in a PSF (Satbhaiapara village, Sonargaon upazila).

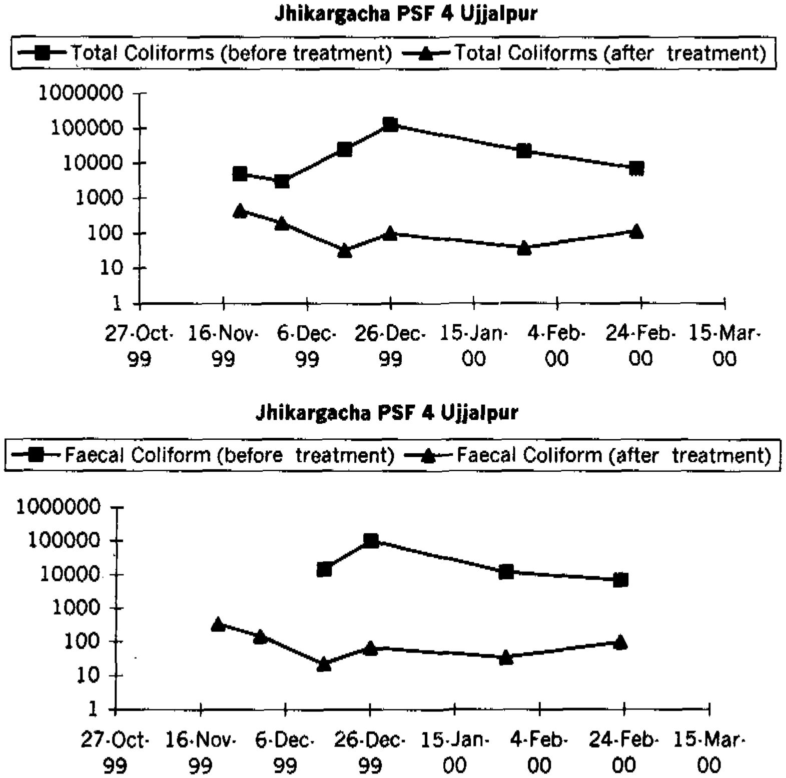


Figure 5.5: Faecal coliform bacteria in pond water before and after treated in a PSF (Ujjalpur village, Jhikargachha upazila).

Table 5.4: Aluminium and total coliform bacteria in pond water before and after treatment in a PSF in which alum was added followed by coagulation and settling on different dates (PSF in Nakatibhanga, Sonargaon)

Location of sample	Aluminium (ppm)	Total coliform counts (per 100 ml)		
	23.11.99	29.8.99	16.9.99	22.9.99
Pond (before filtration)	<2	60,000	6,000	1,000
Chamber 1 (after coagulation and settling)	6.2	130	9	0
Chamber 2 (before sand filter)	-	-	600	210
Chamber 3 (storage tank after sand filter)	<2	7,000	110	30

These results show that there is no residual aluminium in the treated water provided by the PSF. They also show that only with coagulation and settling, alum treatment is reasonably effective in removing coliform bacteria from surface water. In this PSF further contamination was introduced to the water as it passed through the sand filter. This filtration was necessary, however, as following treatment with alum the water contained high levels of residual aluminium (6.2 ppm). It also shows that the coliform reducing capacity increased substantially over time.

5.3.4 Strengths of PSF

1. There is an abundance of surface water in Bangladesh, suggesting good potential for use of PSF.

2. PSFs can fulfil the water needs of a large number of people. The original design was intended to serve 200 families. In reality the distance which people would travel to fetch water limited this number to approximately 40-60 families. However, this is still a large number compared to other options.

3. PSFs can be constructed with locally available materials and by local masons once trained.

4. There is no chemical treatment involved, so no risk of adverse health effects or damage to the environment.

5. It can operate continually throughout the day and throughout the year.

5.3.5 Weaknesses of PSF

1. The prevalence of fish culture in most ponds in rural Bangladesh is a main obstacle to PSF use. Some fish farmers use highly toxic chemicals such as aldrin/dieldrin to kill predator fish before releasing fish fry. They also put different chemical fertilisers, cow dung, mustard cake etc. into the pond as fish feed. Clearly the water from such ponds is not suitable for use as drinking water even after treatment. Furthermore, where fish culture is being practised farmers are reluctant to give up their ponds for PSF construction as they provide a valuable source of income.

2. Surface water available in Bangladesh is highly turbid in both dry and wet seasons. In the dry season, there is excessive growth of algae in pond and lake water. In the wet season, rain water drainage from the catchment area brings a lot of suspended sediment and makes the surface water highly turbid. Slow Sand Filters (SSF) do not work properly for turbidities above 30 NTU. Pond Sand filters operating on the principles of SSF in Bangladesh require frequent washing for high turbidities.

3. Due to high initial loads of bacteria in the surface water of Bangladesh, PSFs will rarely succeed in removing all bacteria. Generally it seems that they can reduce the level of bacteria in water by two orders of magnitude. If the level of total and faecal coliform bacteria in ponds is measured before PSF construction this can be used as a further criteria for pond selection. Once the acceptable level of total or faecal coliform bacteria in treated pond water has been agreed by the government then the amount of bacteria in the original pond water should not be more than two orders of magnitude greater than the required level. For example, if the maximum acceptable level of total coliform bacteria in the treated water is set at 100 cfu/100 ml then ponds with an initial total coliform count of greater than 10,000 cfu/100 ml should not be used. Moreover, the bacteria count changes with seasons.

4. The initial capital costs of construction is high (approx. Tk. 40,000).

5. Pond Sand Filters are not maintenance-free. Eventually the sand filter becomes saturated with solids and the upper sand layer must be removed, washed with filtered water and replaced again. For this the community need to commit to maintaining the PSF and some

people need to be trained in the cleaning and maintenance procedures.

6. This option requires ponds which are perennial. Since this is more appropriate as a community option, the community needs to be organised and willing to maintain it.

7. Masons need to be trained up initially on construction of PSF.

8. It is recommended that bathing, use of soap, and washing of cattle should be discouraged in ponds used for PSFs. In reality this is difficult to achieve in the short run.

5.3.6 Overall assessment

Availability of large numbers of perennial waterbodies seemed initially to be a strong point in favour of constructing PSFs in the project areas. However, it was found later that many of these water bodies were in use for commercial fish culture which made them unsuitable for human consumption.

Generally it seems that PSFs can reduce the level of bacteria in water by an order of two. The level of coliform bacteria in many of the ponds of Bangladesh is so high that even after treatment by a PSF the water will not be completely bacteria free.

The PSF users often complained that PSF water tasted foul. The taste of PSF water was obviously different from the tubewell water to which they were used to. For this reason many people were found using this water only for cooking purposes and very few are using this for drinking purposes.

Overall, Pond Sand Filters may be good potential source of safe water for rural Bangladesh. However, sites for construction of this technology must be carefully chosen and local people must commit to proper use and maintenance of this option.

5.4. Rain Water Harvester (RWH)

5.4.1 Design of the system

Rainwater harvesting is practised in many parts of the world. For example, there is a long tradition of rainwater collection in some parts of Alaska and Hawaii in the USA The city of Austin, Texas, offers a rebate for using rainwater. The island of Gibraltar has one of the largest rainwater collection systems in existence. Rainwater harvesting is also popular in Kenya, South Africa, Botswana, Tanzania, Sri Lanka, Thailand (Daily Star, 24 Sep. 1999).

In some areas of Bangladesh the potential for rainwater harvesting is good. However, rainfall is variable across the country. Figure 15 shows that mean annual precipitation ranges from 1,400 mm (about 55 inches) along the country's east central border to more than 5,000 mm (200 inches) in the far north-east (Rashid, 1977). The wet months of monsoon from mid June to late September have 80% of the annual precipitation .

In the project areas BRAC constructed two types of rain water harvester (RWH). The first is based on the original 3,200 litre model of DPHE which assumes that a family of six in Bangladesh needs about 30 litres of water per day for drinking and preparation of food. It was also assumed that a 30-day dry period requires approximately 1,000 litres of stored water, and therefore, a 3200 litre container would be enough for one family for three months. The cost of constructing this RWH is about Tk. 8,000.

It was observed that although people were happy with the quality of the water the cost was prohibitive. Also in every case, the RWH was used by more than one family so the water only lasted for a limited period (maximum one month), not long enough to cover the full dry period.

Considering the constraints of high cost and foreign technology, a modified system of collecting rain water was designed which was found to be cheaper and could be constructed with locally available materials. The capacity of this system was 515 litres and the cost was approximately Tk. 1,800. The model was meant for people to use rainwater during the monsoon and was not intended for long-term storage. This means that an additional option is required for the dry season.

5.4.2 Technical details

The 3,200 litre RWH is constructed using pre-cast concrete blocks (Fig 5.9). These are set on a concrete base in a cylindrical arrangement and tied together with wire. The inner and outer surfaces are then covered with cement. Water is channelled from collection pipes on the roof into the RWH through a funnel with a mesh filter. The RWH is covered with a lid (Fig 5.8). Figure 5.9 shows a completed rainwater harvester and guttering system set up in the project area.

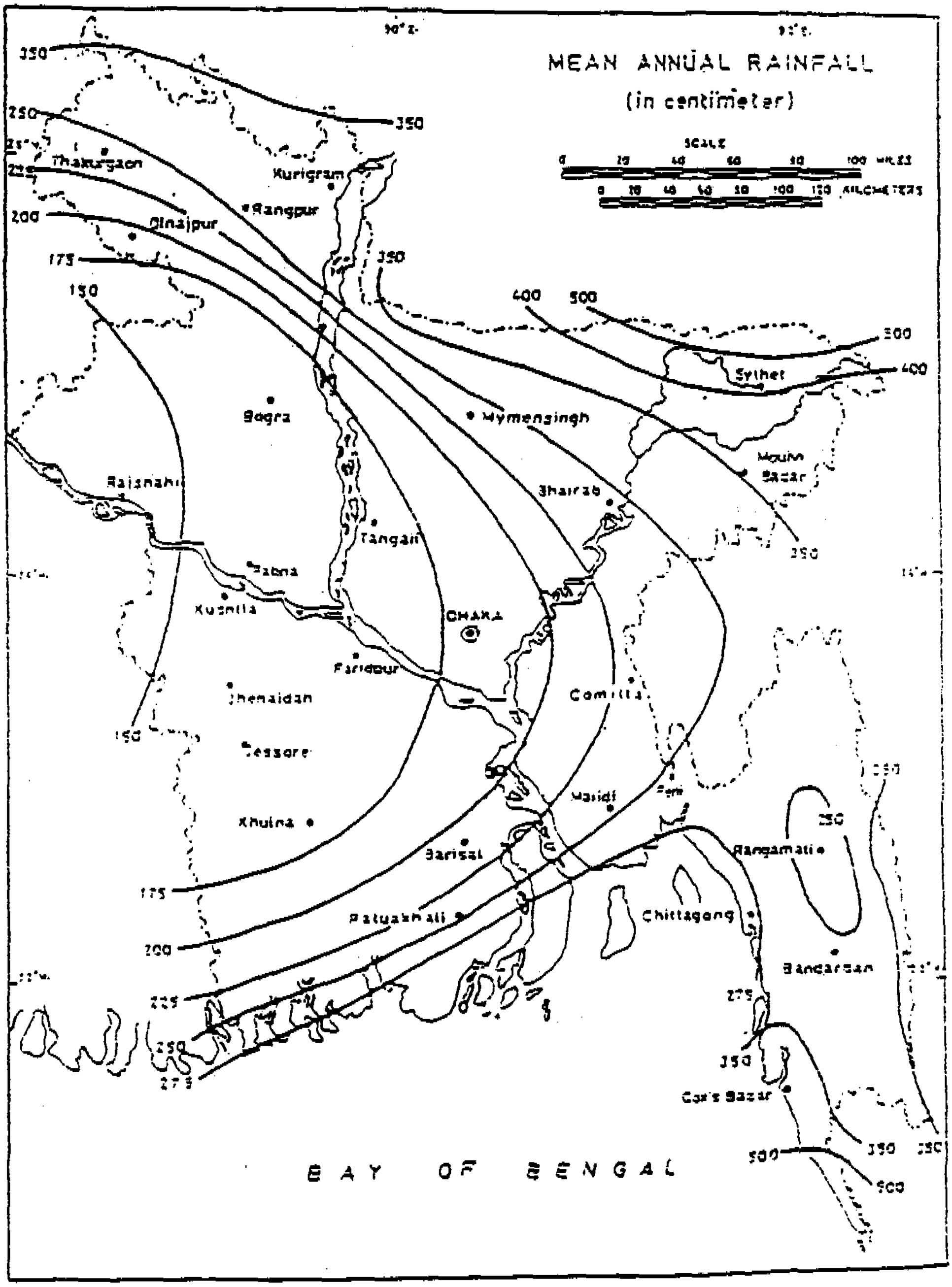


Figure 5.6: Map showing average annual precipitation of rain in Bangladesh (Source: Rashid, 1977).

Figure 5.7: Construction of slabs for the 3200 litres RWH.

Fig. 5.8: Making of lids for the RWH.

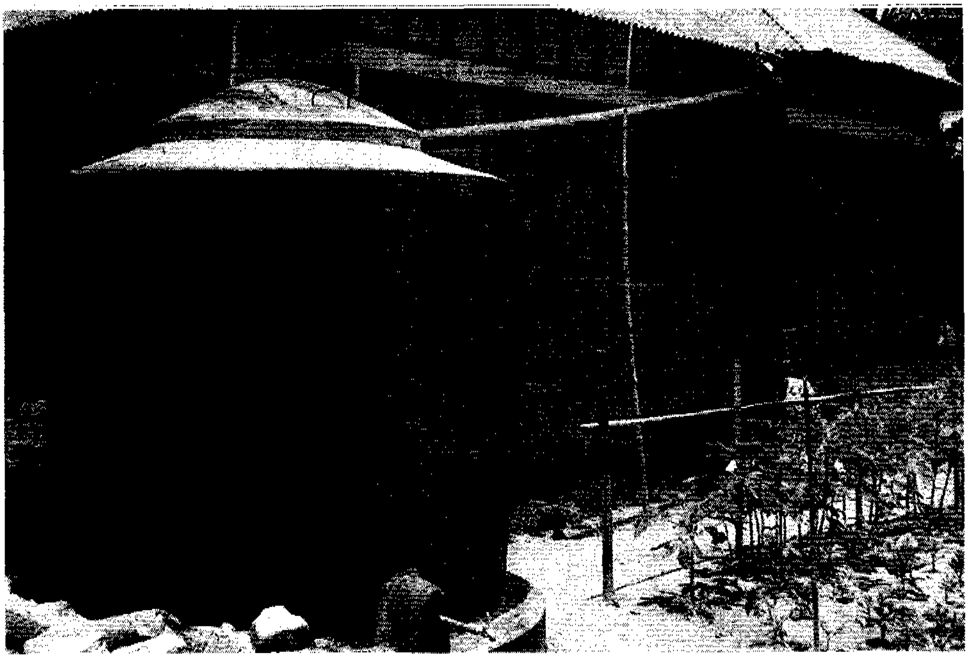


Fig. 5.9: A 3,200 litres RWH and guttering system.

After completing the construction, which takes about seven days, the potential users are advised to fill the tank with rain water and store it for at least seven days. At the end of the seven days they are advised to add ½ kg of bleaching powder to disinfect the tank and to wash the inside of the tank. At the same time the caretaker of the rain water harvester is given training on the operation and maintenance of the system.

The first rainwater collected may carry significant amounts of contaminant (debris, dirt, dust) which accumulate on the roof and in the gutters. It is, therefore, recommended not to collect the first flush of rainwater. A cover for the intake was provided and users were instructed to remove this 5/10 minutes after the rainfall started. The quality of the collected water can be improved by proper maintenance of the roof and gutters and careful cleaning at the beginning of each wet season.

The low-capacity RWH developed by BRAC is shown in Figure 5.10. The technical details of this system are as follows:

- Concrete basement (3 inches thick);
- 5 sanitary rings;
- One slab which is used to cover the top of the system; and
- Funnel gutter and collecting pipes.

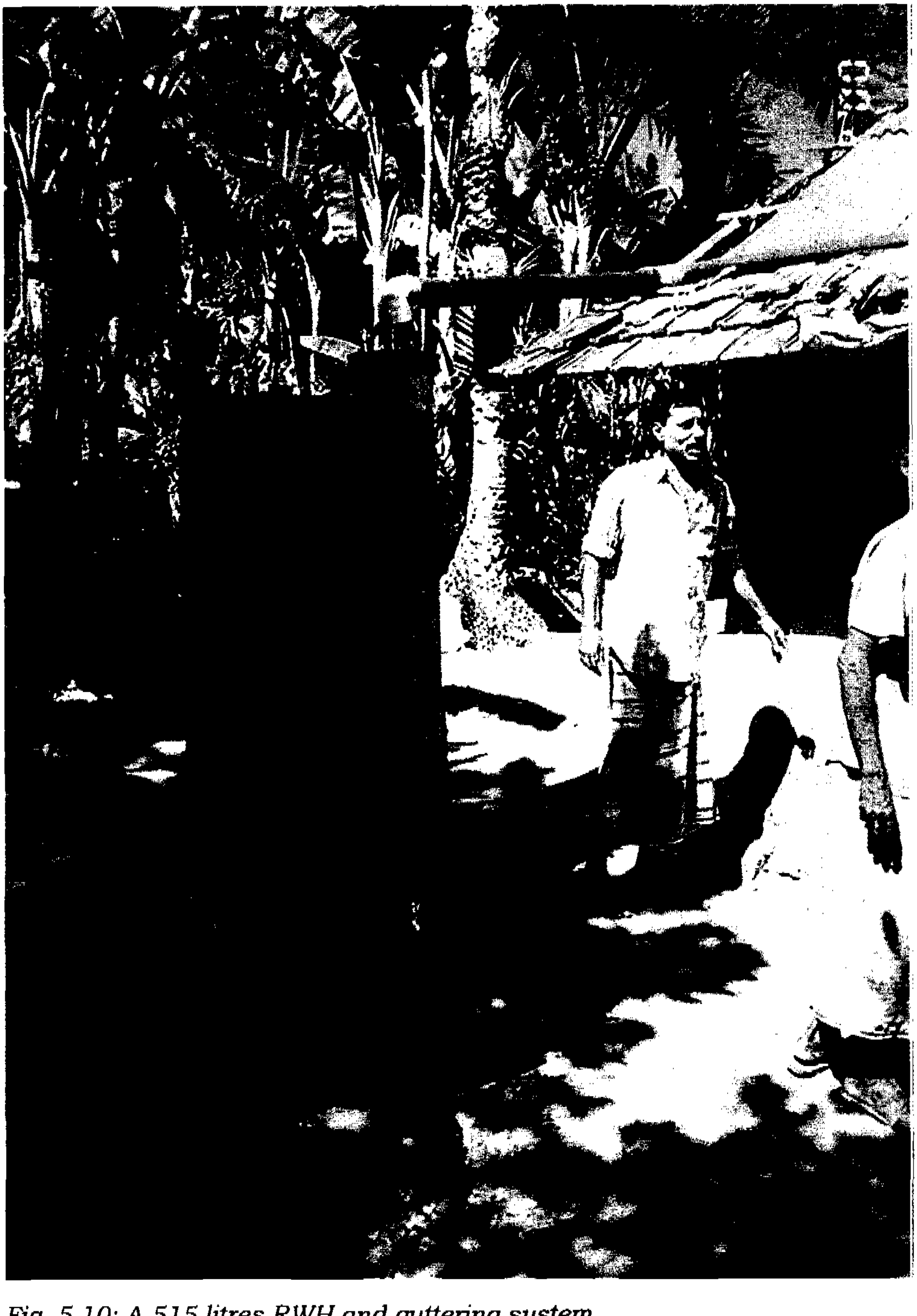


Fig. 5.10: A 515 litres RWH and guttering system.

The cost of the 515-litre tank is about Tk. 1,800. As the installation of a tubewell costs around Tk. 2,000 the new RWH is comparable and within the reach of middle-class villagers. The storage capacity of this design is low, but is enough to provide safe water for the rainy season for a number of families.

5.4.3 Monitoring

Analysis for total coliform and faecal coliform bacteria to assess the safety level of the RWH water for drinking was done at ICDDR,B in Dhaka for Sonargaon samples and at Khulna DPHE laboratory for Jhikargachha samples. Results of coliform bacteria tests in water samples of rain water harvesters of Sonargaon and Jhikargachha have been shown in tables 5.5 and 5.6.

Table 5.5: Total coliform bacteria in rain water samples of rain water harvesters in Sonargaon over time

Period of testing	No. of sample tested	Range of coliform counted	Average coliform bacteria	
			Mean	Median
June 1999	22	0-540	76.14	20
July 1999	33	0-1200	83.09	0
August 1999	33	0-2	0.12	0
September 1999	8	0-0	0	0
November 1999	7	0-0	0	0

Table 5.6: Total and faecal coliform bacterial in three rain water harvesters in Jhikargachha

Location of RWH	Total coliform colony/100 ml	Faecal coliform colony/100 ml
RWH-1	Nil	Nil
RWH-2	Nil	-
RWH-3	Nil	-

Table 5.5 shows that initially the bacteria load was high but soon these returned to normal in subsequent monitoring. Monitoring was discontinued as the dry season set in November and the RWHs contained no water.

However, there was a lack of consistency in the results of laboratory tests, particularly for coliform bacteria, much of which remained unexplained. In future, more attention needs to be given on proper testing of the water.

5.4.4 Strengths of RWH

1. In some areas the potential for rainwater harvesting is good; however, rainfall is variable across Bangladesh. For example, Sonargaon has high rainfall but not Jhikargachha.

2. Bacteriological RWH of rainwater stored in RWH showed it to be of consistently high quality.

3. Materials for construction of RWH (concrete, PVC pipe, funnels, etc.) are easily available in Bangladesh.

4. People in general like the taste of rainwater.

5.4.5 Weaknesses of RWH

1. In the project areas where the designs described above were tested, rainwater harvesting could only provide safe water for part of the year. A large amount of storage would be required to cover the entire dry season. Use of a different designs e.g., underground storage to store enough to cover the dry season may be an answer but would be more expensive.

2. Corrugated iron sheet roofs are best for collecting rainwater. This means that construction of RWHs is not a good option for the poorest households of the society as they have only thatched roofs.

3. The construction cost of Tk. 8,000 is prohibitive for many rural households, since as it only provides a partial solution.

4. Casting the concrete slabs and the lid for the 3,200 litres model requires some specialised knowledge. Local masons would need training to be able to undertake these activities.

5. The roofs must be kept clean and free from dirt and debris as otherwise water in the tank may be contaminated or guttering may become blocked. Thus, some extra care and effort is required.

5.4.6 Overall assessment

In the project areas where the 3,200 litre and 515 litre designs were tested, rainwater harvesting could only provide safe water for part of the year. A large amount of storage would be required to cover the entire dry season. It is, thus, unlikely that people would be willing to pay such a high price for a partial solution.

Although the construction of a RWH focuses people's minds on rainwater it is not necessary to have a container for storage if rainwater is only to be used during the monsoon season. Any bucket (plastic balti), clay pitcher, or other container can be used to collect rainwater from rooftop. Along this line of argument, BRAC distributed 103 Motka (large size clay pitcher) of 70 litres capacity in Sonargaon upazila. The Asian Arsenic Network is promoting a system in Samta village using a piece of old sari material strung from buildings or trees at the four corners with a weight in the centre and a collecting pot beneath the weight. Such innovation provide emergency sources of safe water for part of the year.

5.5 Safi Filter

5.5.1 Design of the system

This household level filtration device developed locally by Professor Sayeed Safiullah of Jahangirnagar University works by filtering arsenic out of contaminated water. This device is known as "Safi filter". One small Safi filter is designed to filter approximately 40 litres of water per day (Fig. 5.11). This should be more than sufficient for the needs of a family of six. The cost of such filter is Tk. 900. Larger filters for schools and other community -- use are available which can filter 80 litres of water per day at a cost of Tk. 2,000 (Fig. 5.12).

5.5.2 Technical details

The Safi filter comprises of two concrete buckets of different sizes, one of which is placed inside the other. The upper bucket is filled with tubewell water which then flows through a permeable 'candle' and is collected in the lower bucket where it is stored. When needed it is drawn off with a tap.

The Safi filter candle is prepared from a chemical mixture of laterite soil, ferric oxide, manganese di-oxide, aluminium hydroxide and mezo-porous silica. These materials adsorb arsenic as the water passes through the candle and thus the contamination is removed. It is also claimed that the candle eliminates pathogenic bacteria from the contaminated water. The manufacturers calculated that after two years of continuous use the candle would need to be replaced with a fresh one. Each new candle costs Tk. 200.

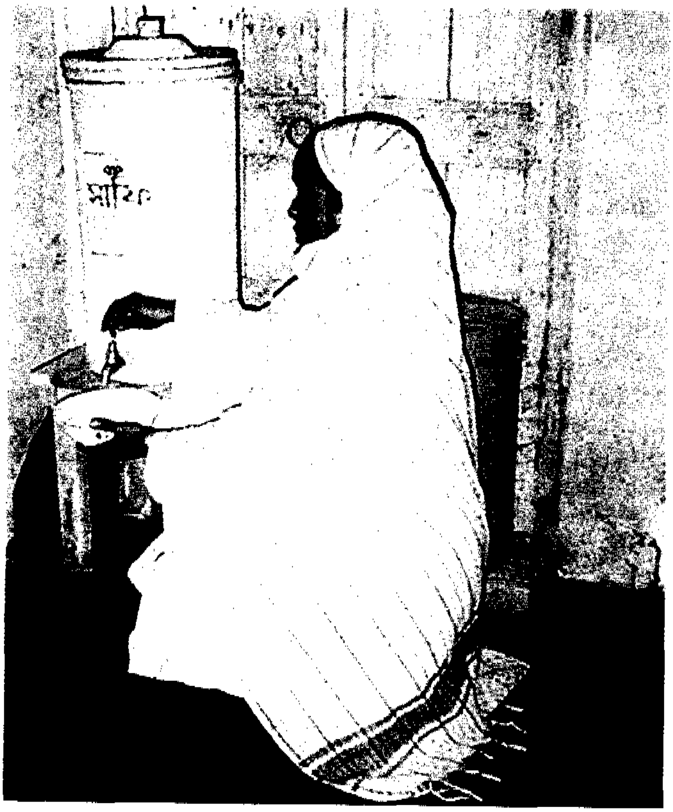


Figure 5.11:
A small Safi filter.

Figure 5.12:
A large Safi filter.

5.5.3 Monitoring

The Safi filter was designed to remove both arsenic and pathogenic bacteria. It was claimed that the life of the candle, which traps the arsenic, is about two years although this depends on the initial concentration of arsenic in the groundwater. Thus, it was thus very important to monitor the effectiveness of the candle on a regular basis.

The arsenic content of the source (i.e. tubewell) and the filtered water were measured. Initial data from Sonargaon given in the Interim report of the project (BRAC 1999) shows that for the first two months of use the filters were generally effective in removing arsenic. In a few cases arsenic was not removed enough to come down below the safe limit mainly due to technical problems with the setting of the candles. This was later adjusted by re-fixing the candles properly.

However, at a later stage of the project a large number of Safi filters had problems. These ranged from very serious problems such as disintegration of the filter candle to minor problems such as broken filter taps. By the end of 1999 almost half of the Safi filters distributed were found to be no longer effective (Table 5.7). These had to be replaced with three-pitcher filters (see later).

By December 1999, of the 104 Safi filters distributed in Jhikargachha only 81 were in operation. The rest were replaced by three-pitcher filters. This trend of deteriorating performance of the filters continued as time passed. In July 2000, only 25 Safi filters were found effective.

Besides failures in removing the arsenic, the Safi filter also showed some technical problems. A breakdown of some of the technological problems recorded in December 1999 in Jhikargachha (Table 5.8).

Table 5.7: Monitoring results of Safi filters distributed between May to August 1999 in Jhikargachha (Tests done using Merck kit)

Date of test	No. of Safi filters showing the concentration of arsenic in the treated water			Total Safi filter tested	Non-functional/ removed
	0mg/L	>0-<0.1mg/L	≥0.1 mg/L		
December 1999	48 (59%)	30 (37%)	3 (4%)	81	23
January 2000	43 ((57%)	28 (37%)	5 (7%)	76	28
April 2000	31 (48%)	19 (30%)	14 (21%)	64	40
July 2000	25 (44.6%)	14 (25%)	17 (30%)	56	48

The bacteria monitoring result was also disappointing. None of the Safi filters tested provided bacteria-free water (Interim report, BRAC, 1999). Preliminary investigation suggested that this bacteria grew in the second jar where the filtered water was stored. The people were advised to clean both the compartments of the filter every week, but many of them did not follow the advice.

5.5.4 Strengths of Safi filter

1. Due to its formal shape, people tended to prefer it. Home-based filters provide a means by which they can remove the arsenic and continue to use the tubewell water.

2. The cost is affordable for many rural middle-class households.

5.5.5 Weaknesses of Safi filter

1. Initially the Safi filter seemed to be one of the most promising options tested (BRAC, Interim Report, 1999). However, over time this proved not to be the case. By December 1999 almost half of the Safi filters distributed by BRAC in the field were experiencing technical problems. These ranged from disintegration of the filter candle to minor problems such as broken filter taps.

2. Clogging of the filter was another problem not related to mechanical breakdown of the filter. In many cases the flow rates from the filters became terribly low over time. This was also found by other organisations such as WaterAid (WaterAid, Preliminary Research Report, 2000).

3. The capacity of the filter in reducing the arsenic contents reduced over time.

5.5.6 Overall assessment

The Safi filter was a promising technology originally, however, with time many problems became apparent. The manufacturer is currently in the process of re-designing the filter to overcome these problems. Until the re-designed Safi filter has been thoroughly tested and evaluated for a period of at least one year no further purchase or distribution of these filter is contemplated.

BRAC has encouraged Professor Safiullah to develop a porous media filter containing chips of the Safi filter candle material. This would overcome many technological problems associated with the candle filter. The process is under development and hopefully will be available for testing and evaluation soon.

Table 5.8: Technological problems with the Safi filters found in field level operation in Jhikargachha in December 1999

Type of problem	Details	Period of operation	No. of filters with the problem
Filtration rate	Filtration rate is reduced drastically. Although the candle is washed after every 2/3 days only 8-10 litre water is filtered per day.	5 and 2 months	32
	Although the candle is washed every day only one jug of water is filtered per day.	2 months	2
Erosion of the candle	Candle has been reduced in size due to erosion for washing even with a cloth.	Both 5 and 2 months	5
	Candle has become powdery after pouring water	2 months	1
	Candle bas been eroded and hole is created	2 months	2
Candle not properly attached	Candle is broken at the base where it is attached with the internal container.	2 months	2
Problem with the tap	Leaking of water through the taps	Both 2 and 5 months	2
	Aperture of the tap is narrow comparing with others which causes reduced flow rate of water	2 months	1
Problem with the container	During using of the filter the lip has been broken off from the internal container	2 months	6
Total number of filters with problems			53

5.6 Three-kolshi or three-pitcher filter

5.6.1 Design of the system

The three-pitcher filter is based on an indigenous method of filtration which has been used in Bangladesh for ages. Local clay pitcher (called kolshi) is partially filled with sand and charcoal, and a small hole made in the bottom. Water is t passed through this pitcher to remove suspended matter from surface water and more recently to remove iron from tubewell water. Scientists from Bangladesh and the USA noted the potential of this simple method to remove arsenic as well. They modified the system by adding iron filings to provide an additional source of iron oxide to adsorb more arsenic (Rasul et al, 1999).

The results obtained by Rasul et al. (1999) using sand, charcoal and iron chips were sufficiently promising to merit further and larger-scale testing.

5.6.2 Technical details

The three-pitcher filter consists of three 18-litre volume clay pitchers stacked one on top of the other in a frame. The first pitcher contains 2 kg of coarse sand with 3 kg of iron filings on top. The second pitcher contains 2 kg of coarse sand with 1 kg of charcoal on top. The third pitcher is for collecting the filtered water (Fig. 5.13 and 5.14). There are small holes in the bottom of the pitchers and a piece of synthetic cloth is placed over this to prevent the sand from spilling out.

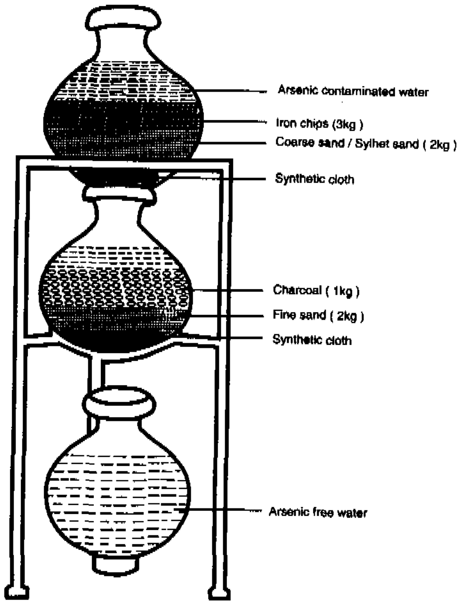


Figure 5.13: Construction of the three-pitcher filter.

Figure 5.14: Three-pitcher filter in a household in Jhikargachha.

5.6.3 Monitoring

A total of 400 three-pitcher filters, 200 in each upazila were monitored for several weeks between February and July 2000 in Jhikargachha and Sonargaon by using Merck kit. Table 5.9 and Table 5.10 show summary of the results.

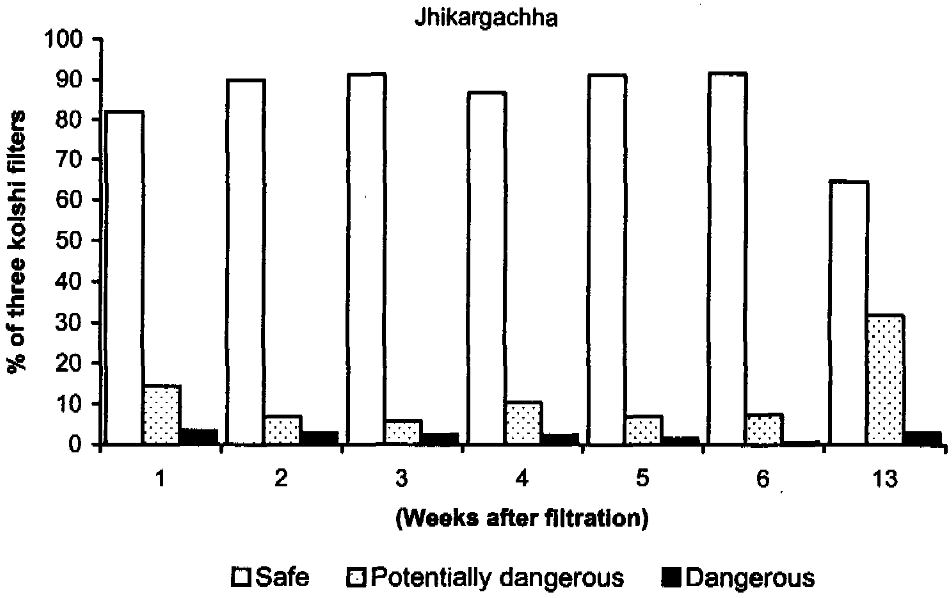
Table 5.9: Results of field monitoring of three-kolshi filters for arsenic in treated water (Jhikargachha). Monitoring started immediately after commencing the operation (February 2000)

	Number of filters (%) in different concentrations			Average flow rate (l/h)
	Safe	Potentially dangerous	Dangerous	
1st week	164 (82)	29 (14.5)	7 (3.5)	2.6
2nd week	180 (90)	14 (7)	6 (3)	2.75
3rd week	183 (91.5)	12 (6)	5 (2.5)	2.87
4th week	174 (87)	21 (10.5)	5 (2.5)	2.87
5th week	183 (91.5)	14 (7)	3 (1.5)	2.81
6th week	184 (92)	15 (7.5)	1 (0.5)	2.81
13th week	113 (65)	55 (32)	6 (3)	1.62

Table 5.10: Results of field monitoring of three-kolshi filters for arsenic (Sonargaon). Monitoring started after three months of commencing the operation (May 2000)

	Number of filters (%) in different concentrations			Average flow rate (l/h)
	Safe	Potentially dangerous	Dangerous	
15th week	147 (76.6)	22 (11.5)	23 (12)	1.27
16 th week	141 (73.4)	27 (14.1)	24 (13)	1.19
17 th week	137 (71.4)	24 (13)	31 (16.1)	1.08
18 th week	127 (66.1)	31 (16.1)	34 (17.7)	1.03
19 th week	126 (65.6)	31 (16.1)	35 (18.2)	1.02
20 th week	125 (65.1)	27 (14.1)	40 (20.8)	1.13

Fig. 5.15: Level of arsenic in water after filtration through three-*kolshi* filters in Jhikargachha and Sonargaon over time



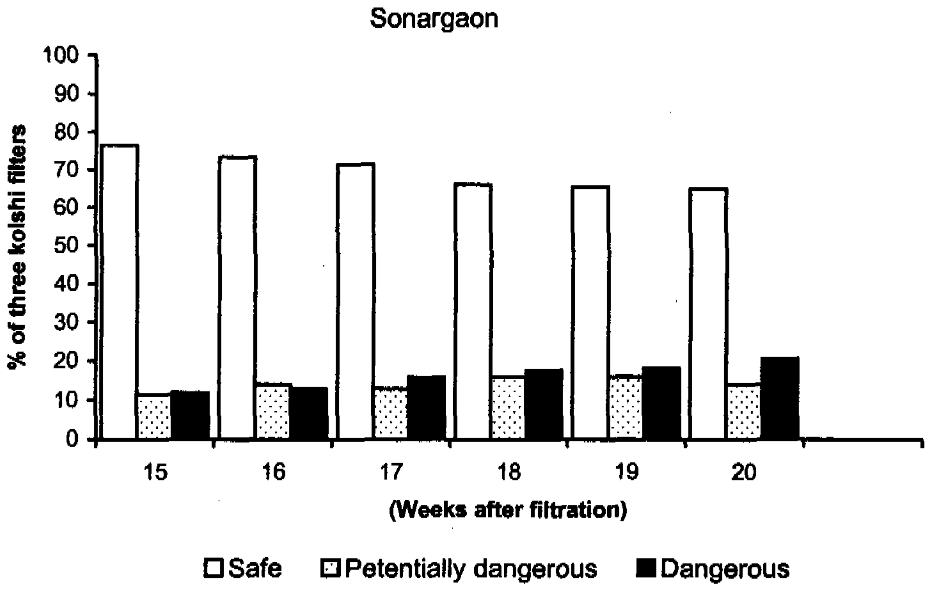


Figure 5.14 shows that at any one time up to six weeks of operation, between 82% and 92% of the filters were found to be completely successful at reducing arsenic from initial levels of between 0.1 and 1 mg/l down to a level of 0 mg/l, as measured with the field kit. Within this period of operation several filters (between 6% and 14.5% at any one time) were found to reduce arsenic concentration to a level above 0 and below 0.1 mg/l (or 'X'). The effectiveness of the filters in reducing arsenic concentration to the required levels dropped steadily over the weeks. During this period the failure rate decreased from 3.5% to 0.5%. No filtered water was found to be above 0.1 mg/l. At 13th week the effectiveness in removing arsenic dropped and at this time only 65% of the three-pitcher filters were found still effective.

It seems that the efficiency of the filter in removing arsenic remained largely active up to the 6th week. Only one filter was found to be consistently ineffective throughout monitoring. This was due to a problem with manufacturing; it was found that insufficient iron filings were added. In Jhikargachha, two-thirds of the filters were giving acceptable quality of water at 18th week (Figure 5.15). These results indicate that after about four months of operation the efficiency of the three kolshis in removing arsenic start to decline. The flow rate also declined gradually from the first week of monitoring; at 18th week, the flow rate was 1.03 litre per hour.

To test the efficiency of the three-pitcher filters in removing arsenic and iron, tests were conducted before and after treatment of tubewell water using AAS. Table 5.11 shows that three-kolshis perform excellently in removing arsenic from water with concentration as high as 388 ppb to a very low level. It also proved to be very efficient in removing iron (table 5.11 and figure 5.16). Water from the three-pitcher filters were also tested for bacteria. Test results for Jhikargachha given in Table 5.12 show that the waters before and after filtration were reasonably free of bacteria.

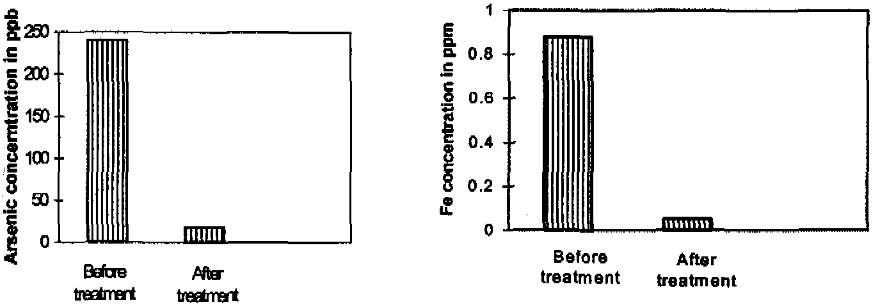


Figure 5.16. Average concentration of arsenic and iron (Fe) in water before and after treatment by three-kolshi filters.

Table 5.11: Laboratory results for iron and arsenic from three-pitcher filters in Sonargaon, using Atomic Absorption Spectrophotometer (AAS)

Sample Source	As (ppb)		Fe (ppm)	
	Before treatment	After treatment	Before treatment	After treatment
3-Kolshi Filter 1	335	28	1.556	0.014
3-Kolshi Filter 2	5	5	0.529	0.017
3-Kolshi Filter 3	195	20	0.495	0.022
3-Kolshi Filter 4	388.2	10	2.041	0.012
3-Kolshi Filter 5	232	31	1.249	0.019
3-Kolshi Filter 6	312	7	1.772	0.014
3-Kolshi Filter 7	81	24	0.110	0.009
3-Kolshi Filter 8	295	25	0.877	0.004
3-Kolshi Filter 9	318	12	0.141	0.001
3-Kolshi Filter 10	233.9	17	1.098	0.006
Average	240	18	0.877	0.012
Minimum	5	5	0.110	0.001
Maximum	388.2	31	2.041	0.019

Note: The tests were done at Intronics Technology Laboratory, Dhaka.

Table 5.12: Total and faecal coliforms after filtration by three-pitcher filters in Jhikargachha

Date tested	Coliform type	Number filters tested	Coliform load (cfu/100 ml)		Range cfu/100 ml)
			Mean	Median	
22.02.00	Total	25	26.20	13	0-94
	Faecal	25	4.16	1	0-27
07.03.00	Total	25	4.24	4	0-10
	Faecal	25	0.92	0	0-4

Note: Tests were done in DPHE Zonal Laboratory, Khulna.

After four months of continuous operation the three-pitcher filters showed some problems in terms of leaching arsenic and clogging with iron. In some cases it has been found that if the iron filings are clogged forming a hard structure then this filing can not be removed from the pitcher. In such cases the pitcher along with the iron filling has to be discarded. Some users getting these three-pitcher free-of-cost have been found to stop using these filters when any problem like clogging occurred with the system.

More monitoring is required for these filters before it can be recommended that they are effective and bacteriologically safe.

The refill materials of charcoal, iron chips and sands of the three-pitcher filters should be available locally so that people can avail them when necessary.

5.6.4 Strengths of 3-pitcher method

1. The three-pitcher filter is inexpensive. One filter can be made for around Tk. 250. Of this, Tk. 170 is for metal frame, Tk. 30 is for the three clay pitchers and the Tk. 50 for sand, iron filings and charcoal. BRAC field staff experimented with wooden and bamboo frames to minimise the cost. However, the price difference was not enough to merit their use in large scale.

2. The filter is simple to construct. With a minimum of skill and information any villager should be able to obtain materials and construct such a device themselves. In this case they may choose to construct the frame themselves with bamboo or wood, and the cost for the user would be less (as they may use home materials).

3. The filter is made from locally available materials. Clay pitchers are available across Bangladesh. Sand and charcoal can be bought or collected easily. Iron filings are produced in most small towns as a by-product of iron works (doors, grills for windows, etc), and the stand can either be welded together in a small town or made from wood or bamboo.

4. The three-pitcher is based on an indigenous technology in Bangladesh and uses materials familiar to the rural people, thus cultural acceptance is high.

5. Use of tubewell water means less risk from water-borne diseases.

6. The system is portable and can be relocated from one place to another.

5.6.5 Weaknesses of the three-pitcher method

1. There is a potential problem of clogging with iron, particularly if the filter is allowed to dry out between uses. Initial observations show that the iron filings may bond together into a solid mass over time making the materials difficult to replace or clean; this also reduces flow-rate and removal capacity.

2. The system produces sludge which contains arsenic. However, scientists believe that this arsenic would not separate from the iron chips under normal atmospheric condition. It may be possible to convert the solid arsenic laden iron oxide produced into iron, or to dispose of the material in bricks or in road construction.

3. The flow-rate of water through the system is low and hence amount of water produced is small.

4. As the three-pitchers are set one-upon-another and not protected from the open air, there exists a risk for water to be contaminated with micro-organisms in the atmosphere.

5.6.6 Overall assessment

The three-pitcher system has enormous potential to provide an emergency drinking water source for the arsenic-affected areas in rural Bangladesh. It is based on an indigenous technology, is inexpensive, and can be constructed with locally available materials. Cultural acceptance is high.

There are, however, a number of unanswered questions about the three pitcher filters which need to be addressed before it is taken up on a larger scale. First, it appears from our results that bacteriological contamination of the water is occurring before or during filtration. If this happen during filtration then all filter materials must be sterilised before the manufacture of the filter. It may be possible to do this by heating under the sun or boiling in water. Experiments are currently underway to overcome the problem of microbial contamination with the three pitcher filters.

It has not been proven beyond doubt that the water from the three-pitcher filter will be completely free of chemical impurities. The potential for trace elements such as lead, chromium, zinc, tin, etc. to enter the water from the iron filings must be conclusively discounted.

The final question about the three-pitcher filter is whether it is technically effective in the long run. Five months of continuous monitoring revealed that after four months the filters start leaching arsenic. Also it becomes clogged with iron and must be cleaned; for future use, a cleaning or regeneration process need to be designed. There are some initial reports that the layer of iron filings forms into a hard mass over time. This must be investigated and the potential for channelling of water through the iron filings, and thus leakage of arsenic through the system, determined.

5.7 Dugwells

5.7.1 Design of the system

Dugwells are an indigenous technology in Bangladesh. Use of dug wells has declined since the 1960s following the introduction of the shallow tubewells. The wells were cheaper and easier to construct and, most importantly, were less susceptible to bacteriological contamination.

Arsenic concentrations greater than the Bangladesh guideline of 50 ppb occur in moderately shallow aquifers in some areas in Bangladesh. Typical depths for arsenic occurrence is a narrow depth range of 20-40 metres below ground, the usual depth for the majority of tubewells. The ultra shallow (1-10m) aquifer tends to have low arsenic concentrations. The British Geological Survey (BGS) 1998 suggests that within the zone of water table fluctuation (season natural fluctuation) and where residence times are short, arsenic is being flushed away or immobilised.

If dugwells are protected properly (i.e., lifting water by a hand tubewell, and by covering the top) they may also provide water of an acceptable bacteriological quality.

In light of their potential, it was decided to install and test dugwells in the project areas. Although these wells were popular among the villagers, initial attempts in August/September 1999 were unsuccessful due to problems with construction during the rainy season. Construction was re-started in November and December 1999 and enthusiasm was observed among the villagers for a slightly modified design for dugwells (lid and hand pump attached).

5.7.2 Technical details

Dugwells have been constructed by following the design of 'converted hand-pumped dugwell' given in WHO Guidelines for Drinking Water Quality Vol. 3 (1997). The wells are covered and water is drawn from the well using a hand pump (Figure 5.17). An apron is constructed around the well to prevent contamination from the surface. Following digging/excavation the well is lined with local materials, either concrete or clay rings to prevent the walls from collapsing. Proper lining and a well-designed apron are crucial for prevention of surface water contamination. A constructed dugwell can be seen in Figure 5.18.

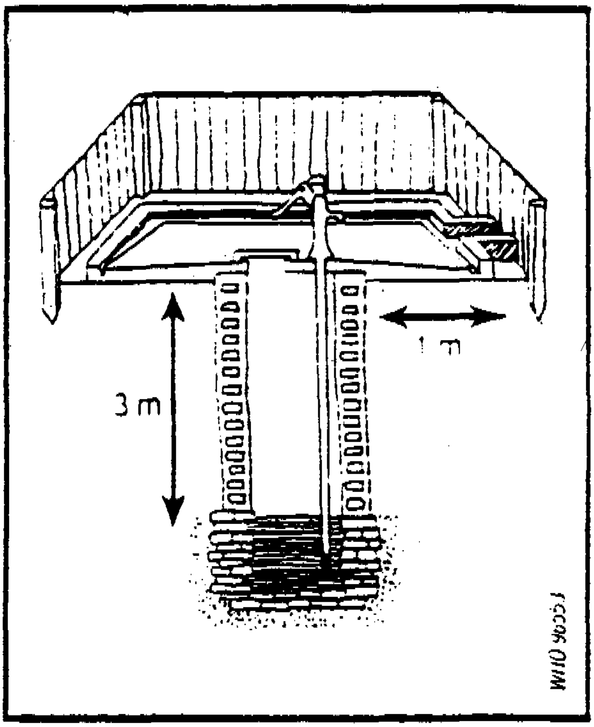


Figure 5.17: Design for a dugwell.

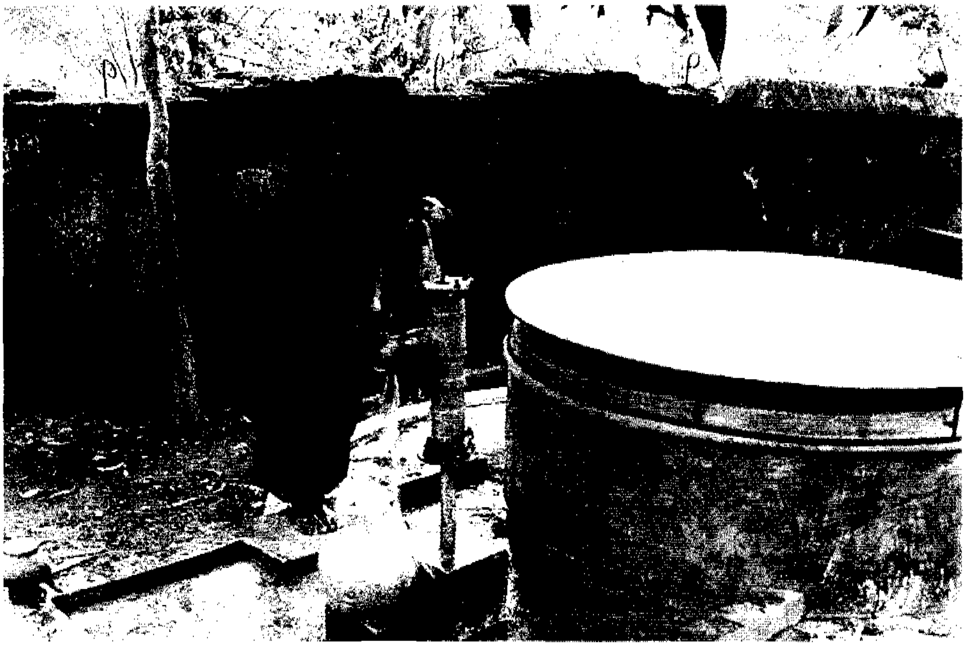


Figure 5.18: A dugwell with a hand pump renovated by BRAC in the project area.

5.7.3 Monitoring

Several dugwells were tested for arsenic and bacteria. Results of laboratory testing for bacteria given in Table 5.13 shows mixed results. It would have been desirable to measure for nitrate and pesticides also, however, this was not possible during the project period.

Table 5.13: Total coliform bacteria in dugwells renovated by BRAC in Sonargaon

Date tested	Number of dugwells tested	Coliform load (cfu/100 ml)		Range (cfu/100 ml)
		Mean	Median	
23.01.00	10	3,226	3,000	0-10,000
09.02.00	13	2,895	220	0-16,000

Note: All tests were done at ICDDR,B laboratory.

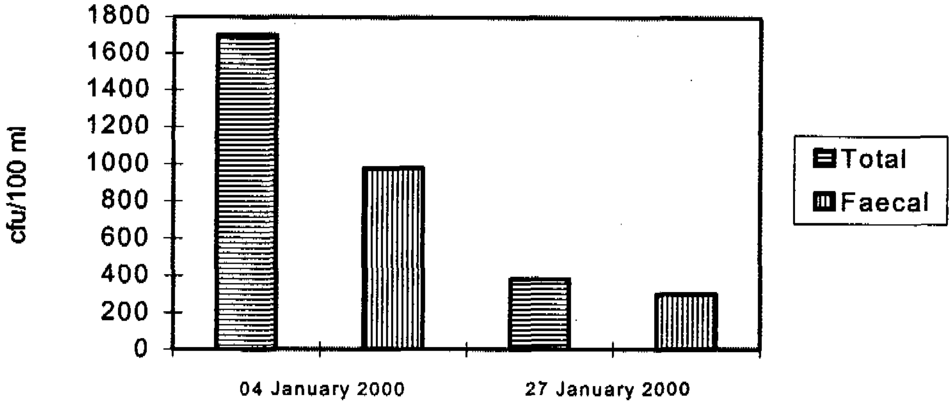


Figure 5.19. Laboratory test results for coliform bacteria in a dugwell over time (Hariadeara, Jhikargachha).

5.7.4 Strengths of dugwells

1. An indigenous technology and thus social acceptance is high.

2. Can be constructed/renovated with locally available resources.

3. One well can provide safe water for several families.

4. Hydrogeological conditions are generally favourable due to high water tables in Bangladesh.

5. The unconsolidated nature of Bangladeshi alluvial sediments means it is generally possible to construct dugwells.

5.7.5 Weaknesses of dugwells

1. Susceptibility to bacteriological contamination is very high. Wells should be covered, water should be extracted with a hand pump, and a proper apron should be constructed around the dugwell.

2. Dugwells cannot be constructed close to latrines or where cattle are kept.

3. Collapse of wells may be a problem where the lining is not maintained or is old or made weak.

4. Wells may dry up or reduce in yield when the water table drops in dry season or if abstraction is greater than recharge.

5. In some areas it may be difficult to locate a sandy layer which will provide sufficient permeability to ensure a working dugwell.

6. Dugwells can only be constructed during the dry season and even then construction may be difficult.

5.7.6 Overall assessment

Dugwells may provide a potable water source in some areas of Bangladesh if they are properly constructed and maintained. However, the susceptibility to bacteriological contamination is very high and this must be borne in mind at all times. It may be possible to combine dug-wells with home-based surface water filters (section 5.8) to provide a socially acceptable, bacteriologically safe water source for rural house-holds.

In this action research project BRAC tried to construct two new dugwells in Jhikargachha upazila but failed to do so properly because it was difficult to reach the appropriate aquifer using the traditional indige-nous method of excavating the dugwells. Very few potter are found to construct such dugwells manually now-a-days. The job of digging a dug-well is very risky for the potter since very often the walls of the wells collapse. The wells thus excavated are always narrow. People, parti-cularly younger generations, therefore, are not interested to use dugwell water for drinking and cooking purposes. BRAC renovated 36 dugwells in Sonargaon and 10 in Jhikargachha. These are widely used.

5.8 Home-based surface water filter

5.8.1 Design of the system

There are some home-based water filters, intended for filtration of iron from tubewell water or bacteria from surface water, which are available locally in the market in Bangladesh. These are candle filters of a similar design as the Safi filter and contain porous ceramic candles. It was decided to test the effectiveness of several of these filters in removing bacteria from surface water.

5.8.2 Technical details

The filters consist of two concrete buckets of different sizes, one of which is placed inside the other. The upper bucket is filled with water to be treated. Water then flows through a permeable 'candle' and is collected in the lower bucket where it is stored. When needed it is drawn off with a tap. A diagram of the filter is given in Figure 5.20. The cost of one filter is between Tk. 300 and Tk. 400.

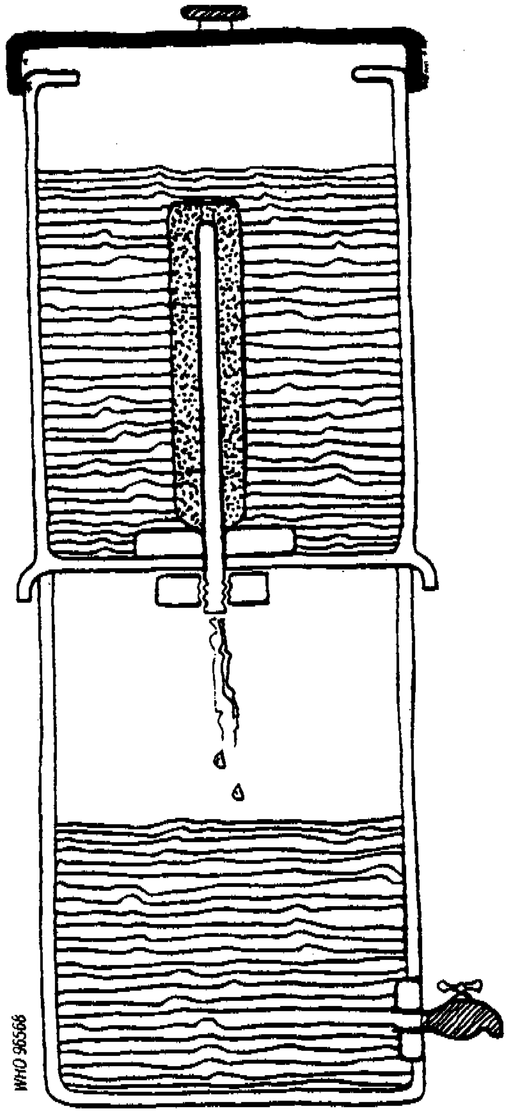


Figure 5.20:
Diagram of a home-based surface water filter.

5.8.3 Monitoring

Limited tests were made for the bacteriological water quality of unfiltered and filtered water from two filters placed at Sagarpur village in Jhikargachha. The water which has already passed through a Pond Sand Filter is placed in Filter 1. Filter 2 contains water directly taken from a pond. The results are given in Table 5.14.

Table 5.14: Testing of bacteriological quality of filtered water from two home-based surface water filter

Date	Filter 1 (PSF water)				Filter 2 (Pond water)			
	Total coliforms (cfu/100 ml)		Faecal coliforms (cfu/100 ml)		Total coliforms (cfu/100 ml)		Faecal coliforms (cfu/100 ml)	
	Before filter	After filter	Before filter	After filter	Before filter	After filter	Before filter	After filter
15.12.99	32	0	20	0	1500	0	800	0
26.12.99	36	0	26	0	7000	0	5000	0

These results show that the home based surface water filter (Iron removal filter) is 100% efficient in removing coliform. In the project area, however, people were not interested in using home-based surface water filter for treatment of surface water, because surface water specially the pond water looks very dirty. For treatment of water to reduce coliform bacteria this kind of filter can be used.

5.8.4 Strengths of home-based filter

1. From very limited test results it appeared that the effectiveness of these filters in removing coliform bacteria from surface water is good.

2. The filters are relatively inexpensive and available in Bangladesh.

5.8.5 Weaknesses of home-based filter

1. The social acceptability of these filters has not been assessed. There are some concerns that people may be reluctant to use surface water (pond) for drinking after filtration as they still perceive it to be unclean.

2. Surface water must be obtained from a protected source to ensure no contamination with chemicals, fertilisers, etc. As discussed in the section on Pond Sand Filters protected surface water sources are difficult to find. Using this filter to treat water from dugwells may be an alternative.

5.8.6 Overall assessment

Some very limited results show that two home-based filters tested are effective in removing bacteria from contaminated surface water. This merits further testing of these filters. The social acceptability of the filters must be assessed to determine whether or not they will be successful in rural Bangladesh. Filters should only be used for the surface water sources which are known to be free of chemical contamination. They have potential to be used as a final 'polishing' step to make PSF or dugwell water bacteria free.

5.9 Arsenic removal plant (SIDKO plant)

5.9.1 Design of the system

A private company (SIDKO Limited) approached BRAC to install a community-based arsenic removal plant in Bangladesh for demonstration. To test its effectiveness and acceptability the plant was installed in Jafarnagar village in Jhikargachha Upazila. This system uses granular iron oxyhydroxide to remove arsenic from groundwater and is manufactured in Germany by Harbauer.

5.9.2 Technical details

Tubewell water is pumped up about 2 metres to a overhead tank using a specially modified handpump which can sustain pressure. The handpump was imported from India, but SIDKO maintained that plans are underway to manufacture them in Bangladesh in future. The water is sprayed into the tank through a shower head to provide aeration. From the header tank it flows downwards under gravity into the first chamber of the system which contains only sand and charcoal and is intended to allow some of the iron in the tubewell water to precipitate to avoid clogging of the main filter. It is probable that a large amount of arsenic also precipitates out in this first chamber (measurements with field test kit on 4.11.99 showed that arsenic in input water was around 0.5 mg/L and after first chamber was around 0.2 - 0.3 mg/L). This part of the filter can be manufactured locally.

From this chamber it then flows into the main chamber which contains granular iron oxyhydroxide which has a high adsorption capacity for arsenic. This media must be imported from outside. Afterwards the arsenic free water flows into a storage tank.

The cost of this system with 1 litre/minute capacity was initially around Tk. 100,000. It has now been brought down to Tk. 75,000 by manufacturing some materials locally. The aim is to bring the cost further down in future until it approaches the cost of a deep tubewell (around Tk. 50,000). This community-based arsenic removal plant can be seen in Figure 5.21.

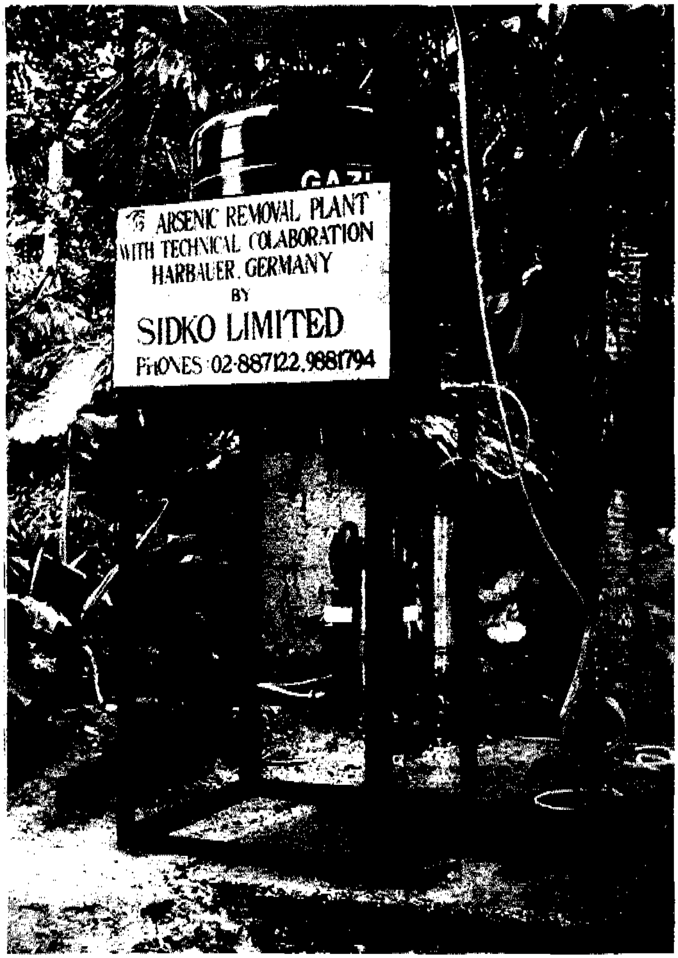


Figure 5.21: Community based arsenic removal plant (SIDKO plant), Jafarnagar village, Jhikargachha upazila.

5.9.3 Monitoring

The system was monitored in the field from October 1999 to March 2000 using the Merck kit and found to be very effective. Arsenic in tubewell water was reduced from around 500 ppb to below the detection limit of the field kit. Some samples were taken and analysed in the laboratory. The results are given in Table 5.15

These samples seem to show much lower initial concentrations of arsenic than were measured in the field. There was some confusion about preservation of the samples and it seems that not enough acid was added to the sample, and thus arsenic and iron has come out of solution between sampling and analysis. Thus, care should be taken in interpreting the above results.

Samples were also taken to assess the bacteriological quality of the filtered water. Total Coliform bacteria decreased from 5 cfu/100 ml before filtration to 0 cfu/100 ml after filtration.

Table 5.15: Results of testing of water before and after treatment by community based arsenic removal plant (SIDKO plant), Jafarnagar village in Jhikargachha upazila

Sample Description (date)	As (ppb)	Fe (ppb)	Mn (ppb)
Raw tubewell water (5.10.99)	140	0.05	-
Treated water (5.10.99)	<0.001	0.6	-
*Raw tubewell water (23.2.00)	53.12	0.04	11
*Treated water (23.2.00)	2.65	0.011	0
*Raw tubewell water (23.2.00)	60	-	-
*Treated water (23.2.00)	2	-	-

Note: '-' indicates test not done.
* Samples taken in two different times on the same date.

5.9.4 Strengths of the 'SIDKO' plant

1. The plant was found to be very effective; after filtration the water is crystal-clear and arsenic free.

2. Another strength is that due to its high-tech appearance people are very keen to use it.

5.9.5 Weaknesses of the 'Sidko' plant

1. The flow rate of the system is only 1 litre per minute. Often several people were found waiting for a long time for water. Furthermore over time the flow rate reduced drastically due to clogging of iron in the media.

2. Cost is Tk. 75, 000 - Tk. 100, 000 per unit; this is dependent on the number of units purchased and does not include replacement cost for the media.

3. Due to the high level of arsenic and iron in the water the media will need to be changed frequently. Initial estimation was that it would last for one year but it was found necessary to change it after six months. To change three kg of the media costs Tk. 3,000.

4. The media and the system has to be brought from Germany and is not available locally. It may, however, be possible to manufacture the media locally in the long run.

5. Production of sludge is a disadvantage of this system. Production of sludge by itself is not a problem as the amount of arsenic which is extracted from tubewells for drinking and cooking purposes is minimal in comparison to the amount which is spread over the ground in irrigation water. However, as many families will take water from the same tubewell this will act to concentrate the arsenic contaminated sludge in one place. SIDKO plans to remove this sludge from the site and dump it elsewhere. For this to be implemented it would first require a large number of units to be installed in order to make it financially viable. The costs of this would undoubtedly entail a further costs to the community pushing the total costs up.

6. It would seem unlikely that this system is sustainable in the long run. Even if the capital costs of providing the system were covered it may not be very likely that the villagers would pay for the water and organise themselves to change the media on a regular interval. Unless there is a large number of plants spread across the country the private sector would not produce or supply the media in rural Bangladesh.

7. Although theoretical capacity of a plant may be high, the actual users would probably be less as people may not be ready to travel far to fetch water. For this system we found that there were about 75 families (roughly 375 people) of initial users but as other options became available (for example, DPHE installed a deep tubewell nearby) this dropped to about 20. Also people generally preferred to have their own water source; to go to another person's house to get water may not be liked by many because of the presence of inter-family fends and vivatries.

5.9.6 Overall assessment

Although technically effective, it would seem unlikely that community-based arsenic removal plants (like the SIDKO plant) are suitable for widespread use in Bangladesh given the current socioeconomic conditions.

5.10 Tubewell Sand Filter (TSF)

5.10.1 Design of the system

Encouraged by the performance of the three-pitcher filter it was wondered how such a system could be used to serve the community needs. The Three-pitcher is home-based, and each can fulfil the demand of only one family. The Tubewell Sand filter (TSF) is a modification of the three-pitcher filter to fulfil the needs of a larger group. In Sonargaon and Jhikargachha 15 TSFs were constructed which were found very popular in the community. Due to technical problem of the concrete structure, two TSFs did not work effectively in removing arsenic at the early stage of construction. Thereafter, all the TSFs were effective and showed very good performance.

5.10.2 Technical details

Based on the three-pitcher method, BRAC developed this community-based option. It includes construction of a concrete structure consisting of three chambers set on a vertical column (Fig. 5.22). In the top most

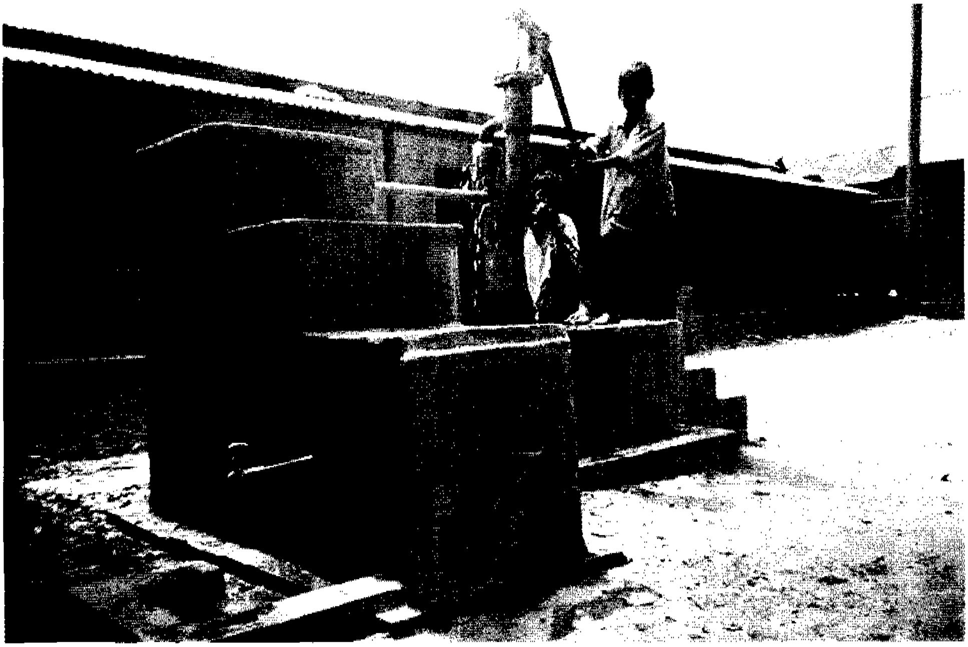


Figure 5.22: A tubewell sand filter (TSF) constructed in Sonargaon.

chamber iron chips and coarse sands are kept, at the middle chamber charcoal and fine sand are kept as like as in the three-pitchers. At the bottom there is a reserve chamber with a tap to collect water. There is also an outlet for washing the chamber. Arsenic contaminated water from a tubewell is pumped into the top chamber and arsenic free water is received at the bottom chamber. After four months of continuous operation iron filling in the TSF needs to be changed.

5.10.3 Monitoring

All the TSFs in operation in the field were monitored since their construction in January 2000 and were found performing satisfactorily. Some monitoring results are shown in table 5.16.

Table 5.16: Monitoring of TSFs constructed in Sonargaon

TSF identity	Raw water (ppb)	Date of testing	Treated water (ppb)	Date of testing	Treated water (ppb)
TSF 1	143.39	04.06.00	1.29	02.07.00	BDL
TSF 2	28.12	04.06.00	8.51	02.07.00	1.26
TSF 3	108.00	04.06.00	11.03	02.07.00	44.65
TSF 4	184.20	04.06.00	1.51	02.07.00	3.40
TSF 5	128.30	04.06.00	2.56	02.07.00	6.10
TSF 6	-	-	-	02.07.00	8.28

Note: Tests were done using AAS; BDL= Below Detection Level,'-' indicates tests not done.

5.10.4 Strengths of TSF

1. This method can be used as community-based option in the arsenic-affected areas.

2. It is technically effective.

3. People showed keen interest in using this option because it is less exposed to outside contaminants compared to the three-pitcher.

4. This method promotes use of indigenous technology.

5.10.5 Weaknesses of TSF

1. As a community-based option it can not fulfil the full satisfaction of the community for they have to wait until the reservoir tank is full of water.

2. Initial installation cost (Tk. 6,000) is high which is not affordable for poor households.

3. It should be monitored continuously for assessing the performance of the system in arsenic removal capacity and clogging. The community needs to take responsibility for maintenance.

4. The chambers of the TSF should be covered properly to protect from insects and earthworms which may cause people lose interest in using this system,

5.10.6 Overall assessment

This can be constructed and used in the places where there is large gathering of people such as schools, or mosques. TSFs should be monitored for water quality on a regular basis.

5.11 Activated alumina filter

5.11.1 Design of the system

MAGC Technologies Limited - a private enterprise imported a US manufactured treatment plant and approached BRAC to test it in the project areas for demonstration purposes. The basic principle of this system is adsorption of arsenic by activated alumina. Two such units have been installed in Sonargaon to test its effectiveness and acceptability. The effectiveness of this system was monitored for three months before July 2000 and found promising.

5.11.2 Technical details

The activated alumina filter consists of two containers; one is filled with sand and the other with activated alumina. The first container with sand gets water directly from the tubewells. The raw water passes downward through the sand and in the second container water passes upward through the activated alumina media. After passing through this activated alumina water becomes arsenic-free.

Activated alumina is formed by the thermal dehydration (250ºC to 1150ºC) of an aluminium hydroxide such as, gibbsite, bayerite, etc. Its principle characteristic is high surface area (>200 m^2/g) and associated porusness. The term activated refers to the capacity of the alumina to enter into adsorption and/or catalytic reactions, and is determined largely by such variables as crystal structure, pore size and distribution, and the chemical nature of the surface.

Activated alumina is able to remove cations and anions by chemisorption. This involves an ion exchange mechanism with the hydroxylated surface. It is able to remove a wide range of anions and cations such as arsenic, fluoride, chromium, zinc, iron, phosphates and organic materials.

5.11.3 Monitoring

The activated alumina filters which were monitored for three months from April 2000 were found effective in removing arsenic from water. Some results of tests for arsenic in water are shown in Table 5.17.

Samples were also taken to assess the bacteriological quality of the filtered water (Table 5.18). In all the treated water samples the number of coliform bacteria was greater than in the untreated water. This increased number may be due to contamination that occurred in the sand used in the first chamber of the units.

Table 5.17: Results of tests for arsenic in water before and after treatment by activated alumina filter

Date	Sources	Unit 1	Unit 2
27.04.00	Before treatment	0.352mg/L	0.337mg/L
	After treatment	0.0012mg/L	0.0025mg/L
02.05.00	Before treatment	0.370mg/L	-
	After treatment	BDL	-
04.05.00	Before treatment	-	0.557mg/L
	After treatment	-	BDL
16.05.00	Before treatment	0.335mg/L	-
	After treatment	BDL	-
23.05.00	Before treatment	0.633mg/L	-
	After treatment	BDL	-
10.06.00	Before treatment	0.580mg/L	0.046mg/L
	After treatment	BDL	BDL

Note: Tests done using AAS, BDL= Below detection level, '-' indicates tests not done.

Table 5.18: Laboratory testing for coliform bacteria in water filtered by activated alumina plant

Source	Unit 1		Unit 2	
	Total coliform/ 100ml	Faecal/ 100ml	Total coliform/ 100ml	Faecal/ 100ml
Untreated	$3.0x10^1$	$1.9x10^1$	$2.2x10^1$	$4.0x10^0$
Treated	$2.0x10^3$	$1.0x10^3$	$5.3x10^1$	$3.1x10^1$

Note: Tests done in ICDDR,B laboratory.

Although this technology has been in use for only the past few months, due to its simple design it has already gained good acceptance. More than 50 families are collecting water from each of the two units. Based on its early monitoring experience, the following are the strengths and weaknesses of the activated alumina plant.

5.11.4 Strengths of activated alumina filter

1. Technically the system is very effective, at least in the short-term.
2. People are interested in receiving water from this unit since it is easy to use.
3. Filtration rate is very good in the sense of serving the demand of the community.

5.11.5 Weaknesses of the activated alumina plant

1. The activated alumina used as media in the system has to be imported.
2. Initial cost is high (Tk. 15,000 per unit). Poor villagers can not afford this on their own.
3. It requires running costs because activated alumina need to be changed after every 120,000 litres of water filtered. The replacement cost of the media is Tk. 10,000.

5.11.6 Overall assessment

Due to its ease of operation this technology has created interest among the users in Sonargaon. Nonetheless, further monitoring is required before any conclusive remarks can be made. The cost is a matter to be aware of.

5.12 Coverage by safe water options

Provision of safe water to people exposed to arsenic contamination was one of the major objectives of the project. The first priority was given to the people who had been affected by arsenicosis. In the two upazilas 403 patients were identified all of whom were provided with arsenic-free 'safe' water.

The next priority was given to villages where 50% or more tubewells were found contaminated. Based on the above criteria 368 out of total 513 villages in the project area were listed for intervention to supply safe drinking water through different options. Within village, poor families were given priority in the distribution of the home-based options like Safi filter and three-pitcher filter. The community-based options were constructed in the places where most of the tubewells were found contaminated. Table 5.19 shows the coverage till June 2000 by safe water options in the project area. It shows that nearly a quarter of the population exposed to arsenic contamination now have access to 'safe' water.

Table 5.19: Coverage by safe water options in the project areas

	Sonargaon	Jhikargachha	Total
Total population	261,881	235,607	497,488
No. of villages	368	163	531
No. of tubewells contaminated	16,171	15,658	31,829
Estimated population exposed to arsenic	165,000	115,000	280,000
No. of villages with 50%+ tubewells contaminated	272	96	368
Families covered by 'safe' water options	7,750	4,980	12,698
% of families covered by 'safe' water options	23.5	21.7	22.6

Although 'safe' water coverage was increased during the course of the project, much needs to be done in the future. The primary objective of the research, however, was to assess the relative strengths and weaknesses of the different treatment procedures. Now that this has been done to certain extent, the next step is to scale up the mitigation operation and continue monitoring of old and testing new options to arrive at a solution which will be accessible, effective, safe, acceptable, sustainable and affordable for every household.

5.13 Involving community in sharing cost for safe water

This action research project has attempted mainly to demonstrate the potential of alternative safe drinking water sources in the context of rural Bangladesh and no deliberate effort was made to recover costs or examine cost-sharing.

The majority of the people of the project area are poor. Their acquaintance with tubewells is relatively recent. When they came to know that their tubewell water was no longer safe for drinking purposes due to the presence of arsenic many became frustrated. Except for the three-pitcher and dugwells, all the other options that were promoted in the project areas were completely new to the people. Moreover, the awareness level about the dangers of drinking arsenic contaminated water was not optimal. Thus, the problem is that people with limited finances are reluctant to spend money on something which they do not perceive to be a major problem. Also the effectiveness of any mitigation procedure is not sufficiently well-established for them to spend money on.

For the constructed options which required a large initial outlay (i.e., PSF and RWH), it would not be easy to convince people to spend money. In the construction of one PSF in Jhikargachha upazila, however, the owner of the land supported the carrying costs of the materials needed for construction amounting to Tk 2,500.

In the case of the home-based filters, the propensity to buy depends on financial status. Before the technical problems with the Safi filters surfaced, people had expressed their desire to purchase these filters and some shop keepers were interested in stocking them.

For a system such as the three-pitcher filter it may be possible in the future to encourage people to manufacture these filters through micro-credit and then sell them in their villages. Training would be required and some form of quality control would be necessary to ensure that the filters were of consistent quality. More work need to be done in exploring the cost sharing options.

At the later stage of the project period, BRAC provided loans to some of its village organisation (VO) members in Sonargaon upazila to construct three kolshi filters fro sale to potential clients. Until the end of the project period, the VO members had sold over 200 such filters to the villagers.

5.14 Assessment of the effectiveness of the safe water options

A number of alternative safe water options are now in operation as demonstration units. The idea of constructing these demonstration units is to raise the awareness level of the community people about the options which later will help in developing a system of involving community members in choosing, financing, and implementing safe water systems on their own.

Alternative safe water options which have been implemented in the field are: pond sand filters (PSF), rain water harvesters (RWH), three-pitcher filters, Safi filters, home-based surface water filters, dug wells, community-based arsenic removal plant (SIDKO plant), tubewell sand filter (TSF), and activated alumina filter. These were assessed with reference to initial and running costs, ease of implementation, requirement for maintenance or ongoing supervision, flow rate, susceptibility to bacteriological contamination, and acceptability to the local community.

The matrix below shows ratings of each of these factors on a scale of 1 to 5. The maximum possible is 45 and a higher rating indicates more potential.

	PSF	RWH (old)	RWH (new)	Safi filter	Three pitcher filter	Surface water filter	SIDKO plant	Dugwell	TSF	Activated alumina filter
Initial Cost	1	2	4	4	5	4	1	3	3	2
Running Costs	4	4	4	3	5	5	1	5	5	1
Ease of implementation	1	1	2	5	5	4	1	3	2	3
Technical effectiveness	2	3	3	1	4	4	5	2	5	5
Maintenance required?	4	3	3	1	2	3	1	4	2	3
Monitoring required?	2	3	3	1	1	2	3	2	2	2
Continuity of supply	4	1	1	1	4	2	1	3	3	5
Susceptibility to bacteriological contamination	2	4	4	2	2	1	5	1	2	2
Social acceptability	1	1	1	3	5	1	3	3	4	4
TOTAL	21	22	25	21	33	26	21	26	28	27

It was found that all the options had limitations. At present the three-pitcher filter with an aggregate rating of 33 is proving to be the best option for its ease of use, low cost, and simplicity. This is followed by TSF and activated alumina filters. The PSF, Safi filter and SIDKO plant could not prove their worth much.

The new design of rain water harvester shows potential as an inexpensive method for providing safe water for part of the year although it is limited by the capacity which it can contain. The old design of rain water harvester and the PSF are both thought to be too costly to be taken up locally. Dugwells may prove cost-effective and acceptable to the community. The limitation of dug-wells is that they may not always provide arsenic-free water, and they have high susceptibility to bacteriological contamination.

The Safi filter initially seemed to be a promising technology for treatment of arsenic contaminated groundwater. However, over time the majority of the filters supplied ceased to be effective. The inventor of the filter is currently working on the problems and to produce an alternative porous media column filter. If proven to be effective these two types of filter may have potential in the future.

Some limited results show home-based water filters to be effective in removing bacteria from surface water. These are cheap and could provide a good method of purifying pond water for drinking in rural Bangladesh. Doubts and uncertainties exist about the social acceptability of drinking pond water even after treatment.

The community-based arsenic removal plant (SIDKO plant), although technically effective, is unlikely to be an economically or logistically viable method of providing safe drinking water in rural Bangladesh.

Tubewell sand filters are a safe and viable community-based safe water option if they can be monitored regularly by the community. Thus, the activated alumina filters seem effective technically but it requires further monitoring.

Chapter 6

AWARENESS BUILDING AND COLLABORATION WITH LOCAL GOVERNMENT BODIES

Collaboration with other agencies

The BRAC arsenic mitigation project maintained a close working relationship with DPHE and local elected bodies like Union Parishad (UP). Accordingly, a monthly field co-ordination meeting was conducted with the Sub-Assistant Engineer (SAE) of DPHE, Jhikargachha and UNICEF Regional Co-ordinator to inform them of the progress of the project activities. A photocopy of the resolution of one of the monthly field co-ordination meetings is attached in Annex 6. It could not be done in Sonargaon as the SAE had time constraints was not always available. The SAE of Jhikargachha assisted in helping site selection for construction and distribution of many options like PSFs, RWHs and dugwells, home based filters like Safi filters and three-pitcher. The mechanics of local DPHE of Jhikargachha were involved in manufacturing and distribution of three-pitcher among the villagers. A total of 650 three-kolshi filters were distributed to the villagers selected by the mechanics and the SAE of Jhikargachha DPHE. Some logistic supply was provided to the SAE of Jhikargachha by BRAC for his field work.

The UP chairmen and ward members of both the upazilas were involved in implementing the project activities. They contributed in site selection, construction of options and distribution of filters. Each of the UP chairmen of Jhikargachha selected 50-100 villagers for the distribution of three kolshi filters. All the UP chairmen of Jhikargachha were invited to BRAC area office for an open discussion meeting to exchange views with them and to inform them of the project activities.

The local DPHE and UP offices have been provided by BRAC with relevant information on the project for display boards to show and update the progress of the project activities.

Awareness development

A combination of approaches were used in raising knowledge about arsenic contamination and the consequences of drinking arsenic water on human health. These included meetings with community leaders, workshops for health and other service providers, school teachers and religious leaders, meetings with villagers at the time of testing tubewells for arsenic, distribution of posters and leaflets at key public places, and the use of print and electronic media. Some printed communication materials used for social mobilisation have been shown in Annex 7. Table 6.1 gives details on the number of different communication materials distributed.

Table 6.1: Communication materials distributed and meetings held for awareness development

Items	Sonargaon	Jhikargachha
Materials		
Poster	20,000	20,000
Leaflet	20,000	20,000
Booklet	20,000	20,000
Sticker	20,000	20,000
Meetings		
Village meeting	85	92
Resource map	60	92
Workshop	29	29

In the second phase, the people of these villages were informed of the status of arsenic poisoning in their locality. They were then solicited to choose a safe water option. Village meetings, school meetings, and meetings with local elected bodies were used to inform people on the arsenic crisis.

A workshop designed to train participants in the communication campaign was conducted in the two upazilas. Representatives of different stakeholders including block supervisors, tubewell mechanics, UP chairmen, ward members, head teachers, imam, health and family planning workers, and NGO workers participated. A total of 475 and 485 participants from Sonargaon and Jhikargachha respectively took part in these workshops in each upazila (Table 6.2).

Table 6.2: Number of stakeholders participated in the communication campaign workshops

Stakeholders	Sonargaon	Jhikargachha	Total
Block Supervisor	28	35	63
Tubewell mechanic	4	4	8
UP chairmen/member	90	143	233
Head Teacher	25	37	62
Imam	112	40	152
Health & Family Welfare worker	135	137	272
NGO worker	81	89	170
Total	475	485	960

A study was conducted by BRAC's Research and Evaluation Division in May 2000 to find out how much awareness had been created in the project area due to the BRAC interventions. In doing this, Jhikargachha was compared with nearby Bheramara upazila. The results shown in Table 6.3 indicates a higher awareness level in Jhikargachha than in Bheramara. As expected BRAC was the primary source of knowledge about arsenic and its mitigation options in the project villages, although health workers of other organisations and media played a role. Grassroots level health workers, arsenic project staff along with the mass media were also crucial in disseminating arsenic information in the comparison villages (Hadi, 2000).

Table 6.3: Arsenic awareness, source and options of arsenic-free water by study area

	Study area		
	Project	Comparison	p-value
Aware of arsenic (Unprompted)	81.8	58.3	<.01
Heard about arsenic (Prompted)	95.4	70.4	<.01
Source of arsenic-free water			
Mentioned at least one	77.8	44.9	<.01
Mentioned at least two	35.8	15.6	<.01

Source: Hadi (2000)

To create increased awareness among the people on the arsenic issue a drama was made by BRAC's "Popular Theatre" programme titled "Banchte Chai" (We want to survive). The drama was written based on the story of Kaiser Ali (45) of Goalbakpur village of Jhikargachha who died of cancer from arsenic poisoning in July 2000 (see Box 3.1). This drama played by the village artists was telecast by Bangladesh Television in its "Diganta" programme. This programme also covered some of the BRAC's arsenic activities including tubewell testing by the VHWs, different safe water options, interviews of the patients being supported by BRAC, etc.

The activities of BRAC on arsenic mitigation in the country was widely covered by different national and local newspapers. This helped people to know and become aware about the issue. Some reports were complementary but others were critical also. This helped us to improve the programme. Clippings of such news articles are reproduced in the Annex 9.

Chapter 7

LESSONS LEARNED AND THE WAY AHEAD

The major lessons learned from the implementation of the action research project in the two upazilas of Bangladesh are summarised in the following:

- Arsenic is a problem which is ravaging a large part of the country. The existence of arsenic in the drinking waters of the two upazilas has been confirmed through this action research project. A blanket testing of all 51,655 tubewells in the two areas reveal that 62% in Sonargaon and 48% in Jhikargachha are contaminated. There are many villages where no arsenic-free tubewells are available.

- With some training it is possible for female village volunteers to test the tubewells for arsenic. The technology for testing, however, needs further improvement.

- Local women with limited educational background can also be trained on preliminary identification of arsenicosis patients, awareness development on the issue, different alternative water supply options and monitoring of the option use in the areas. Local masons can be trained on the construction and manufacture of different options so that their expertise can be used to the maximum extent.

- Community mobilisation and their involvement are essential for arsenic mitigation. People are willing to participate in testing, priority-setting, awareness-building, mitigation and cost-sharing.

- Not all villages are affected equally and hence there is a need for prioritisation in intervention. For this we need to know which villages are most affected (with little or no source of arsenic free water).

- The feasibility, effectiveness, and acceptance of the safe water options available vary from place to place. Some options have been found to be either technically inefficient or disliked by the community; others were found to have good potentials. There may not be a single but a combination of solutions.

- This project tested eleven options for arsenic-free water. Newer options such as piped water supply, deep wells, and 'reserved' ponds should also be tried for feasibility and cultural acceptance.

- The safe water options supplied/installed in the community should be constantly monitored on a regular interval; any option can go wrong for lack of maintenance or other reasons. Regular monitoring of water treated by technologies using either surface or ground water should be monitored for different parameters. In case of ground water arsenic concentration and in case of surface water it should be tested for coliform bacteria. In Bangladesh, surface water is highly contaminated with coliforms.

- There was a lack of consistency in the results of laboratory tests, particularly for coliform bacteria, much of which remained unexplained. In future, more attention needs to be given on proper testing of the water using scientific procedures.

- Awareness level varies from village to village, and hence the rate of people's switching from contaminated tubewells to 'safe' sources varies. Villages with arsenicosis patients have the highest consciousness. Effective awareness campaign is necessary to motivate people to drink arsenic free water. Anecdotal evidences suggest not all options provided by the project area are equally used.

- Many arsenicosis patients have been identified so far and more patients are being identified every day. Action must be taken immediately to avert the threat to health that is looming for much of the nation's population. The first priority to the arsenic exposed people is to provide them with arsenic free safe water for both drinking and cooking purposes.

- Following provision of safe water and some 'treatments', many of the arsenicosis patients report an improvement; research is needed to find out effective treatment regimens for patients in different stages of arsenicosis.

- Many treatment units, either home-based or community-based, produce sludge that contains high concentration of arsenic. A countrywide proper management system for this sludge should be set up so that rural people can manage this sludge in a convenient way.

- There should be more co-ordination among different governmental and non-governmental agencies working in the country. The Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) should take on the task of facilitating different activities of arsenic mitigation. NGOs with their base at the grassroots level and wide network throughout the country are capable of scaling up the arsenic mitigation programme rapidly on emergency basis, particularly in the worst affected upazilas.

- It is likely that multiple solutions will need to be promoted in Bangladesh to tackle the arsenic crisis. It is hoped that workers involved in other arsenic projects in Bangladesh will learn from this small effort of BRAC. Community mobilisation and motivation will be the *sine qua non* in providing the long-term solution to the problem. It must be recognized that we are starting from a scratch with little previous experience to learn from.

Finally, it is clear that the technologies introduced in this project to supply arsenic free safe drinking water are only short-term emergency solutions for areas severely affected by arsenic contamination. The longer term solutions must be based on a long term vision. This may include the provision of piped water supply to its population and the optimum use of surface water. The potential role that the local governments can play in this longer-term vision must be fully explored; towards this, experimentation and pilot projects should not wait. Although we do not have a 'golden' solution as yet, but we have 'something' to move forward to face the crisis. And we do have *hope*.

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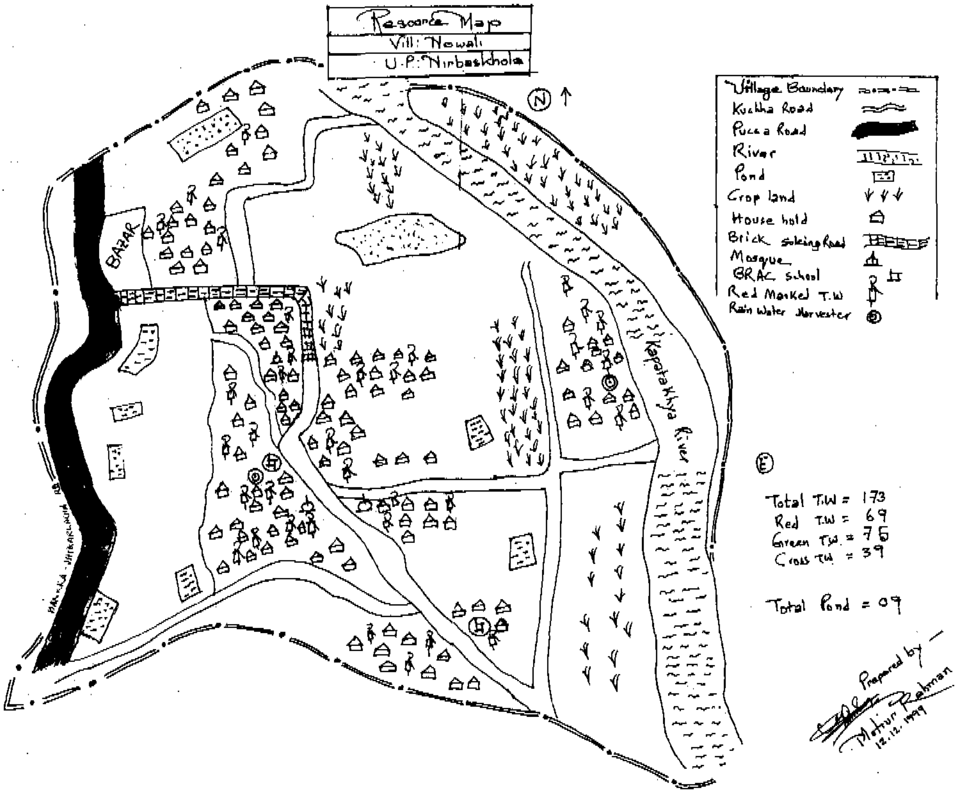
Annex 1

Resource map prepared in a village



Annex 2

Abridged list of visitors to the project areas

Name	Designation	Organisation
Mr. F. H. Abed	Founder Executive Director	BRAC
Mr. M Saber Afzal	Country Director	MAGC Technologies Limited
Mr. Jalal Uddin Ahmed	Programme Coordinator, Essential Health Care	BRAC
Mr. Kazi Nasiruddin Ahmed	Additional Chief Engineer	DPHE, GoB
Dr. Saleh Uddin Ahmed	Deputy Executive Director	BRAC
Dr. Sayed Masud Ahmed	Senior Medical Officer	BRAC
Mr. Aminul Alam	Deputy Executive Director	BRAC
Ms. Shahida Azfar	Country Representative	UNICEF Bangladesh
Dr. Deepak Bajrachariya	Chief, WES	UNICEF Bangladesh
Dr. Richard A. Cash	Faculty	Harvard University
Mr. Faruq A Choudhury	Advisor	BRAC
Mr. Gouri Shanker Ghose	Chief, WES	UNICEF New York
Dr. Abdullahel Hadi	Senior Sociologist	BRAC
Dr. Bilqis A. Haque	Consultant	World Bank, Dhaka
Mr. Han Heijnen	Environmental Health Adviser	WHO Dhaka
Mr. Moaidul Hoque	General Manager	SIDKO Limited
Prof. AM Muazzam Husain	Consultant	BRAC
Mr. Satoshi Ishida	Civil Engineer	Japan
Mr. Shafiqul Islam	Deputy Chief, WES	UNICEF Bangladesh
Dr. Sirajul Islam	Head, Environmental Microbiology	ICDDR,B, Dhaka
Dr. Babar Kabir	Water Sector Specialist	World Bank, Dhaka
Dr. Yamamoto Kazuo	Professor	Tokyo University
Dr. Hidetoshi Kitawaki	Professor	Toyo University, Japan
Dr. Nadim Khondker	Consultant	UNICEF Bangladesh
Ms. June Kunugi	Chief, Information and Advocacy Section	UNICEF Bangladesh
Ms. Mieko Magami	Director of Head Office	Japan-Bangladesh Cultural Exchange Association
Mr. S. B. Mathur	Director	RPM Marketing Pvt. Ltd., India
Mr. Farid Uddin Miah	Project Director	BAMWSP, GoB
Mr. Noriyuki Nakamo	Deputy Resident Representative	JICA, Dhaka

...Continued

...**Annex 2** [Continued]

Name	Designation	Organisation
Dr. KM Shah Newaz	Consultant	Lever Brothers Bangladesh Ltd.
Ms. Priya Patel	Student	Harvard University
Mr. Ranjan Samantarya	Project Officer	UNICEF Calcutta
Ms. Carine Shampoo	Deputy Executive Director	UNICEF New York
Mr. Ameer Siddique	Director	SIDKO Limited
HE. Finn Thilsted	Ambassador	Royal Danish Embassy, Dhaka
Dr. Jens Thogersen	Technical Adviser	DPHE-DANIDA Urban Water and Sanitation Project
Mr. Andrew J. Woodley	Photo-Journalist	National Press Photographers Association, USA
Mr. Peter Wurzel	Consultant	UNICEF Bangladesh
Mr. Ali Zaker	Artist	Asiatic Marketing Communications Ltd.
Ms. Sarah Zaker	Artist	Asiatic Marketing Communications Ltd.
Group	Communication Specialists	Expressions Ltd.
Group	Journalists	BTV
Group	Journalists	Ekushey TV
Group	Development worker	Grameen Bank
Group	Development worker	ADRA Bangladesh
Group	Development worker	NGO Forum for Drinking Water Supply & Sanitation
Group	Development workers	CARE, Bangladesh
Group	Development worker	DASCOH
Group	Water experts	DPHE
Group	Water quality expert	OCETA, Canada
Group	Water/Sanitation Staff	DANIDA
Group	Teachers and students	Dhaka University
Group	Environmentalists	IUCN, Bangladesh
Group	Project staff	WaterAid
Group	Teachers and students	North South University
Group	Teachers and students	BUET
Group	Physicians and Trainers	Dhaka Community Hospital
Group	Students	Harvard University
Group	Students	Columbia University
Group	Students	Independent University, Bangladesh

Annex 3

Results of laboratory testing of 'green' tubewells and 'cross' tubewells

SL.	Name	Father/ Husband	Union	Village	As. Field Result with Merck kit	As. lab. result (ppb)
1	Lutfar	Deen Ali Kha	Nirbaskhola	Nowali	X	
1 (ii)	**BLANK (with acid)**					1
2	Fazlur Rahman	Nowsher	"	"	0	21
3	Zahur Ali	Doud Ali	"	Ballah	X	
3 (ii)	**BLANK (no acid)**					BDL
4	Ali Hossain	Jalal Sarder	"	"	0	23
5	Ripon	Altaf Hosain	"	"	0	15
6	Tarapat	SaratChandra	"	Sadipur	0	36
7	Primary School		Hazirbagh	Hazirbagh	0	23
8	Mosque		"	"	0	22
9	Noor Ali	Hazu Gazi	Barkra	Uzzalpur	0	10
10	**" (Duplicate of 9)**	"	"	"	0	9
11	Ishak	Tomizuddin	"	"	0	6
12	Abul Kasem	Khosdel Gayen	"	Konsal nagar	X	
12 (ii)	**BLANK (with acid)**					1
13	Tomej Uddin	Nasir Uddin	Hazir Bagh	SunaKur	0	20
14	**" (Duplicate of 13)**	"	"	"	0	18
15	Mozammel	Hedayet Ali	"	Sunakur	0	6
16	Hakim	Situ Bepari	Gadkhali	Motbari	X	
17	Arshad	Nobai Moral	"	Sadirali	0	20
18	Liakat	Asmat	Gadkhali	Matuapara	0	29
19	Siddiqua	Latif	"	Fatehpur	0	3
20	Kurban	Tuku Munshi	"	Beneali	0	20
21	Khokan	Josef	Simulia	Mission	0	9
22	Tofazzal	Kashem	"	Gopinathpur	0	10
23	Kurban	"	"	Shimulia	0	31
24	Afzal	Insan Gazi	"	Azampur	0	17
25	Jamal	Amzad	Navaran	Kaliani	X	
26	Abutaleb	Babar Ali	"	Manikali	0	10
27	Chand Ali	Fakir	"	Baisha	0	11
28	Akbar	Osman	"	Ramchandrapur	0	8
29	Rahim	Ramzan	"	Aminee	0	8
30	Hasu	Jhuder	"	Navaran	0	21
31	**BLANK (no acid)**					1
32	**BLANK (with acid)**					1
33	**BLANK (no acid)**					BDL
34	Kalibari		G. Nandpur	Chutipur	X	
35	Kashem	Showkat	"	Magura	X	
36	Abdul Hossain	Gohar Ali	"	Amrit Bazar	0	18
37	Saidali	Saharali	"	"	X	
38	Haroon	Belayet	"	"	X	
39	Sayd	Nuru	"	"	0	16
40	Islam	"	"	"	X	
41	Wahed	"	"	"	X	
42	Mozzammel	Izuddin	"	"	X	
43	Razzak	Sonai	Sankarpur	Naira	0.1	
44	Zinnath	Izzat	"	"	X	
45	Gaffar	Intaz	"	"	0	24
46	Bakkar	Babar	"	"	X	
47	Montaz	Muksed	"	"	X	
48	Lutfar	"	"	"	X	
49	Mataleb	Golam Hossain	"	Rajbaria	0	14
50	Fazlur	Moala	"	"	X	

SL.	Name	Father/ Husband	Union	Village	As. Field Result with Merck kit	As. lab. result (ppb)
51	Hasan	Razzak	"	"	X	
52	Maznu	Adam	"	Ulakole	0	15
53	Akbar	Jumman	"	"	0.1	
54	Rafiqul	Nabi	"	Podalia	X	
55	Ahad	Khaibulla	"	"	X	
56	Aksed	Inser Ali	"	Haridrapota	0	9
57	Haran	Khairulla	"	"	X	
58	School	-	"	"	0	8
59	Habur	Ibadat	Jhikorgachha	Krisnanagar	0	10
60	Aliar	Sulta	"	Jhikorgachha	0	26
61	Siddik	Babar	"	Hariadeara	X	
62	Jibon	Khokan	"	Mollikpur	0	12
63	Fokir	Ibrahim	"	Kirtipur	0	10
64	Aminul	Khalilur	Nilkanthanagar	Panisara	0	36
65	Sanaullah	"	"	"	0	32
66	Aziz	Arshad	"	"	0	30
67	Hanif	Oliur	"	"	X	35
68	Primary School	-	"	"	X	14
69	Nazrul	Md. Hossain	Towra	"	0	3
70	Anser	Babar	"	"	0	4
71	Habibur	Izzat Ali	Nabagram	Ganganandapur	0	13
72	Malek	Samsur	"	"	0	13
73	Harez	Jashim	Ganganandapur	"	0	?
74	Momin	Khorshedul	"	"	0	?

Notes:

1. All samples are taken from green marked tubewells originally tested by VHW's as 0 with Merck field test kit. Field results given here are results for testing with Merck kit on the day of sampling (14-15.2.00) approx three months after original testing (November 1999).

2. Laboratory testing was conducted by Intronics Technology Centre

3. BDL = Below Detection Limit

Change from original testing	
Green (0) -> Green (0) (same)	45 (63%)
Green (0) -> Cross (>0 and <0.1)	24 (34%)
Green (0) -> Red (>0.1)	2 (3%)
Total tubewells tested in field	71 (100%)

Arrsenic testing data from Panisara Union, Jhigorgaccha Thana using Merck Doubling Method and AAN Kit for results between 0 - 0.1ppm						
Sample No.	Original VHW test result	Merck Doubling Method Result	AAN Result	ITC Lab Result		
1				0.0	D.I. water	
2	X	0.1	0.03	42.3		
4	X	0.04	0.05	44.4		
5				48.0	?extra	
17	X	0	0.03	27.2		
18	X	0.1	0.02	54.0		
19	X	0.15	0.09	70.7		
20	X	0.1	0	109.9		
21	X	0.1	0.04	242.1		
23	X	0.02	0.05	14.8		
25	X	0.05	0.09	350.0		
26	X	0.1	0.05	155.8		
27	X	0.04	0.06	127.3		
28	X	0.04	0.09	98.8		
29	X	0.04	0.02	98.8		
30	X	0.05	0.06	85.5		
31	X	0.1	0.1	52.0		
32	X	0.05	0.02	122.8		
33	X	0.04	0.04	229.9		
35	X	0.05	0.03	95.9		
41	X	0.1	0.05	150.8		
46				21.1	?extra	
54	X	0.1	0	102.8		
55	X	0.1	0	26.2		
56	X	0.1	0.05	424.0		
57	X	0.1	0.08	37.0		
60	X	0.05	0.02	48.5		
61	X	0.2	0.01	22.3		
62	X	0.05	0	150.8		
63	X	0.1	0.07	271.3		
64	X	0.2	0.2	86.0		
67	X	0.2	0.05	53.9		
71				0.0	BRAC Tap	
74	X	0.1	0.03	96.8		
75	X	0.05	0.05	130.4		
76	X	0.1	0.05	430.4		
93	X	0.06	0.04	22.9		
94				6.9	D.I. with acid	
97	X	0.15	0.03	424.0		
100	X	0.1	0.08	8.0		
101	X	0.02	0.04	27.0		
104	X	0.02	0.01	37.0		
107	X	0.02	0	1.8		

108	X	0.02	0.02	39.0		
109	X	0.04	0.01	19.0		
Sample No.		Merck Doubling Method Result	AAN Result	ITC Lab Result		
110	X	0.04	0.01	23.0		
112	X	0.05	0.05	26.7		
113	X	0.03	0.03	13.0		
114	X	0.02	0.02	18.5		
115	X	0.03	0.01	10.6		
116	X	0.03	0	19.0		
117	X	0.04	0.04	23.6		
118	X	0.1	0.06	41.3		
119	X	0.02	0.04	8.4		
120	X	0.04	0.08	28.0		
121	X	0.1	0.01	23.0		
123	X	0.1	0.04	39.4		
124	X	0.03	0.09	27.4		
125	X	0.01	0.02	31.0		
126	X	0.05	0.07	31.1		
127	X	0.03	0.03	14.0		
128	X	0.01	0.01	13.1		
129	X	0.05	0.07	20.0		
130	X	0.08	0.06	32.0		
131	X	0.1	0.09	46.3		
132	X	0.05	0.07	15.0		
133	X	0.05	0.04	3.0		
134	X	0.1	0.07	37.3		
135	X	0.05	0.03	36.0		
136	X	0.1	0.09	32.3		
137	X	0.03	0.02	27.0		
139	X	0.01	0	27.0		
145				0.5	BRAC Tap	
149	X	0.05	0.03	26.1		
150	X	0.1	0.05	18.6		
151	X	0.06	0.03	29.3		
152	X	0.1	0.05	31.2		
154	X	0.06	0.1	19.0		
156	X	0.04	0.03	9.8		
158	X	0.03	0.05	26.0		
159	X	0.05	0.08	25.0		
164	X	0.1	0.08	23.2		
166	X	0.05	0.04	25.0		
167	X	0.2	0.05	28.3		
168	X	0.1	0.05	34.0		
169	X	0.1	0.08	30.8		
171	X	0.15	0.04	33.4		
172	X	0.1	0.09	61.0		
174	X	0.1	0.04	29.0		

175	X	0.04	0.04	32.3		
176	X	0.04	0.05	22.0		
178	X	0.04	0.07	21.5		
179	X	0.1	0.01	32.0		
Sample No.		Merck Doubling Method Result	AAN Result	ITC Lab Result		
180	X	0.03	0.06	29.2		
181	X	0.02	0.04	20.5		
183	X	0.05	0.04	23.5		
184	X	0.05	0.02	22.4		
185	X	0.1	0.2	44.2		
186	X	0.05	0.01	15.0		
187	X	0.05	0.06	71.0		
188	X	0.05	0.03	20.2		
189	X	0.06	0.04	22.0		
192	X	0.04	0.01	16.4		
193	X	0.1	0.02	10.8		
195	X	0.05	0.02	15.4		
197	X	0.05	0.07	30.0		
198	X	0	0.02	11.4		
199	X	0.1	0.09	46.0		
200	X	0.02	0.03	14.9		
201	X	0.2	0.5	173.2		
202	X	0	0.01	22.5		
203	X	0	0.01	21.9		
204	X	0.05	0.09	15.9		
205	X	0.05	0.08	17.9		
207	X	0.2	0.5	103.5		
209	X	0.05	0.06	37.0		
210	X	0.04	0.02	12.9		
212	X	0.02	0.02	23.1		
213	X	0.04	0.01	12.9		
214	X	0.05	0.03	20.0		
215	X	0.04	0.01	66.0		
217				11.5	BRAC Tap	
220	X	0.05	0.01	20.6		
222	X	0.1	0.05	148.4		
223	X	0.06	0.06	50.0		
224	X	0.1	0.08	73.5		
228	X	0.2	0.09	53.1		
229	X	0.06	0.02	32.7		
230	X	0.04	0.01	31.9		
231	X	0.02	0.01	35.5		
236	X	0.05	0.03	74.3		
237	X	0.05	0.03	109.9		
238	X	0.04	0.06	30.8		
239	X	0.05	0.07	35.4		
240	X	0.05	0	10.8		

241	X	0.04	0.01	43.3		
251	X	0.02	0.09	40.9		
252	X	0.08	0.04	46.6		
253	X	0.08	0.08	43.7		
254	X	0.1	0.3	79.0		
255	X	0.05	0.06	118.4		
Sample No.		Merck Doubling Method Result	AAN Result	ITC Lab Result		
257	X	0.03	0.04	44.3		
259	X	0.1	0.01	76.6		
260	X	0.02	0.03	59.5		
264	X	0.04	0.01	38.6		
265	X	0.04	0	22.9		
266	X	0.05	0.03	30.5		
267	X	0.05	0.08	49.2		
268	X	0.1	0.2	69.2		
269	X	0.1	0.09	113.4		
270	X	0.05	0.04	171.2		
273	X	0.03	0.02	34.3		
274	X	0.02	0	42.7		
275	X	0.04	0.02	29.6		
276	X	0.02	0.04	8.3		
277	X	0.01	0.04	32.5		
288	X	0.05	0.05	20.0		
289	X	0.04	0.04	44.9		
290	X	0.02	0.03	17.3		
292	X	0.02	0.03	29.7		
293	X	0.02	0.02	20.0		
294	X	0.04	0.01	204.3		
295	X	0.05	0.05	222.1		
297	X	0.05	0.02	60.3		
298	X	0.2	0.09	482.7		
299	X	0.01	0.01	36.0		
300	X	0.02	0.06	29.7		
301	X	0.05	0.04	66.1		
302	X	0.02	0.06	31.2		
304	X	0.02	0.09	20.0		
305	X	0.05	0.03	16.0		
306	X	0.05	0.05	30.2		
307	X	0.02	0.03	46.0		
308	X	0.05	0.05	35.0		
309	X	0.06	0.05	28.8		
310	X	0.02	0.03	46.0		
313	X	0.07	0.04	55.0		
314	X	0.02	0.02	13.5		
316	X	0.07	0.07	42.0		
317	X	0.03	0.05	3.2		
318	X	0.05	0.04	32.0		

321	X	0.1	0.07	26.7		
322	X	0.01	0.04	45.0		
324	X	0.04	0.03	36.0		
326	X	0.05	0.06	48.1		
327	X	0.04	0.02	30.7		
328	X	0.04	0.03	40.1		
329	X	0.02	0.01	40.1		
331	X	0.02	0.05	22.4		
Sample No.		Merck Doubling Method Result	AAN Result	ITC Lab Result		
333	X	0.02	0.02	33.3		
334	X	0.2	0.02	52.8		
335	X	0.04	0.02	45.4		
336	X	0.04	0.04	34.0		
337	X	0.01	0.01	11.0		
338	X	0.04	0.01	41.3		
339	X	0.01	0.02	30.2		
341	X	0.03	0.01	39.2		
347	X	0.04	0.02	47.5		
348	X	0.1	0.01	69.4		
349	X	0.03	0.04	234.2		
350	X	0.02	0.02	23.3		
351	X	0	0.05	19.3		
353	X	0.1	0.09	60.0		
354	X	0.06	0.06	44.7		
357	X	0.02	0.01	10.3		
358	X	0	0.01	39.7		
359	X	0.01	0.01	12.4		
360	X	0.08	0.06	25.3		
361	X	0.05	0.1	63.0		
384				0.0	BRAC Tap	
401	X	0.05	0.02	10.0		
403	X	0.05	0.03	32.6		
404	X	0.05	0.01	10.5		
405	X	0.05	0.02	183.3		
406	X	0.05	0.03	10.2		
407	X	0.01	0.02	24.1		
408	X	0.1	0	34.0		
409	X	0.04	0.04	32.2		
410	X	0.05	0.01	29.0		
411	X	0.2	0.06	27.6		
412	X	0.05	0.05	41.0		
415		0.03		47.0	?extra	
417	X	0.04	0.04	38.9		
418	X	0.04	0.3	39.0		
419	X	0.02	0.02	33.4		
420	X	0.02	0.03	32.0		
421				10.7	BRAC Tap	

422	X	0.03	0.02	32.0		
423	X	0.05	0.02	36.0		
424	X	0	0.02	20.0		
425	X	0.01	0.01	38.0		
428	X	0.05	0.05	26.0		
429	X	0.05	0.01	53.0		
430	X	0.05	0.09	19.0		
431	X	0.07	0.3	11.0		
432	X	0.04	0.3	52.1		
433	X	0.05	0.1	59.2		
Sample No.		Merck Doubling Method Result	AAN Result	ITC Lab Result		
445				26.7	?extra	
451	X	0.05	0.03	27.0		
453	X	0.06	0.03	44.7		
454	X	0.02	0.03	31.0		
455	X	0.01	0.02	10.6		
460	X	0.1	0.06	13.0		
462	X	0.1	0.07	41.4		
466	X	0	0.02	9.8		
470	X	0	0.01	27.4		
472	X	0.02	0.03	46.0		
474	X	0.05	0.04	30.4		
475	X	0.05	0.08	43.0		
476	X	0.05	0.2	12.1		
477	X	0.2	0.3	27.0		

Annex 4

Results of blank and duplicate testing in laboratory

1. Blanks included in 255 samples analysed to assess the effectiveness of the Merck Doubling Method and the AAN Method. Analysis was conducted during October/November 1999 by Intronics Technology Centre.

Sample No.	Composition	As (ppb) Expected Result	As. (ppb) Actual Result
1	De-ionised water	0	0
71	BRAC treated tap water	0	0
94	De-ionised water (acidified)	?	6.9
145	BRAC treated tap water	0	0.5
217	BRAC treated tap water	0	11.5
384	BRAC treated tap water	0	0
421	BRAC treated tap water	0	10.7

2. Blanks included 51 samples submitted to assess effectiveness of Merck field kit at determining 0ppb. Analysis conducted in February 2000 by Intronics Technology Centre.

Sample No.	Composition	As (ppb) Expected Result	As. (ppb) Actual Result
1	BRAC treated tap water (acidified)	?	1
3	BRAC treated tap water	0	BDL
12	BRAC treated tap water (acidified)	?	1
31	BRAC treated tap water	0	1
32	BRAC treated tap water (acidified)	?	1
33	BRAC treated tap water	0	BDL

BDL = Below Detection Limit

3. Duplicates included in 51 samples submitted to assess effectiveness of Merck field kit at determining 0ppb. Analysis conducted in February 2000 by Intronics Technology Centre.

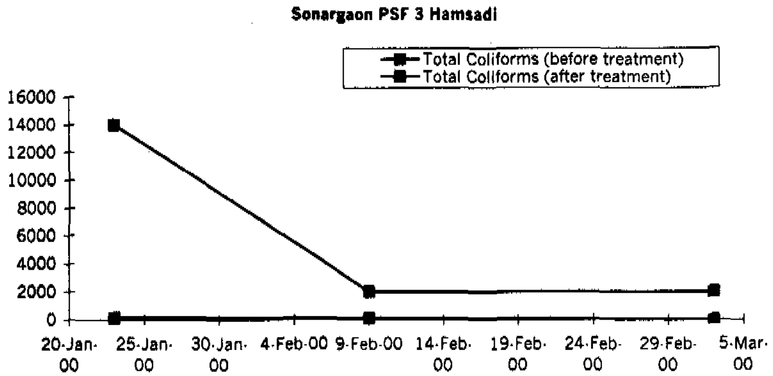
Sample Number	As. (ppb)	Duplicate Number	As. (ppb)
9	10	10	9
13	20	14	18

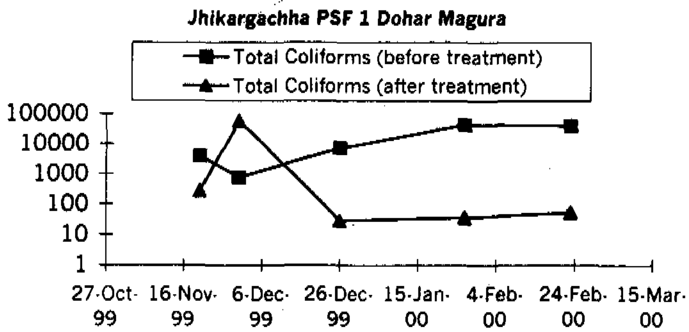
4. Blanks included with samples for analysis for Aluminium from Pond Sand Filter using alum and coagulation and settling tank at Shatbaipara, Sonargaon.

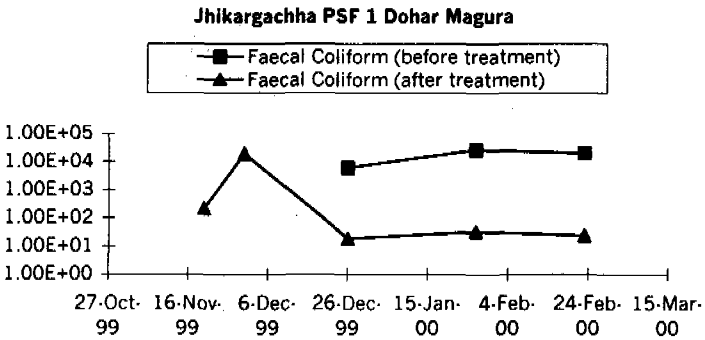
Sample No.	Composition	Al. (ppm) Expected Result	Al. (ppm) Actual Result
A5	BRAC treated tap water	0	<2
A6	BRAC treated tap water	0	<2

Annex 5

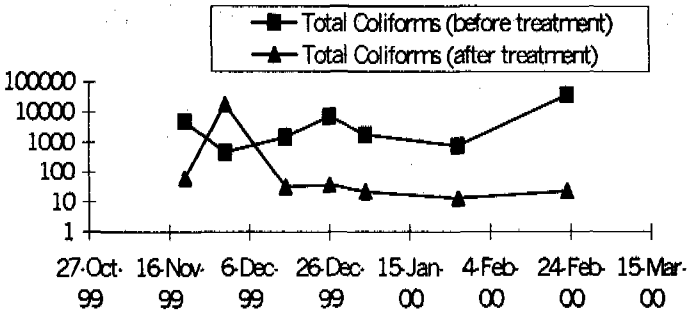
Results of monitoring of Pond Sand Filters

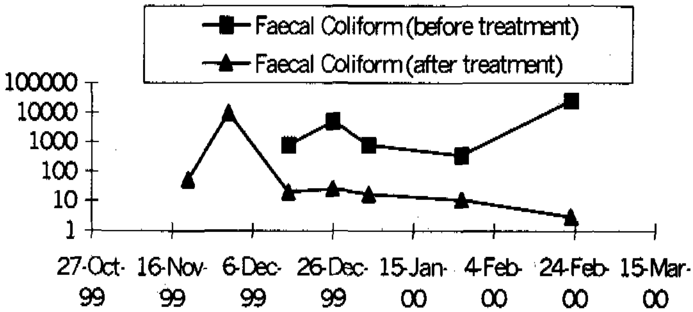




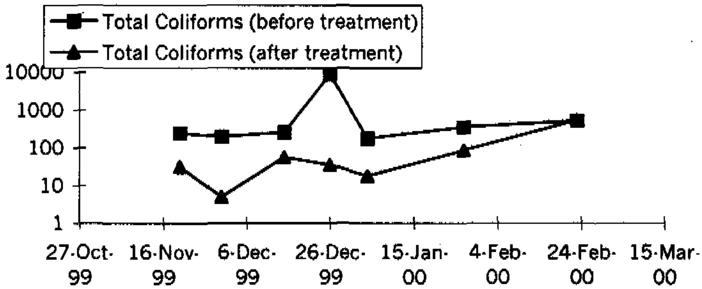


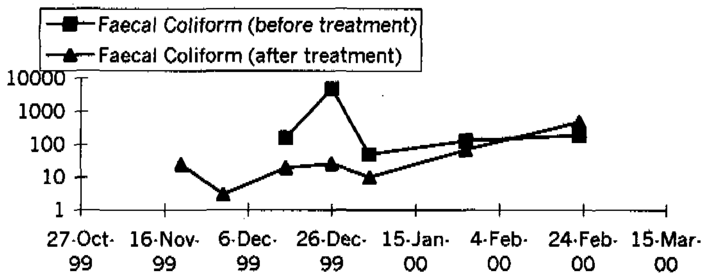
Jhikargachha PSF 2 Sagarpur



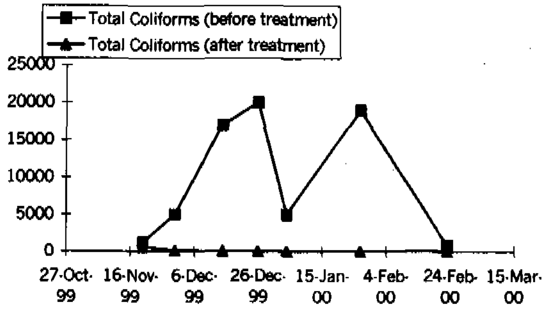


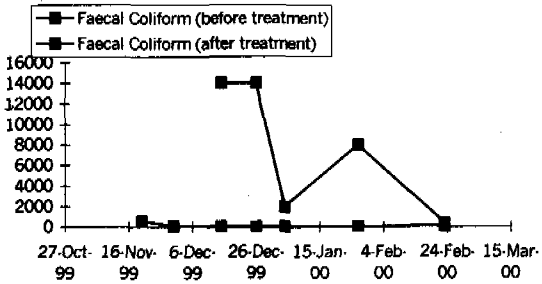
Jhikargachha PSF 3 Padmapukur



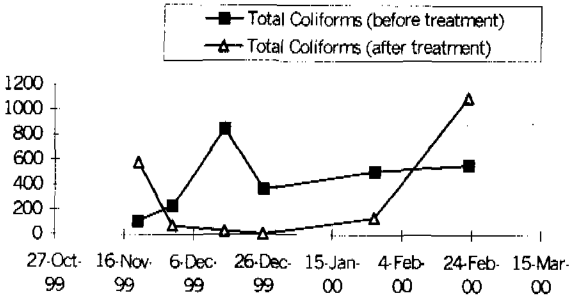


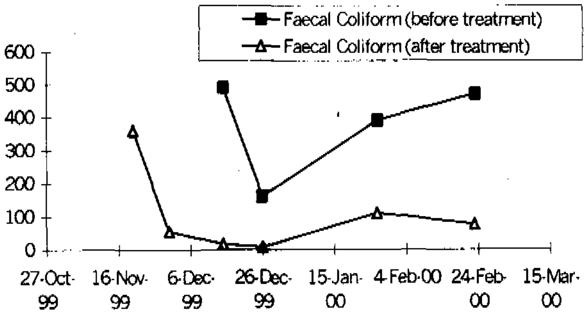
Jhikargachha PSF 5 Alipur



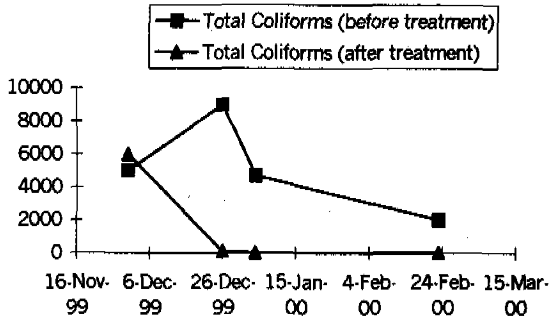


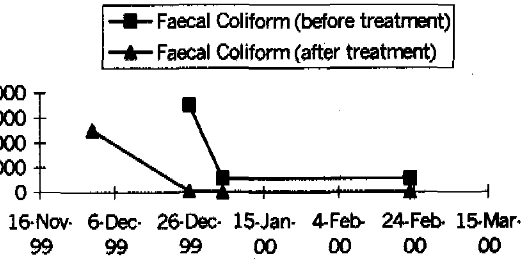
Jhikargachha PSF 6 Bishnapur



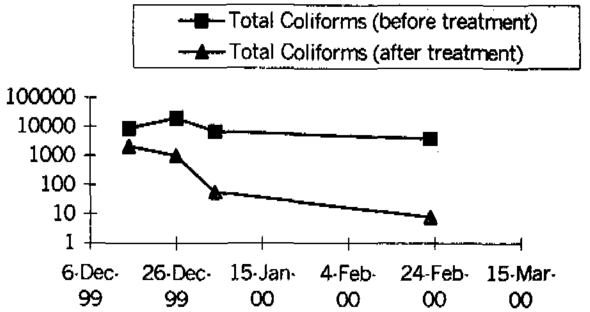


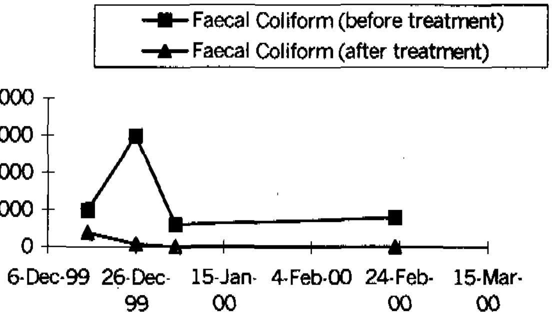
Jhikargachha PSF 7 Balla



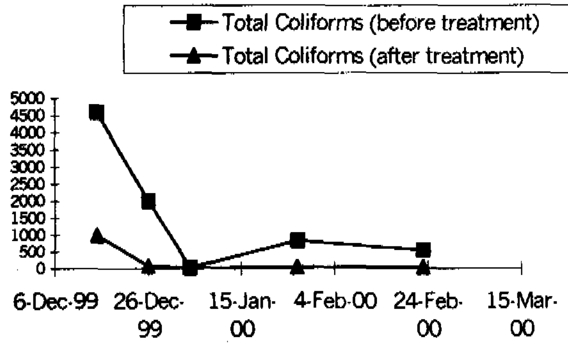


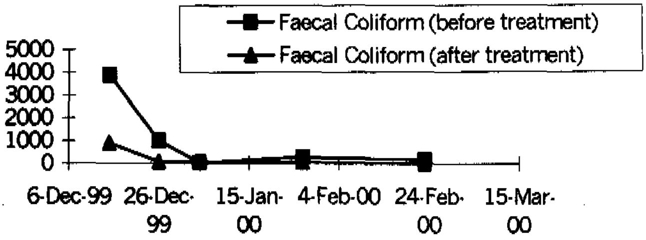
Jhikargachha PSF 8 Raipatan



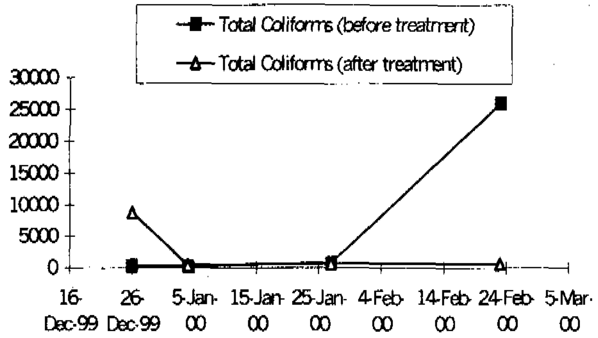


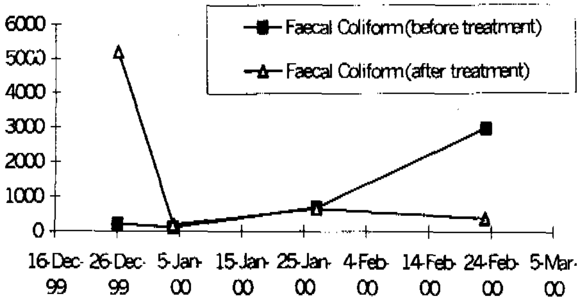
Jhikargachha PSF 9 Haridrapota



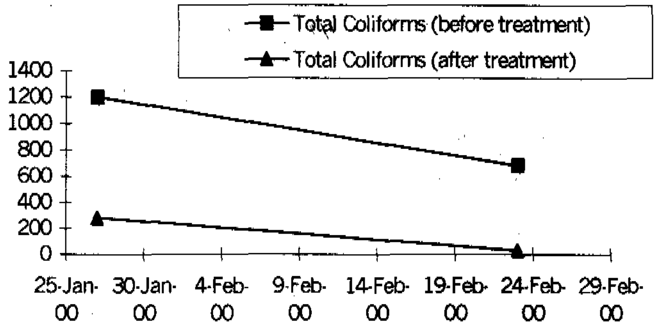


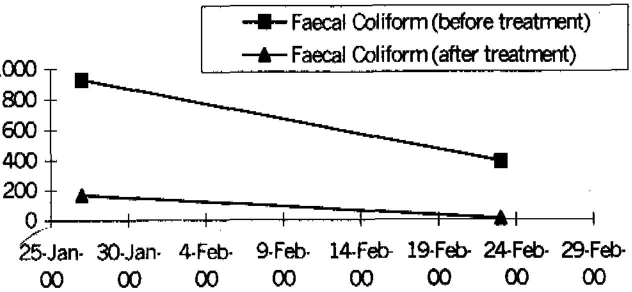
Jhikargachha PSF 10 Bokuli



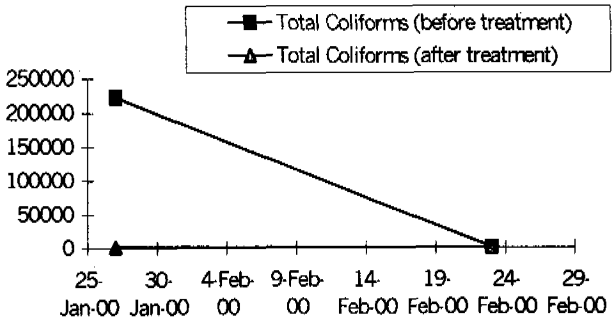


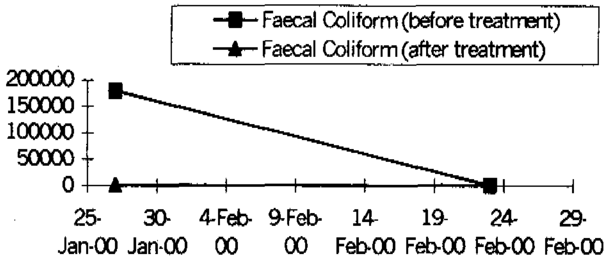
Jhikargachha PSF 11 Mattsia

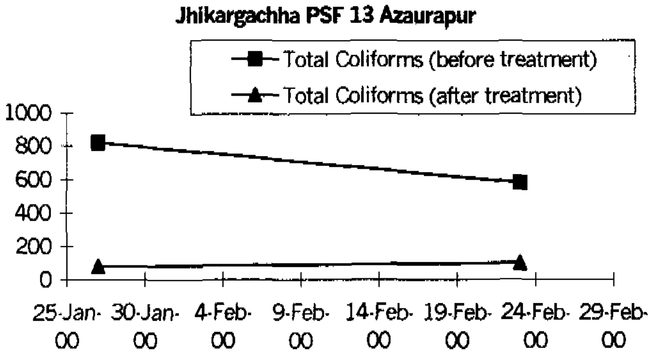


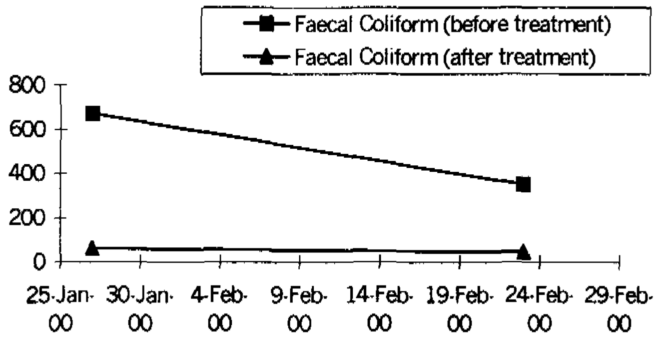


Jhikargachha PSF 12 Makindapur






Jhikargachha PSF 13 Azaurapur
Total Coliforms (before treatment)
Total Coliforms (after treatment)
1000
800
600
400
200
0
25-Jan-00
30-Jan-00
4-Feb-00
9-Feb-00
14-Feb-00
19-Feb-00
24-Feb-00
29-Feb-00


Faecal Coliform (before treatment)
Faecal Coliform (after treatment)
800
600
400
200
0
25-Jan-00
30-Jan-00
4-Feb-00
9-Feb-00
14-Feb-00
19-Feb-00
24-Feb-00
29-Feb-00

Annex 6

Resolution of a monthly field co-ordination meeting

RDP 02-01-00

অদ্য ০২-০১-২০০০ ইং তারিখে মাসিক পর্যালোচনা সভা বেলা ৩.০০ ঘটিকায় ব্র্যাক RDP কার্যালয়ে শুরু হয়।

বিষয়বস্তু আর্সেনিক মিটিগেশন প্রকল্পের বিভিন্ন option সম্পর্কে আলোচনা।

নিম্নে উল্লেখিত ব্যক্তি বর্গ অদ্যকার সভায় উপস্থিত ছিলেন।

নাম	স্বাক্ষর
১) জনাব গোলাম রাব্বানী জনস্বাস্থ্য প্রকৌশলী ঝিকরগাছা, যশোর।	
২) জনাব জাবেদ হোসেন আর্সেনিক প্রকল্প কোঅর্ডিনেটর	02.01.00
৩) জনাব মোঃ আলমগীর হায়াত খাঁন আর্সেনিক প্রকল্প (সুপারভাইজার)	02 01. 2000
৪) জনাব মোঃ রফিকুল ইসলাম (সবুজ) আর্সেনিক প্রকল্প (সুপারভাইজার)	02.01.00
৫) জনাব মোঃ মতিয়ার রহমান আর্সেনিক প্রকল্প (সুপারভাইজার)	02.01.2000

আলোচ্য বিষয় সমূহ :—

① আর্সেনিক রোগী সম্পর্কে আলোচনা।
রোগীর সংখ্যা — ১০৯জন

② PSF কোথায় কোথায় হয়েছে এবং সামনে কোথায় হবে। বিস্তারিত আলোচনা করা হয়েছে।
মোট ২৬টি PSF স্থাপন হয়েছে বিভিন্ন গ্রামে।

③ ইদারা কতগুলি সমাপ্ত হয়েছে।
ইদারা মোট ৪টি সমাপ্ত হয়েছে

④ PSF এর কোন সমস্যা দেখা দিলে, জনস্বাস্থ্য প্রকৌশলীর সাথে যোগাযোগ করতে হবে PSF এর কমিটিকে।

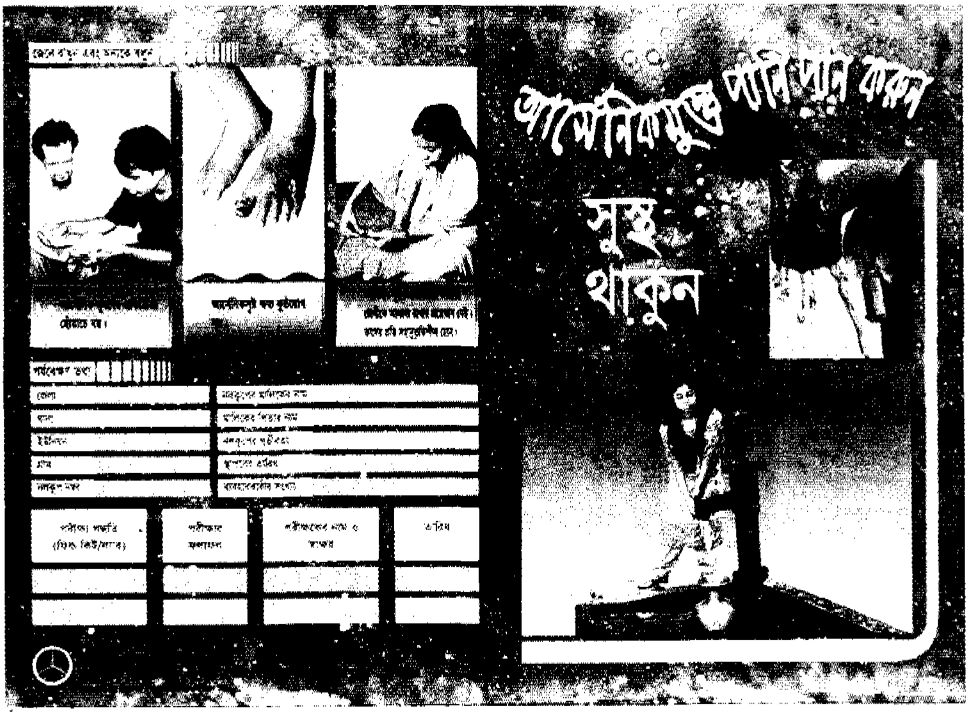
⑤ মাহমুদপুর ও সোনাকোড় এ দুইটি কোয়া সংস্কার করতে হবে, জনস্বাস্থ্য প্রকৌশলীর আবেদন এবং তা সাথে সাথে কর্ম রোপে পাস হয়ে যায়। এবং ইহাদের পরে কাজ শুরু হবে।

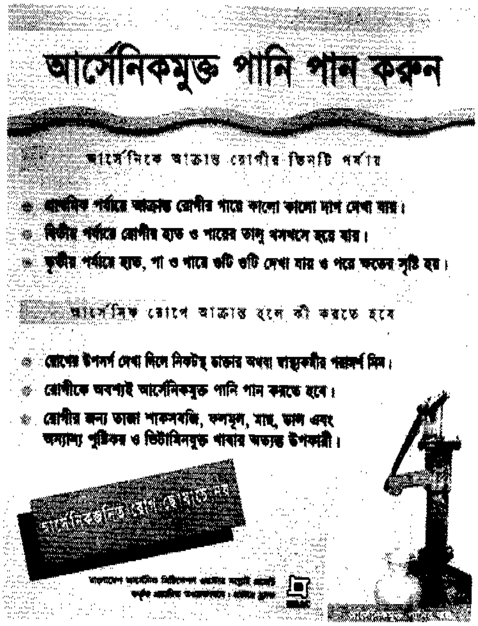
সর্বশেষে অদ্যকার সভার সভাপতি জনাব গোলাম রাব্বানী সাহেব (জনস্বাস্থ্য প্রকৌশলী) ঝিকরগাছা আর্সেনিক মিটিগেশন প্রকল্পের অগ্রগতি সম্পর্কে বিস্তারিত আলোচনা পর্যালোচনা অন্তে সভা সমাপ্তি ঘোষণা করেন।

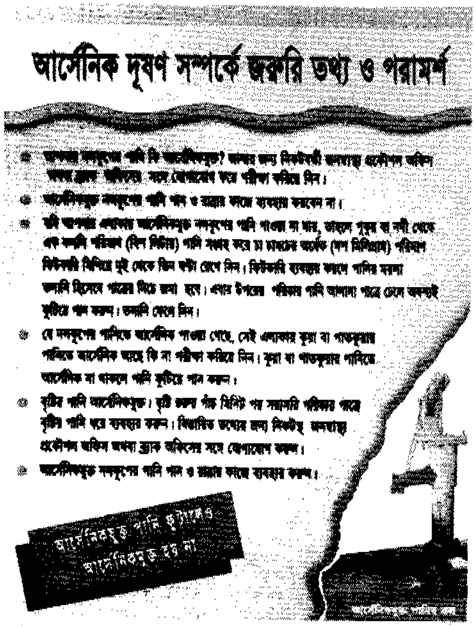
— x —

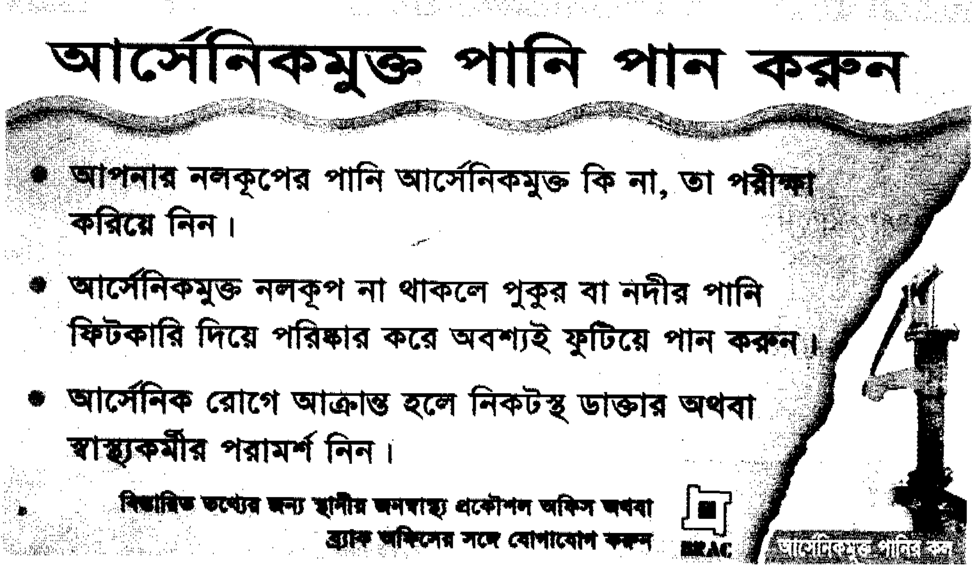
Annex 7

Communication materials used for awareness development




আর্সেনিকমুক্ত পানি পান করুন
আর্সেনিকে আক্রান্ত রোগীর তিনটি পর্যায়
প্রাথমিক পর্যায়ে আক্রান্ত রোগীর গায়ে কালো কালো দাগ দেখা যায়।
দ্বিতীয় পর্যায়ে রোগীর হাত ও পায়ের তালু খসখসে হয়ে যায়।
তৃতীয় পর্যায়ে হাত, পা ও গায়ে গুটি গুটি দেখা যায় ও পরে ক্ষতের সৃষ্টি হয়।
আর্সেনিক রোগে আক্রান্ত হলে কী করতে হবে
রোগের উপসর্গ দেখা দিলে নিকটস্থ ডাক্তার অথবা স্বাস্থ্যকর্মীর পরামর্শ নিন।
রোগীকে অবশ্যই আর্সেনিকমুক্ত পানি পান করতে হবে।
রোগীর জন্য তাজা শাকসবজি, ফলমূল, মাছ, ডাল এবং অন্যান্য পুষ্টিকর ও ভিটামিনযুক্ত খাবার অত্যন্ত উপকারী।


আর্সেনিক দূষণ সম্পর্কে জরুরি তথ্য ও পরামর্শ


আর্সেনিকমুক্ত পানি পান করুন
আপনার নলকূপের পানি আর্সেনিকমুক্ত কি না, তা পরীক্ষা করিয়ে নিন।
আর্সেনিকমুক্ত নলকূপ না থাকলে পুকুর বা নদীর পানি ফিটকারি দিয়ে পরিষ্কার করে অবশ্যই ফুটিয়ে পান করুন।
আর্সেনিক রোগে আক্রান্ত হলে নিকটস্থ ডাক্তার অথবা স্বাস্থ্যকর্মীর পরামর্শ নিন।
বিস্তারিত তথ্যের জন্য স্থানীয় জনস্বাস্থ্য প্রকৌশল অফিস অথবা ব্র্যাক অফিসের সঙ্গে যোগাযোগ করুন
BRAC

Annex 8

Weekly monitoring results of rain water harvester in Sonargaon

Location of RWHs	Date of Sample Collection	Total Coliform Bacteria (cfu/100ml)				
		June 1999	July 1999	August 1999	September 1999	November 1999
DIGHICHANDPUR	1st week	270	10	0	-	-
	2nd week	0	-	0	-	-
	3rd week	0	36	0	0	-
	4th week	10	0	-	-	-
HARIA	1st week	130	0	-	-	0
	2nd week	-	0	-	-	-
	3rd week	0	1200	0	0	-
	4th week	0	0	0	-	-
KHONGSADI	1st week	540	130	0	-	-
	2nd week	0	4	-	-	-
	3rd week	70	0	0	0	-
	4th week	130	0	-	-	-
RAMGANJ	1st week	120	-	-	-	0
	2nd week	0	0	-	-	-
	3rd week	0	100	0	-	-
	4th week	-	0	0	-	-
HAMSADI	1st week	30	5	0	-	0
	2nd week	0	0	0	-	-
	3rd week	0	32	0	0	-
	4th week	50	4	0	-	-
BASANDARDI	1st week	-	6	0	-	0
	2nd week	-	0	0	-	-
	3rd week	0	0	0	0	-
	4th week	60	0	0	-	-
MOBARAKPUR	1st week	-	175	0	-	-
	2nd week	-	27	0	-	-
	3rd week	-	1000	0	0	0
	4th week	175	0	0	-	-
KHAMARGAON	1st week	-	0	0	-	0
	2nd week	-	-	2	-	-
	3rd week	-	4	0	0	-
	4th week	-	0	0	-	-

[Continued]....

SARKERBARI	1st week	-	9	0	-	-
	2nd week	-	-	0	-	-
	3rd week	-	0	0	-	-
	4th week	90	0	0	-	-
TECPARA	1st week	-	-	0	-	0
	2nd week	-	-	2	-	-
	3rd week	-	-	0	0	-
	4th week	-	0	0	-	-

Note: '-' indicates tests not done.

Annex 9

Newspaper clippings of BRAC activities on arsenic mitigation


আর্সেনিকের বিরুদ্ধে একটি মানবিক আয়োজন

গদখালাতে আর্সেনিক পরীক্ষার কাজ সম্পন্ন

বিকল্প ব্যবস্থা না থাকায় মানুষ জেনে-বুঝেই বিষাক্ত পানি খাচ্ছে

লোকসমাজ

আর্সেনিকে আক্রান্ত গদখালীর সালাম মোল্যার পরিবারের একমাত্র ভরসা ব্র্যাক

UNICEF launches projects for safe drinking water

বিভিন্ন রোগে আক্রান্ত ব্যক্তিদের আর্সেনিকে আক্রান্ত রোগী হিসেবে দেখানো হচ্ছে