# Searching for a sustainable arsenic mitigation strategy in Bangladesh: experience from two upazilas

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**Abstract:** Arsenic concentrations of tubewell water that exceed the Bangladesh Drinking Water Standard pose a serious health problem for millions of people in Bangladesh. Groundwater is the source of drinking water for 98% of the population. The main object of the study was to review the status of the provided options, which were distributed during 1999–2001 in two upazilas. It was observed that acceptability of the distributed options was not encouraging; less than 2% of the provided options were found to be in operation. However, two new approaches emerged from people's initiatives, which are making rapid and positive contributions to safe water coverage.

**Keywords:** sustainable arsenic mitigation; groundwater; alternative safe water option; people's initiatives; reinstallation of tubewell; Bangladesh.

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## 1 Introduction

In 1993, the presence of arsenic, above the limits of Bangladesh Drinking Water Standard (BDWS, 50 μg/L), was detected in the groundwater of the Bengal Delta Plain (BDP) aquifers in Bangladesh (Ahmed et. al., 2004; Bhattacharya et al., 2002, 2004; Nickson et al., 2000; Smedley and Kinniburgh, 2002; WHO, 2001; BGS/DPHE, 2001). Since groundwater is the main source of potable water for nearly 98% of the population, this resulted in a severe environmental disaster, affecting several million people in the region (Unicef, 2003). The number of tubewells present today is estimated between 8–10 million whereas it was only about 50,000 during the British colonial rule (Black, 1990). The recent discovery of arsenic in groundwater in Bangladesh has destroyed this decade-long success, and the access to safe drinking water has now dropped to almost 80% (WHO, 2001).

Arsenic is a naturally occurring poisonous – colourless, tasteless and odourless metalloid – and is widely distributed in the sediments as a component of different minerals. It occurs in Bangladesh in the naturally occurring sediments at shallower depths (usually at 15–50 m). Generally shallow tubewell water is found to be highly contaminated.

Several factors have been assumed to have caused the substantial input of arsenic in the aquatic environment of Bangladesh (BGS/MML, 1999). The current consensus is that the cause of widespread arsenic contamination in the groundwater of the Bengal Delta Plain (BDP) is geogenic. Arsenic is released in groundwater from the sediments deposited during the Holocene period (Bhattacharya et al., 1998, 1999; BGS/MML, 1999).

Though the cause of the widespread occurrence of arsenic in groundwater of the BDP is a matter of debate, the most widely accepted theory suggests that mobilisation of arsenic from the alluvial aquifers of the BDP groundwater is primarily due to the mechanism of reductive dissolution of the Fe-oxyhydroxides in the sediments (Bhattacharya et al., 1996, 1997; Nickson et al., 1998; BGS/MML, 1999). Pyrite oxidaion was advocated as a mechanism of the release of arsenic in the groundwater of the BDP (Das et al., 1996; Chowdhury et al., 1999). However, evidences based on the groundwater chemistry, indicate that arsenic is mobilised in the alluvial aquifers under reducing environment, where secondary pyrites are found to be stable. Thus, mobilisation of arsenic is primarily caused due to the reductive dissolution of the iron oxyhydroxides within the sediments, rather than due to oxidation of pyrite, as hypothesised by other workers.

The toxic properties of arsenic have been known for centuries. The symptoms of acute intoxication by arsenic have been reported in many countries, including Argentina, Bolivia, Chile, Taiwan, India, Bangladesh, and others (Borgoño et al., 1977; Mazumder et al., 1988, 1992). Long-term exposure to high levels of arsenic leads to public health problems including melanosis, leuko-melanosis, hyperkeratosis, black foot disease, cardiovascular disease, hepatomegaly, neuropathy and cancer. Arsenic accumulates in the liver, kidneys, heart, and lungs. It is also deposited in bones, teeth and hair (Khan, 1997). There is no known treatment available for arsenic related disease; so, drinking arsenic free water is the only way to avoid arsenic poisoning (Smith et al., 2000; Jakariya et al., 2003b). About 35 million people living in 59 out of 64 districts are at potential risk of arsenic poisoning in Bangladesh (Akmam and Higano, 2002; WHO, 2002).

Seeking to mitigate the deadly menace of arsenic poisoning in Bangladesh, Sonargaon and Jhikargachha were the first two focus upazilas in Bangladesh where all available alternative safe water options were provided to the arsenic exposed people. The project was started in late 1999 and was completed in mid 2001. During this project period, more than half a million US dollars were spent to distribute 10,905 alternative safe water options in these two upazilas (BRAC, 2000). Before distributing these options, various motivational and training activities were used to increase awareness, including organising village meetings, staging popular theatre, forming different users' groups on mitigation options, and showing videos on arsenic. In spite of doing all these promotional activities, safe water coverage did not increase during the second phase of project implementation. Therefore, the main objective of this paper was to assess the current status of the provided options and to make specific recommendations for sustainable future promotion and distribution of alternative safe water options.

## 2 Materials and methods

The total populations of Sonargaon and Jhikargachha were 261,881 and 235,607 respectively, living in 368 and 163 villages respectively. Sonargaon is a low-lying area, which experiences flooding every year; in contrast Jhikargachha experiences relatively low rainfall and is flood free.

The project activities included:

- the determination of the extent of arsenic contamination in the water in all the tubewells of the project area
- involvement of villagers in choosing, implementing and maintaining alternative sources for safe drinking water
- determination of the viability and effectiveness of different mitigation options and assessment of their relative acceptance by villagers
- identification of arsenic-affected patients and provision of necessary treatment
- making the community aware of arsenic poisoning.

The Merck field-kit was used to test all the tubewell water of the two upazilas before distribution of alternative water options. Wells with arsenic levels >50 μg/L were painted red to indicate that the water is unsafe for drinking, and those with levels <50 μg/L were painted green to indicate that the water is safe. Tubewells were purged adequately (20/30 strokes) prior to testing and collecting of water sample for laboratory analysis. One Merck field kit is capable of performing ca. 80 tests and costs around $50, implying an approximate unit cost of $0.63 per test.

The Merck kit uses a semi-quantitative colorimetric method. Arsenate and arsenite present in the water are chemically converted to arsine gas, which then colours a mercury bromide impregnated test paper. The colour change indicates the amount of arsenic present in the water sample. About 2% of the tested tubewell water was re-tested with an atomic absorption spectrophotometer to validate the field-kit results.

The project period was divided into two phases. During the first phase of the project (i.e., July 1999 to June 2000), different alternative safe water options were demonstrated and distributed among the exposed villagers. These options were distributed free of cost to assess the efficacy of these options. Villagers were not consulted for selection of options; rather, they were consulted at the time of installation of these units to select sites for such installation. Only the options preferred by the villagers during the first phase were offered in the second phase.

All provided options were revisited in March 2004 to assess their performance and their preference by users, using Focus Group Discussion (FGD). Information regarding sharing of existing green-marked tubewells and the present coverage of safe water options were also collected using the same FGD technique.

## 3 Results and discussions

### *3.1 Results of tubewell testing*

Village health workers (VHWs) tested a total of 25,048 tubewells in Sonargaon upazila and 26,637 in Jhikargachha upazila. The work in the two upazilas was done simultaneously and it took about 50 days to complete testing and painting of tubewell spouts. According to the test results 62% of the wells in Sonargaon and 48% of those in Jhikargachha were contaminated with arsenic levels that are above the Bangladesh Drinking Water Standard, i.e., 50 μg/L.

### *3.2 Safe water options*

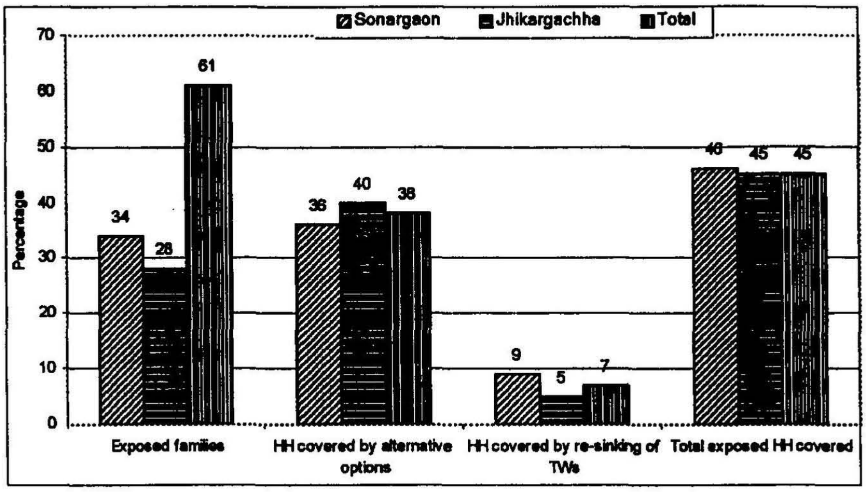
Three potential sources of arsenic-free drinking water were identified, namely, (i) treated surface water, (ii) rainwater and (iii) alternative groundwater. Later, different options using these sources were identified and implemented. The options installed were assessed on several criteria and continuously monitored during the whole project period. A description of each of these options is presented in the Appendix.

## 4 Safe water coverage

### *4.1 Safe water coverage by different alternative safe water options*

As shown in Figure 1, the percentage of families covered by the above mentioned safe water options was almost identical in both the upazilas. At the end of the second phase, it was observed that the safe water coverage reached 38%, including 25% of exposed families covered in the first phase.

**Figure 1** Safe water coverage, provided by different options, at the end of the project period




At the end of the first phase it was observed that local drillers (masons) started motivating relatively well-off villagers to re-sink their existing tubewells or to install new wells within a depth range of 50–100 metres (m) to get arsenic-free water which is easier and less expensive than installing deep tubewells. *Consequently, re-sinking/reinstalling tubewells emerged as another alternative safe water option.*

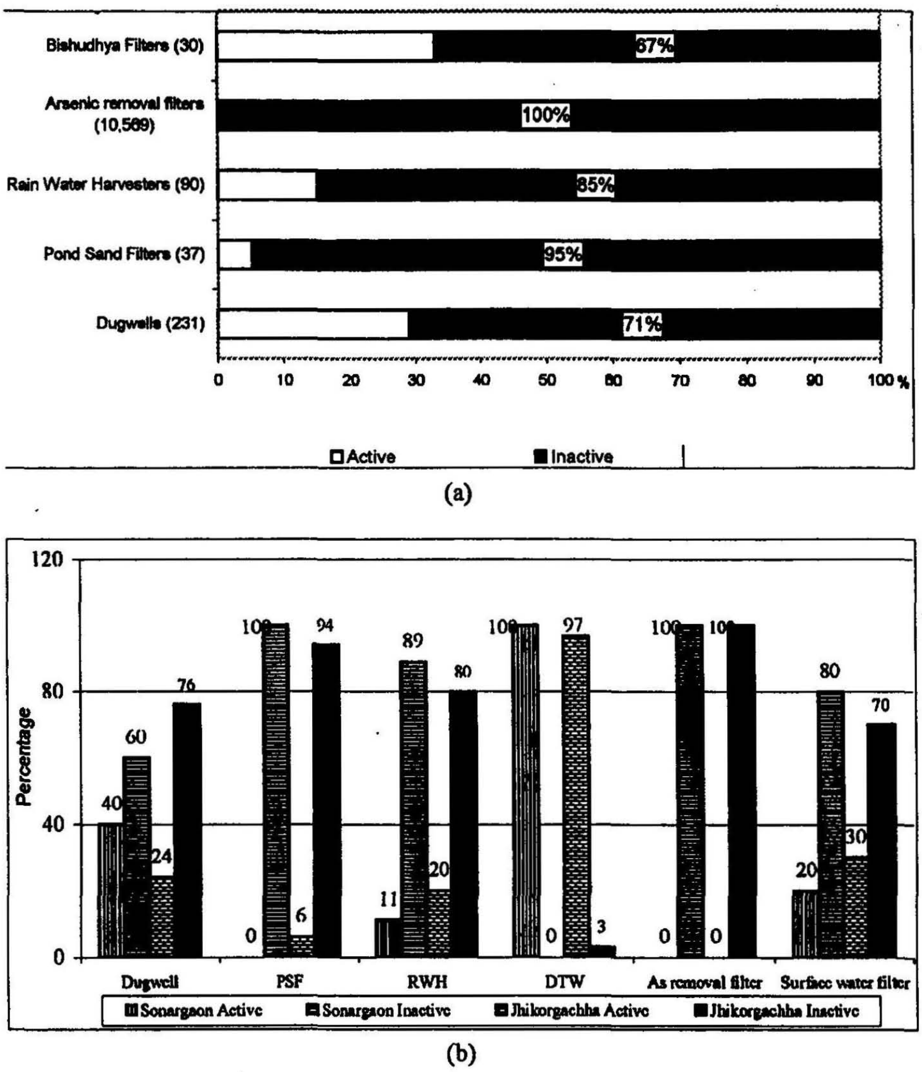
It has been observed that the masons have the pre-requisite knowledge about safe depth of the villages where they have been installing shallow tubewells for a long time. According to masons, the 'safe depth' varies from village to village. It costs US$ 80–100 to install tubewells within this depth range, whereas about US$ 600–650 is needed to install a deep tubewell at a depth below 200 m. It was found that about 34% of the total red-marked tubewell owners followed the mason's advice. Based on the masons' indigenous knowledge, visual inspection of sediment colours and types indicated that this technique was successful (in terms of targeting arsenic-safe aquifers) for about 75% of the tubewells that were re-installed during the project period. This indigenous coping mechanism has received popularity among the relatively well-off villagers in the absence of any better alternative to tubewell options.

At the end of the project period it was observed that about 45% of the total exposed population was brought under safe water coverage (Figure 1).

## 5 Present status of safe water coverage

Upon completion of the project in May 2001, the distributed options were not monitored closely, with the expectation that the villagers would be able to maintain their own system properly, since enough information and training was provided to the users for sustainable use of these options. However, the present status of the provided options was not encouraging. On an average, less than 2% of the provided options were found to be in operation in both upazilas (Figure 2(a)). The detailed reasons of inoperability of these options are presented in Table 1.

**Figure 2** (a) Averages for functional sites for different options in the study (arsenic removal filters includes safi filter, 3-pitcher filter, Alcan filters) and (b) segregated data on functional sites for the different options in the study




Among all the 'provided' options, the *Three-Pitcher Filters* showed promise at the beginning. However, the acceptance dropped at the end due to clogging of iron chips, which almost stops water flow altogether.

**Table 1** Problems encountered by users of different alternative safe water options

| *Option* | *Water source* | *Major disadvantages* |
|---|---|---|
| PSF | Surface | Many ponds used for fish-culture with use of poison to kill predator fishes |
| | | High initial load of bacteria in pond waters |
| | | Acceptability not universal |
| RWH | Rainwater | Rains not uniformly abundant in all areas |
| | | There is little or no rain in dry season |
| | | Prohibitive cost for poor households |
| Arsenic removal filters | Arsenic-contaminated groundwater | Effectiveness in removing arsenic questionable |
| | | Unaffordable |
| | | Disposal of sludge is environmentally problematic |
| | | Expensive and thus less sustainable on a long-term basis particularly, for poorer households |
| Dugwell | Sub-surface | Susceptible to bacteriological contamination |
| | | May dry up during winter |
| | | Presence of manganese, iron, and arsenic in some wells |
| Deep wells | Deep aquifer (200 m or more below the surface) | More expensive than tubewells |
| | | Some uncertainties as a long-term source for arsenic-free water |
| Piped water | Deep aquifer or treated surface water | Expensive for country-wide adoption |
| | | Requires organisation |

As the 'community-based' option for arsenic mitigation, the *Pond-Sand Filters (PSF)* initially generated great interest among people. Later, it was found that people were more interested in using the PSF-treated water for cooking rather than for drinking purposes. Also, it was a difficult challenge (in this option) to find ponds that were perennial, free from pisciculture, and protected from other domestic activities. One of the main challenges to this option (besides bacteriological contamination) was ensuring that owners did not recommence commercial fishing activities in the ponds provided for construction of PSF. It was found in both project areas that owners were in breach of their formal agreements with the users regarding recommencement of commercial fishing activities, and consequently, almost all the PSFs were not functioning. Since ponds are privately owned, users have little to say to change owner's decisions, in spite of having formal agreements with them.

Villagers, in general, were found to be less enthusiastic in using *Rainwater*. In Sonargaon, villagers used this option more than those in Jhikargachha. Dugwells had good potential in the arsenic-affected areas. However, the presence of iron, bacteria, manganese and arsenic in many of the dugwells made this option unsuitable, contrary to what was anticipated at the beginning of project implementation.

The newly introduced household-based and community-based *Activated Alumina Filters* (*Alcan filters*) were found to be technically sound but none of the users changed filter media when it was exhausted after two years of use. This option was not well accepted by the people mainly because of two practical reasons:

i media replacement cost

ii presence of excess iron (which was more than the WHO recommended value for iron, i.e., 1–3 μg/L) in raw water, which creates bad smell in the treated water.

It was also reported that the same is true for Safi and three-pitcher filters. Overall, all the arsenic removal filters were not well accepted by the villagers in spite of their technical competence (Hoque et al., 2003).

The acceptance of Bishuddhya Filters was found to be high among villagers who were living close to rivers/canals and who prefer to use surface water mainly because of the presence of iron in tubewell water. Similarly, villagers who were drinking from provided deep handset tubewells were found to be highly satisfied. In fact, they did not have to change their source of drinking water. Nevertheless, villagers also encountered problems with deep handset tubewells; sand boiling, and the presence of iron and occasional arsenic in the deeper aquifer – demand prior investigation of the groundwater chemistry and the geology of a particular area. The piped water system constructed in Sonargaon upazila targets the long-term sustainability of this option. Although the system was designed to cover all the 450 households of the village, only 150 households are presently connected. The key reasons for the reluctance of the remaining households to be connected with the system were primarily due to the requirement of initial down payment for connection, monthly bill, and more importantly availability of other safe water options.

## 6 Safe water coverage by people's own initiative

Owing to the strong awareness campaigns during the implementation of the study activities, almost all villagers realised the urgency for drinking arsenic safe water. Thus, the following two practices emerged on the people's initiative:

- preferred use of arsenic safe hand tubewells that were painted green (referred here as green marked tubewells) after examination by BRAC field personnel
- reinstalling tubewells to a depth below 50–100 m instead of the common practice to install at 20–30 m depth.

### *6.1 Preferred use of arsenic-safe hand tubewells*

Collection of water from green marked tubewells is considered to be a preferred option for drinking water by the rural population. Our study indicated that the percentage of such tubewells (i.e., green marked tubewells) in Sonargaon and Jhikargachha upazilas was 38% and 52%, respectively. It was observed during revisit that the number of users per green marked tubewell had increased by about 50% in both the study areas. In most of the cases, owners of green marked tubewells were willing to share water with neighbours. However, there were a few cases where owners were reluctant to share water with non-relatives or distant neighbours. Given the present nature of the safe water source crisis, the intensity of such types of conflicts might increase in the near future.

### 6.2 *Reinstalling tubewells to a depth below 50–100 m*

The tubewell reinstallation option promoted by local drillers was found to be popular among relatively affluent villagers. The percentage of such initiatives had increased from 10% in 2001 to about 35% in 2004, in both study areas where the alternative water options were located. Also, the success rate of targeting arsenic safe-aquifers by local drillers had increased marginally in this period. This practice is based on the indigenous knowledge of local drillers by looking at sediment colours (Table 2). The yellowish to reddish colour of the sediment reflects a fairly oxidised status of the aquifer, with an abundance of Fe-oxides. The groundwater abstracted from these sediments has lower arsenic concentrations (<50 μg/L).

**Table 2** Litholog at a borehole site in one of the study areas as described by the local drillers. The description of the sediments and their colour is given as perceived by the drillers and thus might not be consistent with a scientific interpretation

| *Depth* (ft) | *Sediments* | *Colour* | *Comment* |
|---|---|---|---|
| 0–60 | – | – | – |
| –100 | Sand | – | High Fe, 'no good water'[1] |
| –130 | Silt | – | – |
| –150 | Silt | Red/yellow | No water |
| –200 | Fine sand | Red/yellow | No Fe, 'good water'[2] |
| –300 | Sand | White | High Fe, 'no good water' |
| –<600 | – | – | High Fe and 'bitter taste' |

[1]The tubewells used to install at 60–90 ft.

[2]Masons are proposing for this depth to avoid arsenic and iron, as well.

It was observed that the perception of the sediment colour concept varies with the local drillers and hence needs a unified approach for sustainable application.

## 7 Discussions and conclusion

Supply of safe drinking water remains the most crucial issue in the whole arsenic mitigation programme. Provision of safe drinking water reduced the risk of health hazards and disease caused by drinking arsenic-contaminated water (Jakariya et al., 2003a; Smith et al., 2000). Providing or arranging for alternative safe water for the millions of rural poor is not an easy task. It took more than two decades to bring this huge population under the tubewell water source from the pathogen load surface water sources. In early 1999, this project started with the main objective of providing safe water to the arsenic-exposed population. All the possible and available options that were provided to that end were assessed in this study with respect to their effectiveness in replacing the contaminated tubewells.

These options were assessed on the following criteria:

- initial and running costs
- ease of implementation
- running and maintenance
- continuity and flow of supply
- arsenic removal capacity
- susceptibility to bacteriological contamination
- acceptability to the community.

All the options had their own strengths and limitations, although none were as easy as fetching water directly from tubewells. At the end of the study period, a total of about 49% of the exposed population was brought under the coverage of different alternative safe water options at a cost of more than half a million US dollars. Less than 2% of the total provided options were found to be in operation at the time of recent revisit of these options. Interestingly, it was observed that those alternative options were active only in those cases where highly motivated caretakers took personal initiatives to run the options.

As a result of a strong awareness campaign, villagers understood the urgency for drinking arsenic-free water and the need for switching to green-marked tubewells and re-sinking/reinstalling tubewells within 50–100 m depths over these years. The number of people per green-marked tubewell has increased many times without facing any practical difficulties in sharing. This excess number of people sharing green-marked tubewell poses the possibility of social and cultural chaos, and thus, further research is needed to develop coherent strategies that will motivate owners to share their safe water (van Geen et al., 2002). At the same time, research is also needed to investigate whether arsenic concentration in the tubewell water changes with time, in order to make this option a sustainable one.

The tubewell reinstallation/re-sinking option promoted by local masons was found to be popular among the people. The percentage as well as success rate of targeting arsenic-safe aquifer for such initiative has also increased remarkably over the period. It is mentioned here that this total mechanism is based on the indigenous knowledge of local masons. This technique may not be risk-free and thus might invite arsenic-contaminated shallow aquifer water to the deeper aquifers. Many of the arsenic exposed village population were found to be reluctant about this option and, instead, continued drinking from arsenic contaminated water, since masons were not confident enough about the precision level of this technique. Hence, proper geological investigation is needed to validate or substitute this indigenous practice.

Finally, it could be said that the alternative safe water options provided under this project were not well accepted by the local population. In fact, tubewell water is so deep-rooted in the mind of the people that it seems difficult to change to other sources that are not as easy and convenient as fetching water from a tubewell. At the same time, it would not be wise and economical to discard the existing 8–10 million tubewells of the country, which took millions of dollars to install.

Two primary challenges need to be overcome to regain the lost coverage of safe water in Bangladesh within a short period of time. The first is to tackle socio-cultural problems in sharing the existing green-marked tubewells. The second is to better understand the technicalities of lowering the tubewell depth to below 50–100 m. On the other hand, identification of the best suitable alternative safe water options might still be needed for areas where neither of the two techniques mentioned above would be suitable to provide safe water options.

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## Appendix 1

### *Pond sand filter (PSF)*

In the coastal belt of Bangladesh, where salinity in the shallow groundwater is reported to be a severe problem, the Department of Public Health Engineering (DPHE) and UNICEF have installed slow sand filtration units linked with hand pumps which are used to deliver pond water to the units, which are called Pond Sand Filters (PSF). In this slow sand filtration system a bed of fine sand is used through which the water slowly percolates downward, resulting in the removal of pathogens through a combination of physical and biological processes. One PSF can supply the daily requirement of drinking and cooking water for about 40–60 households with a cost of about US$ 600. Once trained, masons with locally available materials can construct PSF. There is no chemical treatment involved in this process and little effect on the environment.

The greatest challenge for this option is to find suitable ponds which are perennial, free from pisciculture, and protected from use for bathing and washing clothes, cattle, etc. PSFs constructed in the past in other arsenic affected areas where BRAC is providing arsenic mitigation options, are now abandoned as the owners of the ponds restarted commercial fishing activities (BRAC, 2000). Most ponds are privately owned and therefore, villagers have little to say about changing owner's decision about restarting commercial fishing activities, in spite of having formal agreements with the community that they will reserve the ponds for drinking water use only. However, there is potential that PSFs could be one sustainable alternative to the arsenic problem in some areas.

### *Rain water harvester (RWH)*

Rainwater harvesting is utilised in many parts of the world to meet the demand for drinking water. There is a long-established tradition of rainwater collection in some parts of Bangladesh, where shallow groundwater water has elevated salinity. Although the potential for rainwater harvesting is good in some areas of Bangladesh, the amount of rainfall varies widely across the country. Rashid (1977) shows that mean annual precipitation varies from 1,400 mm (about 55 inches) along the country's central western border to more than 5,000 mm (200 inches) in the far northeast. The wet months are mid-June to late September and the dry period is from January to April. About 80% of the annual precipitation occurs in the monsoon period. Rainfall patterns were also confirmed with local communities in order to ascertain the feasibility of RWH, and alternatives and parallel use of other options were considered before constructing RWH jars in Matlab. The capacity of a jar is about 3,200 litres and the cost is about US$ 130 (DPHE/UNICEF, 1988-93).

### *Safi filter*

This household level filtration device was developed locally by Professor Sayeed Safiullah of Jahangirnagar University, Dhaka, Bangladesh. The Safi filter was designed to remove both arsenic and pathogenic bacteria. The filters distributed initially had many problems in terms of flow rate and arsenic removal efficiency (BRAC, 2000). The Safi filter consists of two concrete buckets of 20 litre storage capacity, 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. One small Safi filter is designed to filter approximately 40 litres of water per day. The cost of each filter is US$ 15.

The Safi filter candle is prepared from a chemical mixture of laterite soil, ferric oxide, manganese di-oxide, aluminium hydroxide and meso-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 about US$ 4.

### *Bishuddhya filter*

This non-chemical based filter is basically designed to remove pathogen load from surface water. The filtration and purification technique used in this system is similar to PSF technology. *Bishuddhya* filters are relatively inexpensive and produced in Bangladesh. The main material used in this filter is different mesh sizes of locally available rocks. The water passes from the bottom through different layers to remove bacteria before it arrives at a storage chamber. The cost for this household-based device is US$ 45 with virtually no operation and maintenance cost, except for washing the materials after a certain interval depending on the suspended loads of raw water. The plastic container of this filter is made from food-grade plastic. The only precautionary measure that needs to be ensured here is that surface water must be obtained from a protected source to ensure no contamination with chemicals, fertilisers, etc. This filter could be an ideal option for areas where protected surface water is available and for southwestern part of the country where most people still use surface water for drinking and cooking purposes.

### *Three-kolshi or three-pitcher filter*

The three-pitcher filter is based on an indigenous method of filtration, which has been used in Bangladesh for ages. Traditionally, two local clay pitchers (called *kolshi*) are used to filter water. The top pitcher is partially filled with sand and charcoal, and a small hole is made in the bottom. A piece of synthetic cloth is placed over the hole to prevent sand from spilling out. Water is passed through this pitcher to remove suspended matter from surface water and more recently to remove iron from tubewell water. After passing through the top pitcher, filtered water is stored in the bottom pitcher. Scientists from

Bangladesh and the USA noted the potential of this simple method to remove arsenic well. They modified the system by adding a third pitcher above the sand/charcoal pitcher, which is filled with iron filings to provide an additional source of iron oxide to adsorb more arsenic (Rasul et al., 1999). The total cost for developing such a unit is less than US$ 5.

There are, however, a number of unanswered questions about the three pitcher filters that need to be addressed before they are taken up on a larger scale. First, does bacteriological contamination of the water occur before or during filtration. It has not been clearly 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 since it has been observed that after three/four months of continuous use the filters start leaching arsenic. However, the three-pitcher system has enormous potential to provide an emergency drinking water source for the arsenic-affected areas in rural Bangladesh, if the problems mentioned above are taken care of.

*Activated alumina filter (ALCAN filter)*

The basic principle of this system is adsorption of arsenic by activated alumina. In this filter, the raw water passes upward through the activated alumina media and the treated water becomes arsenic free. Activated alumina is formed by the thermal dehydration (250–1150°C) of an aluminium hydroxide such as, gibbsite, bayerite, etc. Its principle characteristic is high surface area (>200 $m^2/g$) and associated porosity. 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.

The activated alumina used as media in the system has to be imported. The initial cost is high for both type of units: US$ 260 per unit (unit + media), and US$ 52 (unit + media) for the household based unit. Running costs are required because the activated alumina needs to be changed periodically. The replacement cost of media for community-based units is US$ 140 to treat 80,000 litres of water, and for household based unit it is US$ 12 to treat 11,000 litres of water. Apart from the cost which seems to discourage villagers, disposal of used material is also another issue of concern not only for Alcan filter but also for all other arsenic removal filters available in Bangladesh. These two issues need to be monitored properly to avoid further hazard.