

Regular Article

Comparative Analysis of Arsenic Detection in Water by Field Test Kit and AAS Methods

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ABSTRACT: Methods for detection of arsenic in water samples from ground water under field conditions have been studied. A comparative analysis based on experimental determination of arsenic in large number of water samples by Test Kits (Gutzeit Method) and by atomic absorption spectrophotometry (AAS) has been made. It is observed that when the actual concentration of arsenic in water is below 100 ppb, the result of measurement by test kit is lower than that obtained by AAS. On the other hand, higher values of arsenic concentration are given by test kit, when the actual concentration is over 100 ppb. In general, the result obtained by test kit is found to differ by 20 - 50 % from that obtained by sensitive laboratory method AAS.

Key words: Arsenic, Detection, Field test kit, AAS

Introduction

Arsenic contamination of ground water has created a big public health problem in Bangladesh. Without being aware, people are drinking & using arsenic contaminated tube well water everyday. As a result, people have been suffering from various diseases. To solve the problem it has been felt that the sources of arsenic contamination & the level of contamination should be determined as a first measure. Arsenic poisoning was first detected in Bangladesh in 1993 by the Department of Public Health Engineering (DPHE). The DPHE recently indicated that about 59 out of 64 districts have been affected by arsenic contamination. The known contamination covers almost 60 percent of the total area of the country. During 1998 under "A Rapid Action Program", 200 Villages were surveyed for studying arsenic poisoning by the Dhaka Community Hospital (DCH) and Jadavpur University of Calcutta, India. They estimated that about 50 percent of all the tube wells in the country exceeded the safe maximum contamination level. In another report, UNDP claimed that 40 percent of all wells are contaminated by arsenic.

The World Health Organization (WHO) has set 0.05mg/L as the upper permissible limit for arsenic in drinking water. An excess of arsenic leads to serious human health problems. It may take 8-14 years after starting to drink arsenic contaminated water for symptoms to appear (Nikolidis, 1998). This period depends on the amount of arsenic ingested, the length of exposure and immunity level of the person. People with poor socioeconomic & nutritional status are also more vulnerable to arsenic poisoning.

International organizations like UNICEF & WHO have come to the aid of Bangladesh in resolving the crisis. The government of Bangladesh has also mobilized some of its agencies towards this end. Different NGO's like "Grameen Bank" have also stepped in to investigate the extent of arsenic contamination and to help people suffering from arsenicosis.

Arsenic enters the human body through ingestion, inhalation, or skin ailments through disruption. Most ingested arsenic is well absorbed through the intestinal tract and lung and then into the blood stream (Karim, 1997; Chakraborti, 1996; Gorbi, 1994). It is distributed in a large number of organs including the lungs, liver, kidney and intestine within 24 hours of ingestion & to skin, hair and bone thin two weeks. Inorganic (trivalent) compounds are absorbed more readily than organic (pentavalent) forms, with greater than 80 percent of an ingested dose absorbed by the gastrointestinal tract.

Inorganic arsenic compounds are found in concentrations in leukocyte. Inorganic arsenic does not cross the blood-brain barrier but does cross the placenta. Between 5 and 10 percent is excreted in the feces and 90 to 95 is excreted in urine (Harison, 1995). Small amounts are recovered in bile, feces saliva, and breast milk.

It is not possible to recommend one method all over Bangladesh to get rid from arsenic contamination in groundwater. The people of Bangladesh are so poor that they are not able to buy any chemical for disinfection of surface water or for purifying arsenic tainted water. On the other hand, all chemical methods producing high concentrated arsenic containing sludge, which is another problem. At present, it is suggested by the researchers to dispose off the arsenic rich sludge into a hole containing cow-dung and expected that by biomethylation, a certain type of bacteria will convert arsenic to arsine gas (AsH_3) and will free to the atmosphere. Since, the hole is uncovered and duration of biomethylation is unknown, so in the mean time, arsenic can leach again from cow-dung and may contaminate the groundwater (Shafiullah, 1996). Is there any problem of using this cow-dung as fertilizer? Is there any possibility of arsenic contamination in the food cycle through crops? Till now it is not clear to us.

Experts think that pesticides and chemical fertilizers may be the source of contamination. If this hypothesis would be true, then at first water must be contaminated by arsenic, but after laboratory analysis it was found that surface water both soft & hard is free from contamination. Only exception was found in Narayanjang district industrial arsenic waste were dumped (BANL). From this view point, it is clear that pesticides and chemical fertilizers may not be the major of arsenic contamination in ground water.

If one tube well is not contaminated- we can't tell that after a short period it will be free from arsenic contamination. Till now surface water is out of arsenic contamination. We should try to keep it safe. If we take out more arsenic contaminated water and after using- ultimately it will mix up with the surface water and contaminate it. So, it is utmost pressing to stop taking out of arsenic tainted water. In view of the overwhelming dependence of the population on groundwater as the source of drinking water, there is an urgent need to develop suitable methods for removal of arsenic from groundwater. Socioeconomic conditions of Bangladesh demands low cost, as well as, small scale treatment systems that could be implemented in the rural areas at household or community level.

The aim of the present work was to make comparative study of existing methods for detection of arsenic in water samples by field test kits and by laboratory based instrumental methods.

Materials and Methods

The experiment was set in the Analytical Chemistry Laboratory, Institute of Nuclear Science & Technology, Bangladesh Atomic Energy Commission, Savar, Dhaka and the field study contacted in Kochua, Chandpur, Bangladesh.

Materials of test kit

Flanges (plastic), clip, test tube, light proof container, disc paper, (Mercury (II) bromide paper), color scale, tissue paper, test tube holder, Caring box, etc.

Reagents of test kit

Potassium iodide (KI), highly pure Zinc (Zn), Stannous chloride ($SnCl_2$), Hydrochloric acid ($HCl: H_2O = 1:1$) and Mercuric bromide ($HgBr_2$) solution.

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Method for detection of Arsenic using Test Kit

15 ml water sample is taken in a test tube and very small amount of potassium iodide (KI) & stannous bromide (SnBr_2) are added which act as a reducing agent. Then small amount of Zinc (Zn) and Hydrochloric acid (HCl) is added, which reacts with As^{3+} present in water sample and produce arsine gas. Color change (Yellow to reddish brown like diabetes) produced by reaction of arsine gas with modified mercury (II) bromide disc indicates the presence of arsenic in water sample (no color = absence or below detection level). So, by observing the color scale (Annex-1), and by taking the help from Chemistry of Arsenic measurement by Mercuric Bromide stains method (Annex-2) the water samples can be readily detected.

Instrument used

In this study computerized Shimadzu model AA-6800 atomic absorption spectrophotometer (AAS) coupled with Shimadzu model hydride vapour generator, hvg-1 was used where computer controlled single beam instrument having: a grating monochromator, photomultiplier detector adjustable spectral bandwidth, provision for interfacing with a strip chart recorder, burner in this case used as an atomizer, hollow cathode lamp and hydride vapor generator was the main apparatus.

Reagents of AAS

SM HC1, 0.5% w/v NaBH_4 in 0.5% NaOH, Potassium iodide (KI) and Ascorbic acid

Conditions for hydride generation

Reagent flow rate = 2.5 ml/min, Sample flow rate = 3.5 ml/min, Carrier gas (Ar) flow rate = 8 L/min Optics Parameters: Element: As, Socket # 1, Lamp Current Low (mA): 12, Wavelength: 193.7 nm, Slit Width: 0.5nm, Lamp Mode: BGC-D2, Atomizer Gas Flow Rate Setup: Fuel Gas Flow Rate: 2.0 L/min, Flame Type: Air C_2H_2 , Burner Height: 16mm, Burner Angle: 0, Measurement Parameters: Order: 1 St, Zero Intercept: Yes, Conc. Unit: ppb, Repetition Sequence: SM-SM-..., Pre-Spray Time: 3 sec, Integration Time: 5 sec, Response Time: 1sec

Model sample prepared for arsenic detection

Preparation of stock solution

4.5 gm caustic soda (NaOH) is taken in a 500 ml beaker and dissolved in 50 ml distilled water. Then As_2O_3 (Powder form) is added and the mixture stirred with a glass rod for a few minutes. This mixture is heated up to boiling for dissolving As_2O_3 . The hot solution is allowed to cool and transferred to a 1000 ml volumetric flask and diluted by adding distilled water up to the mark. This solution is called stock solution.

Specification of As_2O_3 used

Arsenic content not less than 99.8% (As_2O_3) So. Purity of As_2O_3 , $x = 0.998$

Preparation of standard samples (model mixtures)

Model samples of definite arsenic concentration e.g. 300, 200, 100 and 50 ppb are now prepared by taking accurately 0.3, 0.2, 0.1 and 0.05 ml respectively of the stock solution in separate 1000 ml volumetric flasks, adding 1 drop of concentrated sulfuric acid (H_2SO_4) into each flask and diluting the content with distilled water up to the mark.

Construction of Calibration Curve

1.0 ppb, 2.0 ppb, 4.0 ppb and 6.0 ppb standard samples were prepared carefully. Then these samples were passed through the Atomic Absorption Spectrophotometer (AAS) which coupled with Hydride Vapour Generator (HVG) and the Calibration Curve (Absorbance vs. Concentration) is made automatically.

Results and Discussion

In order to assess the deviation in the results of measurement of arsenic content from the actual value in water samples by field test kit and by AAS method, the four (4) prepared model samples were analyzed for As^{3+} content. The results are shown in Figure 1- 3.

Fig. 1. Arsenic concentration in model samples

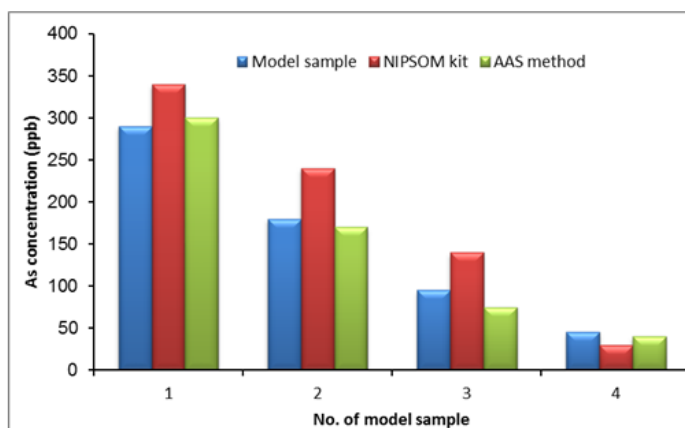


Fig. 2. Comparison graph between original concentration of model samples and NIPSOM Kit results

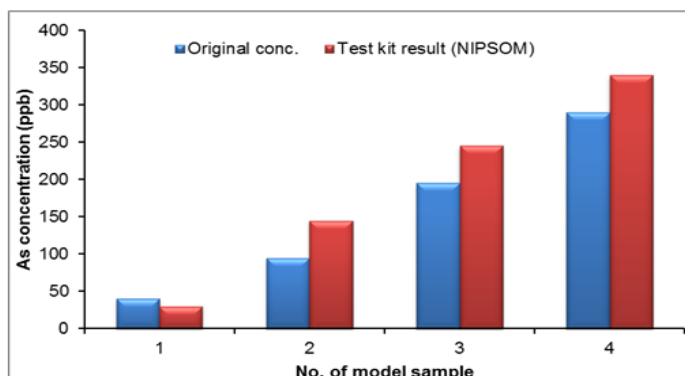
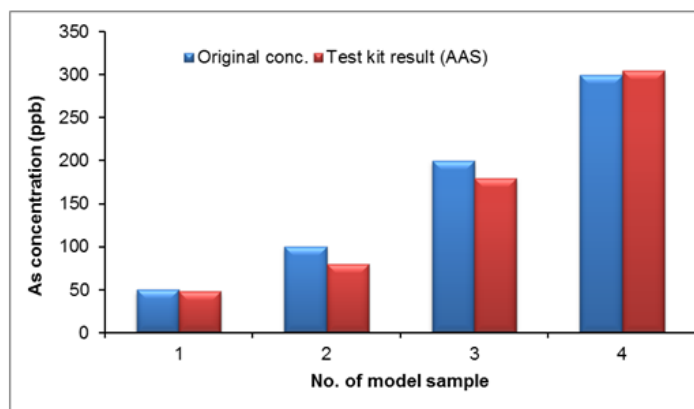


Fig. 3. Comparison graph between original concentration of model samples and AAS results



From the data of above graphs, it may be observed that the results of arsenic concentration by AAS are close to the actual value. But the results from Kit deviate from the real value of arsenic concentration by 20 to 50 %.

Sample analysis in the field

After collection of water samples from four different tube wells (Table 1-2), concentration of arsenic was measured with the help of E-Mark arsenic test kit (Germany).

Table 1. Samples of tube well waters from 4 tube wells owners Kachua, Chandpur

Sample number	Owner of the tube well from where sample was collected	Depth of tube well (ft)
R-1	Mr. Gibon Sarker	150
R-2	Mr. Sukumol Sarker	160
R-3	Mr. Jatindra Mohon	180
R-4	Mr. Pranodhon Dev	200

Table 2. Arsenic content in tube well sample waters

Original tube well water sample no.	Concentration of arsenic, determined by E-Mark Kit
R-1	200
R-2	250
R-3	400
R-4	350

Analysis of samples in the laboratory

The original arsenic contaminated water samples from 4 different tube wells (Table 3; Fig. 4) were collected in separate plastic of 200 ml capacity and quickly transferred to the analytical laboratory of Institute of Nuclear Science & Technology (INST), Savar Dhaka

where the samples were analyzed for arsenic content Atomic Absorption Spectrophotometer (AAS). Separate measurements were also made by NIPSOM Kit to determine the concentration in all the above water samples.

Fig. 4. Graphical representation of arsenic content determined by three different test kits

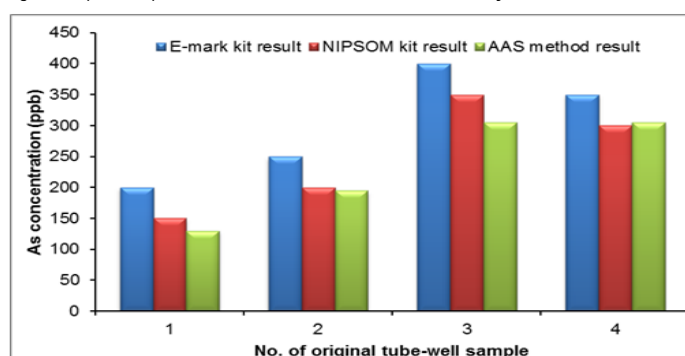


Table 3. Contrast of results of measurement of arsenic concentration in water samples by Field Test Kit and AAS methods

Source of water sample	As content determined by		Deviation	% deviation
	Field Test Kit	AAS method		
Model sample-1	350	307	+43	14.01
Model sample-2	250	184	+66	35.8
Model sample-3	150	82	+68	82.8
Model sample-4	35	46.6	-11.6	24.9
Tube well water sample, R ₁	150	126.03	+23.97	19.2
Tube well water sample, R ₂	200	195.67	+4.33	2.2
Tube well water sample, R ₃	350	308.99	+41.01	13.3
Tube well water sample, R ₄	350	306.23	+43.77	14.4

In the field test kit arsenic can be detected from 0.01 mg/L to 0.5 mg/L and above. In the range below 0.1 ppm, Field Test Kit gives smaller values than those by AAS and large values in the range over 0.1 ppm. There is 90-100% applicability of Field Test Kit for the arsenic concentration below 0.05 ppm and 88% for the range between 0.05-0.10 ppm and 87% in the range of 0.1-0.5ppm. Field Test Kit method is applicable in the range below 0.10 ppm and has hit of 90% over 0.1 ppm. Table 3 indicates that result obtained by field test kit is 20-50% higher than the sensitive laboratory method AAS.

Conclusion

Presently, Arsenic content in water is measured by either of the two methods: laboratory based instrumental methods like AAS, TXRF etc. or by Test Kits (Gutzeit Method) at the site. In this work, a comparative study of the AAS method with Test Kits was done. Arsenic concentrations in some prepared model samples were determined by NIPSOM Test Kits and the results were verified by Atomic Absorption Spectrophotometry (AAS) method. It was observed that in the field test kit arsenic can be detected from 0.01 mg/L to 0.5 mg/L and above. In the range below 0.1ppm, Field Test Kit gives smaller values than those by AAS and large values in the range over 0.1 ppm. There is 90-100% applicability of Field Test Kit for the arsenic concentration below 0.05 ppm and 88% for the range between 0.05 to 0.10ppm and 87% in the range of 0.1-0.5ppm. Field Test Kit method is applicable in the range below 0.10ppm and has hit of 90% over 0.10ppm. Table 3.3.17 indicates that result obtained by Field Test Kit is 20-50% higher than the

sensitive laboratory method AAS. In about 59 out of 64 districts of Bangladesh, the tubewell waters are found to be contaminated with arsenic. Arsenic concentration in most of the tube well waters in those districts are found to be above the upper permissible limit of 0.05 mg/L set by World Health Organization (WHO).

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