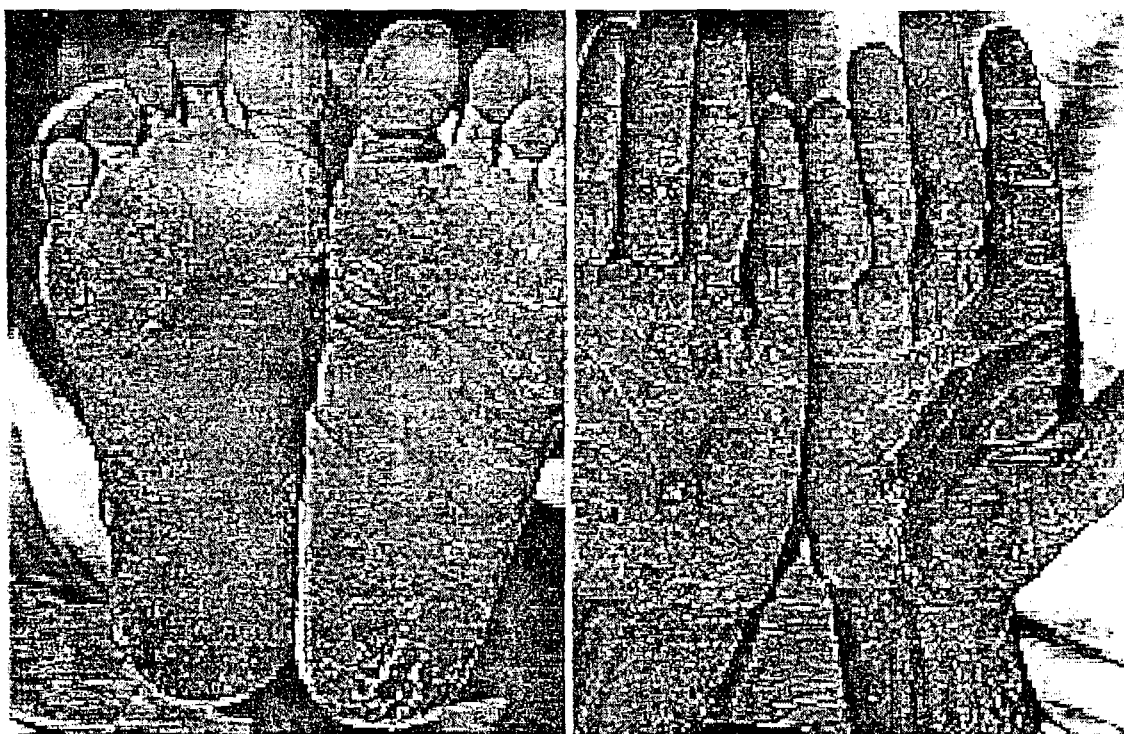


Government of the People's Republic of Bangladesh  
Department of Public Health Engineering (DPHE)  
&  
Danish International Development Assistance (Danida)

## DPHE-Danida Urban Water & Sanitation Project

IRC International Water  
and Sanitation Centre  
Tel: +31 70 30 689 80  
Fax: +31 70 35 899 64

# Guideline for arsenic



*Library*  
IRC International Water  
and Sanitation Centre  
Tel: +31 70 30 689 80  
Fax: +31 70 35 899 64

April 1998

Central Co-ordination Unit  
DPHE Bhaban (Ground Floor)  
175-178 Kakrail, Dhaka

Project Management Unit  
DPHE Building (1<sup>st</sup> Floor)  
Maijdee Court, Noakhali

Project Management Unit  
DPHE Building (1<sup>st</sup> Floor)  
Police Line Rd, Patuakhali

822-BD98-16803

# DPHE-Danida Urban Water & Sanitation Project

## Guideline for arsenic

---

### Preface

This Guideline for arsenic has been prepared based on discussions with key-persons from institutions and organizations working within the area of arsenic contaminate water. Furthermore a workshop on arsenic were held with participation of DPHE Project staff, Danida Project staff, Danida staff and an international expert as facilitator. The outcome of this workshop is reflected in this Guideline.

We hope, this Guideline will assist the authorities and staff of all concerned agencies to take necessary and relevant actions for project implementation.

On behalf of the project management, we thank all persons who put their valuable contributions in preparation of the Guideline for arsenic.

# DPHE-Danida Urban Water & Sanitation Project

## Guideline for arsenic

---

### Background

Arsenic has been called the King of Poisons and is found in drinking water spot wise all over the world. The arsenic problems are related to its chronic toxicity and to the fact that it is tasteless, odorless and colorless.

During recent years arsenic has been measured in the groundwater, people with arsenic related symptoms is increasingly observed among communities of Bangladesh and thus adding one more serious calamity and creating a new major health concern in the country. Moreover, an increasing understanding and awareness of the arsenic problem within the Bangladeshi people are reported from different agencies and is also observed in our two PMUs where users frequently raise the question: What will our Project do regarding arsenic?

The Project will cover 43 towns of varying sizes in Feni, Noakhali and Laksmipur districts to the east of Meghna river and 12 towns in Patuakhali and Barguna districts to the west of Meghna river. According to the Project Document (PD) and the Project Proforma (PP) for the Project, the choice of technology for supplying drinking water is different at the two sides of the river. In Feni, Laksmipur and Noakhali Districts the Project is supposed to install 1918 shallow-HTWs according to the PD. These areas, however, are badly affected by arsenic contaminated shallow TWs. Existing knowledge indicate that only about 10 % of existing shallow HTWs produce water with an acceptable level of arsenic (less than 0.05 mg-As/L). Furthermore, the fact that some of the towns in greater Noakhali like Noakhali Pourashava don't have a fresh-water deep aquifer is complicating the problem. In Patuakhali and Barguna districts the problem is different and seemingly much smaller. In these areas the shallow aquifer is saline, so the only option for drinking water is to abstract water from the deep aquifer which reportedly is free from arsenic. In the long run however, sinking of large numbers of deep-TW may puncture the sealing layer between the deeper fresh water aquifer and the layer above which is saline and may be arsenic contaminated. This can create an irreversible situation where the deep fresh water aquifers, which often are pockets with little or no regeneration capacity, are getting contaminated with water from the above aquifers.

To solve the problem, assuring that the users have access to fresh water with an acceptable level of arsenic, there are only two options:

- To identify one or more alternative water source(s) or;
- To remove arsenic from the water by some kind of treatment.

At present it seems like an alternative water source must be found within: Deep HTWs which generally are free of arsenic; extending piped water supply schemes; treating surface water; rain water harvesting and; rely on water vendors to distribute arsenic free water.

To remove the arsenic from water abstracted from existing shallow HTWs, the Project has at present established 2 methods on a pilot basis. A bucket-alum system which can be applied on household level; and an Arsenic Removal Unit (ARU), which can be connected to an existing HTW on a community basis.

# DPHE-Danida Urban Water & Sanitation Project

## Guideline for arsenic

---

The Project will, when dealing with arsenic, aim at:

- a high level of knowledge of the present situation (100% monitoring in selected area);
- to cover the whole population within this selected area;
- to identify appropriate solutions;
- to give the users proper information and sufficient training in the method selected and;
- to make any information and knowledge obtained, available through reporting and mapping.

### Objective

The Development Objective of the Project's arsenic activities is in line with the development objective of the whole Project: To improve health conditions of the target communities by providing safe drinking water to the users.

The Immediate Objectives of the arsenic activities are:

- To identify safe water sources (sources where arsenic concentrations are acceptable);
- to identify immediate and possible long term solutions to the problem;
- to raise awareness of the users about arsenic and to instruct / train the users in how to get arsenic and hygienic safe drinking water.

### Target areas (where)

To prioritize our work we have divided our project areas into 4 categories:

- Piped water supplied areas. Piped water supply scheme installed by our Project will obviously supply arsenic safe water. Users who connect to the schemes will not have the arsenic problem. Within such geographical area, however, there will be users who already have access to water from existing HTWs and who, for a variety of reasons, might not be willing to connect to the schemes. Furthermore, these schemes will not be in operation within the next few years
- HTW supplied areas. Areas where the Project will install water supply installations, and where the type of technology for water supply will be HTWs, likely deep-HTWs in both greater Noakhali and greater Patuakhali Districts.
- Un-served areas. Pockets within core areas, which will not be served by the installed piped water supply schemes; and parts of fringe areas which, are sufficiently served by existing HTWs. So areas, within the boundaries of Project towns, where, according to the PD, no water supply installations will be supplied by the Project.
- Phase-1 Project areas. Laksmipur and Chaumohani Pourashava where approximately 900 HTWs have been installed. The phase-1 Project has been finalized and arsenic problems in these areas is officially not the responsibility of our Project. However, a follow-up agreement has been signed with the two Pourashavas, and they are supposed to act as model-towns for our present Project. It is clear that there will be no more financial input to the Phase-1 towns from the Project. However, water and sanitation operations are self-supporting through

# DPHE-Danida Urban Water & Sanitation Project

## Guideline for arsenic

---

water tariffs, and funds are available in the respective accounts in the Pourashavas. It is felt that this Guideline together with limited assistance like advises and training could significantly improve the situation in the two towns. The initiative to any such activities, however, must come from the Pourashavas.

### Strategy (how)

**Sampling and analysis.** Sampling for arsenic monitoring is different from making an inventory. The aim of an inventory is normally to assess the coverage of e.g. HTWs in an area. Here the exact location is not essential and if the location of two HTWs are confused it will normally not create any problems. When sampling, a situation where it is not possible to identify the HTW after analysis of a sample, can be very critical, and should be avoided to the highest possible extent. During sampling an identification code must be attached to each individual HTW and painted on the hand pump and at the sampling bottle.

Sampling will be carried out in accordance with the area based planning. E.g. an area will be selected and all existing HTWs, in operation, will be sampled.

Apart from monitoring existing HTWs in a area where the Project will start to work, a number of HTWs will be sampled and analyzed repeatedly with reasonable intervals to see if the concentration of arsenic change during time. Furthermore piped water supply systems installed by the Project will be monitored for arsenic on a routine basis.

**Checklist for sampling:** The sampling staff will be equipped with a reasonable verified map of the area, paint for marking the hand pumps, and clean sample bottles. Then the sampling procedure will be as follows:

- Identify a HTW;
- Plot the HTW into the map as accurate as possible;
- Report other necessary identification parameter (name of owner, name of bari, age, and depths of well);
- Pump the hand pump for 3-5 minutes;
- Rinse the sampling bottle in the HTW water 3 times before the final sampling.

After sampling the water samples will be brought to the laboratory in PMU Noakhali where 3-mL hypo-chloric acid will be added for conservation before analysis.

In Noakhali PMU a laboratory has been established which is capable of analyzing for tri-valent arsenic, penta-valent arsenic and total inorganic arsenic. Research indicate that the tri-valent form of arsenic is 10-20 times more toxic than the penta-valent form, making the tri-valent form more interesting from a health concern point of view. However, there is no National Standard or WHO guideline for the individual forms but only for total arsenic. Thus for monitoring purposes the water will be analyzed for total arsenic only.

**Solution.** After the monitoring program has been carried out for the selected area, and results have been obtained from the laboratory, the results will be analyzed. HTWs

# DPHE-Danida Urban Water & Sanitation Project

## Guideline for arsenic

---

with an acceptable concentration of arsenic will be identified and treatment options will be introduced.

Treatment at household level. A household level treatment method, the bucket alum method, has been tested technically by the Project, and proved efficient in removing arsenic. The method implies that the user must buy one 20-L bucket with a tap installed 5 cm from the bottom and alum. The principle of the method is:

- Fill the bucket with the arsenic contaminated water;
- add approximately 5 g of alum in powder form (addition of 5 g alum will add less than 40 mg-Sulfate/L to the water, WHO guideline: 250 mg/L);
- stir the water rapidly (about 60 rotations per minutes) for app. 15 sec.;
- stir the water slow (about 15 rotations per minutes) for app. 10 minutes;
- leave the bucket with lid on for minimum one hour; and
- take water from the tap without disturbing the bucket.

The Project has carried out experiments with the method, and found a removal efficiency of 90 %. That means that as long as the raw water contains less than 0.5 mg-As/L (90 % of HTWs in Noakhali Pourashava) the treated water will have an arsenic concentration of less than 0.05 mg-As/L (the acceptable limit).

The investment for the users will be the cost for one 20 L bucket and one plastic tap (app. 300 Taka), and the running cost will be the cost of alum, 34 Taka for one kg, enough to treat 200 buckets of water (17 pasha per 15 L of water).

The method, however, implies an extra workload on the main water handler in a household. In a family of 6 to 7 people the demand for drinking and cooking water may be 2 buckets of arsenic free water daily. That means that somebody will have to stir the water for nearly ½ hour a day.

Treatment at community-level. The Project has built two Arsenic Removal Units (ARUs) in Noakhali Pourashava on a pilot basis. The ARU can be built directly in connection with a hand pump. The principle of the ARU is very much like conventional water treatment: Aeration; alum addition; mixing; flocculation; sedimentation; and filtration. The ARU is like a closed box (2x1x1 m) where arsenic contaminated water enters in one end and come out free of arsenic in the other end. However, some maintenance is required: Addition of alum in stock solution chamber on a weekly basis and backwash of sedimentation and filtration chambers on a monthly basis.

The ARU is designed to supply arsenic free water to 25 to 50 families. The construction cost is about 15.000,- Taka, and operation cost is about 10 Taka per family per month.

The ARU is still in a development stage and will probably need some modification to be optimized. However, preliminary results from the two ARU in operation indicate that it's capable of removing 70-75 % arsenic from the water.

# DPHE-Danida Urban Water & Sanitation Project

## Guideline for arsenic

---

### Awareness-building

It is important to consider the role of the communities as their awareness of arsenic issues and involvement in finding sustainable solutions are mandatory components upon which an effective arsenic action program must be built. Bearing in mind the critical role of communication the Project has to work closely with various stakeholders including Governments Agencies, NGOs and Donor organizations to develop a flexible communication strategy, which is responsive to the needs of the local communities. However, it appears that until today there is no national training plan, no methodology and only a handful of trainers. Presently, there is no mechanism for co-ordination and sharing experience.

Obviously, the target groups in our Project areas have the right to accurate information helping them to make informed decisions on what to do if their tubewell water contains risk levels of arsenic. They also need to know the risks of continuing drinking arsenic contaminated water, as well as the risks of turning to other unsafe sources of water. They must be informed where the tubewells that have been tested safe for drinking are even if this might mean that they have to walk further to collect water. People also need to be informed that, at least temporarily, arsenic contaminated water can be used for domestic and household chores. They also have to become ware that affected victims are not carriers of contagious diseases. Consequently, appropriate information is needed now and cannot wait until a national strategy for communication and awareness building has been formulated and agreed to.

The following development partners will receive orientation training on arsenic issues:

- The caretakers of the ARUs;
- Users employing the alum-bucket methods or the users having access to ARUs;
- Relevant Pourashava staff;
- Assistant Engineers at PMU-level; and
- The staff of the local NGO contracted by the Project

Awareness building attempting not to create panic:

- General awareness building campaigns;
- Health education court yard sessions (carried out by the selected NGOs) in which the problem of arsenic will be raised. Targeting mainly the poorer sections and in particular the main water-handlers

The sustainability of the bucket alum method and the ARUs shall be monitored at household and community level in selected areas. Step-to-step guidelines, in Bangla, shall be developed for the benefit of the users. Similarly training materials will be developed, in Bangla, for the ARU caretaker training. Improvements of both methods and materials will be based on field experience, recent thinking and research.

Reporting and mapping. A database based on all necessary identification parameters will be build for exiting HTWs, the arsenic concentration, depth of the well, age of the well etc. A GIS application will be used to map and document the situation. DPHE or WHO may in the long run operate the database. The database and GIS application, however, will also be operated by the Project as a tool for the area based planning.

# DPHE-Danida Urban Water & Sanitation Project

## Guideline for arsenic

---

All pilot arsenic activities will be monitored and evaluated. Reports will be prepared and will be used as background materials for deciding further action.

### Implementation

When dealing with the arsenic problem in an area all the above mentioned activities will be addressed if not simultaneously then within a reasonable period of time. When a water source is tested, information about the arsenic concentration is gained. The users must be informed about the result, and if the concentration is un-acceptable high, advised how to obtain arsenic free water at least for drinking and cooking purposes.

Arsenic is not mentioned in our PD and PP as the problem was not recognized at the time of writing these documents. Furthermore, no national strategy or guideline is available. The Project will handle the arsenic problem according to this Guideline and to an extent and with a speed, which can be operated by our organization. In practice the Project will carry out arsenic as well as other activities according to an area based planning. The area basic planning implies that a reasonable sized area is selected according to some criteria's (such as poverty, service level, level of arsenic contamination etc). The Project will try to incorporate arsenic activities into activities which must be carried out anyway (arsenic awareness activities can be incorporated in health & hygiene education activities and other awareness activities).

Apart from the above the Project will start arsenic activities on a piloting scale and carefully monitor results and workloads and evaluate the capacity of the Project with the existing organogram to deal with the problem on a larger scale within the Project area.

The Project has bought our own lab equipment and set up the procedure for arsenic analysis as recommended by Standard Method for Water and Wastewater Analysis (AWWA). The procedure is now functioning at the laboratory in the PMU-Noakhali.

The laboratory is at the moment staffed by one Senior Chemist and has a capacity of analyzing app. 100 samples for arsenic per week, which can be expanded to app. 200 samples per week if one additional lab technician is employed. The laboratory also has the potential to analyze water samples for other physical and chemical parameters like conductivity, pH, iron, manganese, chloride, etc.

As the laboratory is situated in Noakhali PMU, the day to day operation of the lab and the co-ordination of its capacity will be the responsibility of the TA and SA from Noakhali PMU. The TA from CCU will be responsible for the quality of the work carried out by the laboratory, that is:

- Selection and introduction of chemical analysis procedures;
- purchasing of chemicals and equipment; and
- supervision of the Senior Chemists work.



# DPHE-Danida Urban Water & Sanitation Project

## Guideline for arsenic

---

The lab shall function as a service to all Project staff. That means that the co-ordinating role of the Noakhali PMU is to assure that all staff from both PMUs and from CCU can get the services offered from the laboratory if needed.

### Co-ordination

Regular co-ordination, consultation and experience sharing with other role-players, e.g., the World Bank, Unicef, major NGO's, and DFID etc. will be carried out by the Project.

At the national level the CCU will co-ordinate to share ideas with other organizations. At the local level the PMUs will co-ordinate in order to find appropriate messages and means of technological solutions.