

Technical Bulletin No.8

## MONITORING ARSENIC IN WATER

### Background

The exploitation of ground water to replace the use of surface water in the beginning of the 1970s was instrumental in reducing the incidence of water born diseases, and made an important contribution to the improvement of public health in many developing countries. Since then, the number of tube wells has been increasing. In Bangladesh alone, there are over six million wells. A more accurate figure is unavailable because the private sector has driven most of the shallow tube wells and records are incomplete.

However, the improvement in water quality has been negatively affected by the presence of arsenic in ground water. The first study that reported the existence of arsenic in ground water was published in India in 1976. Further studies were carried out in India and neighbouring countries and raised concern among various governments, organizations and researchers.

Severe poisoning can arise from the ingestion of as little as 100mg of arsenic trioxide. Chronic effects may result from the accumulation of arsenic compounds in the body at low intake levels. Arsenite (AsIII) is many times more toxic than arsenate (AsV). The maximum level of arsenic in irrigation water recommended by the Food and Agriculture Organization (FAO) is 0.1 mg/L. The World Health Organization (WHO) recommends that the maximum level of arsenic in drinking water should not exceed 0.01 mg/L (10 ppb). Some countries still accept the level of 0.05 mg/L (50 ppb) in their national standards. However, some studies suggest that there is a high possibility of arsenic being taken in by plants from soil or irrigation water, which eventually transfers to humans. Further studies are needed, especially surrounding the effects of arsenic on main crops and vegetables.

### Occurrence

Arsenic occurs naturally in sulphide minerals such as pyrite. It is found in many countries but especially those located south of the Himalayas, such as Bangladesh, India (West Bengal), and China.

The main challenge in tackling arsenic in ground water is that it does not follow a specific pattern. For example, it can occur in one tube well and not in another one located less than 100 metres away. Furthermore, a tube well that was previously tested to show an acceptable amount of arsenic might test non-acceptable at a later date.

It is therefore vital to test and monitor on a continual basis, with blanket coverage of all tube wells in those countries affected. It is equally important to ensure that people are made aware of the arsenic content in tube well water and promote arsenic mitigation activities.

### Monitoring

Monitoring arsenic in ground water should be planned nationally, starting with random testing of tube wells throughout the country to determine the extent of the problem. Subsequently, blanket testing of all wells in selected districts should follow, to identify each and every contaminated well. Blanket testing programmes could also include other activities that are essential for additional monitoring and management operations, such as the location of each well using a Geographic Information System (GIS), the diagnosis of arsenicosis patients in the district surveyed, and the introduction of various water treatment measures in that district.

Water testing for arsenic can either be done in a laboratory, where the water samples are delivered, or can be done using field testing kits. Each methodology has its own advantages and disadvantages that vary according to the resources available within each country.

### Laboratory testing

An assortment of methods is available to identify and determine levels of arsenic, arsenite and arsenate. The methods described below are considered standard by the American Water Works Association (AWWA), the American Public Health Association (APHA) and the Water Environment Federation (WEF). These methods are listed in the "Standard Methods for the Examination of Water and Wastewater, 20th edition, APHA, AWWA, WEF".

Regardless of how accurate these methods may be, test results will be significantly affected by the condition of the sample that reaches the laboratory. Samples must be in a good condition and truly representative.

1. Electro-thermal Atomic Absorption Spectrometric Method (method 3113 B).  
This is the preferred method in the absence of overwhelming interferences.
2. Manual Hydride Generation/ Atomic Absorption Spectrometric Method (method 3114 B).  
This is used when interferences that are present cannot be overcome by standard electro-thermal techniques.
3. Silver Diethyldithiocarbamate Method (method 3500-As B).  
This method is applicable in determining total inorganic arsenic when interferences are absent and when the sample contains no methyl-arsenic compounds. This method also has the advantage of being able to identify and quantify arsenate and arsenite separately by generating arsine at different pH values.
4. Inductively Coupled Plasma (ICP) Method. (method 3120 B).  
This method is useful at higher concentrations (greater than 50 µg/L).
5. Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) Method (method 3125).  
This method is applicable at lower concentrations, if chloride does not interfere.

### Field testing

Field testing is an important tool for the extended or blanket testing and/or monitoring of arsenic. Several advantages can be achieved from implementing field testing. These include:

1. avoiding the transfer of samples to laboratories and the associated logistics involved with transfer;
2. the possibility of immediately identifying contaminated wells and instructing the people concerned to avoid consuming the contaminated water;
3. ease of transporting testing kits to remote areas in comparison to having to transport all samples to the laboratory.

In recent years there have been many efforts to develop local testing kits further. Several studies have been conducted to evaluate various kits including many that are locally produced, resulting in some being accepted. Work is still ongoing in various countries to develop, test, and approve new field testing kits.

### Training of testing personnel

For all field testing kits, it is essential to ensure the technicians who will be performing the tests are properly trained. Training must be planned and implemented at the time of ordering the testing kit.

Several kit manufacturers offer training programmes for local technicians. UNICEF Supply Division can assist in arranging these training programmes.

### Procedure for field testing

In most field testing kits, powdered zinc reacts with the acid (supplied either in liquid or powdered form, depending on the manufacturer and/or the kit) to create a reducing condition in the water sample, in which inorganic arsenic is reduced to arsine gas (AsH<sub>3</sub>). The arsine gas reacts with the mercuric bromide on the test strip to form mixed arsenic/mercury halogenides that discolour the reaction zone of the test strip. The colour change ranges from yellow to brown, depending on the concentration of arsenic in the water. A comparison is made against the colour on the testing strip with a colour scale provided in the kit, to give a semi-quantitative value of the inorganic arsenic in the water.

The various kits differ in their presentation of the reagents (liquid, powder, or tablets), the shape of the reaction vessel, the design of the reaction vessel cap where the testing strip or the filter is inserted, and the removal of the interference of sulphides. A few kits offer digital readout of the colour range instead of the visual comparison.

### Standard field testing kits

The following standard kits are considered acceptable in most countries and can be ordered through UNICEF Supply Division, Copenhagen. This list does not imply that UNICEF endorses these kits only, or that UNICEF endorses the brand. UNICEF is open to consider any new kit that comes on the market and to share information and experience with partners. When new kits are accepted, they might be introduced into the UNICEF Supply Catalogue. Or, when appropriate, the relevant Catalogue Number

Description may be modified to a generic specification without branded product reference.

**(Catalogue number - Description)**

**1) S0005500 - Arsenic testing kit (solid reagents)**

This kit is manufactured by Merck KGaA, Germany.

1. Manufacturer reference: Merckoquant®, Arsenic Test, 1.17917.0001 As. (Having replaced the former reference 1.17926.0001 As (Sensitive), which did include liquid reagents)
2. Measuring range (colour scale graduation): 0.01, 0.025, 0.05, 0.1, 0.5 mg/litre As III/V. This is equivalent to 10, 25, 50, 100, 500 ppb (parts per billion).
3. The kit does not allow for the removal of the sulphide interference, but tolerates up to 1% sulphide without interference.
4. The kit contains the following: two reagents (Zinc and acid in solid form, as two bottles of reagent As-1 (with micro-spoon in the cap) and one bottle of reagent As-2), test strips, two reaction test tubes with screw caps, a 5ml measuring syringe for the water sample, a red dosing spoon for the powders and an instruction sheet in four languages (English, French, Spanish and German).
5. Sufficient reagents and strips are provided to perform 100 tests.

**2) S0005510 - Arsenic testing kit (powdered reagents)**

This material number covers kits manufactured by Hach Company, or by Industrial Test Systems, USA.

1. Manufacturer reference: Arsenic test kit 28000-00 (Hach) or 481396 (ITS).
2. Measuring range (colour scale graduation): 0.01, 0.03, 0.05, 0.07, 0.3, 0.5 mg/litre As III/V or 0.005, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.08, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5 mg/litre As III/V. This is equivalent to 10, 30, 50, 70, 300, 500 ppb respectively 5, 10, 20, 30, 40, 50, 60, 80, 100, 150, 200, 250, 300, 400, 500 ppb.
3. The Hach kit tolerates up to 5 mg/litre and the ITS kit tolerates up to 2 mg/litre (hydrogen-) sulphide without interference.
4. All the reagents are packed in powdered form and four of these reagents are pre-measured and individually packed in single use powder pillows.
5. The kit contains the following: five (Hach) or three (ITS) reagents, test strips, two reaction vessels with special caps and instructions in English.
6. Sufficient reagents and strips are provided to perform 100 tests.
7. A replacement kit for reagents only is available (manufacturer ref. no. 27999-00 or 481396).

**3) S0005520 - Arsenic test kit, highly sensitive**

This kit is manufactured by Merck KGaA, Germany.

1. Manufacturer reference: Merckoquant®, Arsenic (highly sensitive), 1.17927.0001 As.
2. Measuring range (colour scale graduation): 0, 0.005, 0.01, 0.025, 0.05, 0.1, 0.25, 0.5 mg/litre, which is equivalent to 0, 5, 10, 25, 50, 100, 250, 500 ppb.
3. An oxidizing agent is provided to remove the effect of sulphide interference.
4. The kit contains the following: two powdered reagents bottles, oxidizing agent in a dropper bottle, a reaction vessel with a special cap, two measuring spoons for the reagents and instructions in four languages (English, French, Spanish and German).
5. Sufficient reagents and strips are provided to perform 100 tests.

**4) S0005521 - EZ Arsenic test kit**

This kit is manufactured by Hach Company, Colorado, USA.

1. Manufacturer reference: EZ Arsenic test kit 28228-00.
2. An optional step is included to remove the interference of sulphide by scrubbing the gas stream through a cotton ball soaked with lead acetate 10%.
3. The two reagents are pre-measured and individually packed in single use powder pillows. The lead acetate is supplied in a dropper bottle.
4. Measuring range (colour scale graduation): 0, 0.01, 0.025, 0.05, 0.1, 0.25, 0.5 mg/litre, which is equivalent to 0, 10, 25, 50, 100, 250, 500 ppb. However, this high-range kit recovers only 90% of inorganic As<sup>+5</sup>.
5. The kit contains the following: Two reagents, optional lead acetate and cotton, two reaction vessels with a special cap, a dilution tube, a waste disposal bag and instructions in English.
6. Sufficient reagents and strips are provided to perform 100 tests.
7. The manufacturer offers the same kit with instructions in both English and Bangla languages (ref. no. 28178-00)
8. A replacement kit for reagents only is available (manufacturer ref. no. 28232-00).

### 5) S0005522 - Visual Arsenic Detection Kit, 200

This kit is manufactured by Wagtech International Ltd. Berkshire, UK.

1. Manufacturer reference Wag-WE10600, Visual Arsenic Detection Pack-200
2. The kit features a reaction vessel with a unique tri-filter cap, which removes excess arsine gas as well as any hydrogen sulphide which may also be given off as a by-product of the reaction.
3. Measuring range (colour scale graduation): <10, 20-40, 50, 60-80, 100, 100-200, 200-300, 300-400, 400-500µg / litre (ppb).
4. The results can be compared visually with the colour scale or the filter holder inserted in the photometer of the digital Arsenator (UNICEF item no. 0005523) to get a digital readout of the results.
5. The kit contains the following: two reagents (one in tablet form and the other in pre-measured individually packed sachets), a reaction vessel, a dilution graduated tube, four filter holders for the collection and detection of arsenic, four filter holders (scrubber) for the elimination and removal of any arsine gas, four hydrogen sulphide filters, a colour comparison chart, and waste disposal bags.
6. Sufficient tablets, powder sachets and filters are provided to perform 200 tests.
7. A set of reagents and consumables to perform 200 additional tests is available (manufacturer ref. no. Wag-WE10560).

### 6) S0005523 - Digital Arsenator / Digital Reader As

The kit branded as Digital Arsenator is manufactured by Wagtech International Ltd. Berkshire, UK, while another digital reader kit branded as Arsenic Quick Scan is manufactured by Industrial Test Systems, South Carolina, USA.

1. Manufacturer references: Wag-WE10500 -Wagtech Digital Arsenator, and 481305 -Arsenic Quick Scan.
2. Both digital readers are fully portable battery-operated arsenic detection systems. The Digital Arsenator featuring a portable digital photometer capable of giving accurate digital readings of the discolouration of the filters as a result of the reaction of the two reagents with the arsenic in water. It gives a direct readout in (ppb) of arsenic in water specifically within the critical range of 2 µg/ litre (ppb) to 100 µg/ litre (ppb). The photometer includes a timing device to monitor the length of the chemical reaction. The Arsenator is operationally product specific to the filter based Wagtech Arsenic test kits. The Arsenic Quick Scan featuring a portable digital colorimeter capable of giving accurate digital readings of the colour density of the reacted arsenic test strips. The user then matches that density value against a supplied look-up table and records

the ppb ( $\mu\text{g}/\text{litre}$ ) result. This digital device gives colour density readout within the critical range from 0.1  $\mu\text{g}/\text{litre}$  (ppb) to  $>100 \mu\text{g}/\text{litre}$  (ppb).

3. The kit contains the following: reagent types and accessories as per above 0005522 (Wagtech) or 0005510 (ITS), a colour comparison chart, waste disposal bags, a digital reader device and a spare battery for the reader.
4. Sufficient reagents and filters or strips are provided to perform 420 tests.
5. A set of reagents and consumables to perform 200 additional tests is available (manufacturer ref. no. Wag-WE10560, or ITS Quick and Quick II series kits e.g. 481396, 481303, 481304).
6. As an accessory for the Digital Arsenator, a multi-pack generator is available with enough reaction vessels and filter holders to enable five tests to be run simultaneously (manufacturer ref. no. Wag-W10540, Arsenic Generator Multi-pack).

At this stage, renewables and accessory kits are not specified as standard items in the UNICEF Supply Catalogue. These are available from the manufacturers and UNICEF Supply Division can assist in procuring these kits upon request.

**Also, it is to be underlined that though above Catalogue Material Numbers are referring directly to specific products, brands and manufactures, equivalent products of other brands and manufactures may be supplied, in respect of the UNICEF procurement policies.**

For more details, please contact UNICEF Supply Division, at [customer@unicef.org](mailto:customer@unicef.org).

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