AN ANALYTICAL ASSESSMENT OF GPL KIT FOR FIELD LEVEL DETECTION OF ARSENIC IN WATER

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ABSTRACT

An attempt was taken to evaluate the suitability of GPL kit for field level detection of arsenic in water. The sources of variation in results of tests for arsenic determined by GPL kit seemed to be use of different sets of apparatus, reagents and person to person handling of the apparatus. Variation in results of tests due to use of different sets of the GPL kit was more prominent (Standard deviation 76.524) than that of the reagents used and person to person handling (Standard deviation 40). Among the three sources of variation person to person handling of the kits had the least effect on the test results. Results given by GPL and NIPSOM kits did not differ qualitatively although differed quantitatively.

INTRODUCTION

Background

Arsenic is an element with metalloid property and is known for its toxicity. It occurs naturally in the environment and in different forms, organic and inorganic with different toxicity. Humans are exposed to arsenic mainly through eating, drinking and breathing. The GOB has provisionally set 50 ppb as the upper permissible limit for arsenic in drinking water (DoE, 1991). An excess of arsenic leads to serious human health problems. Estimates suggest that at present nearly 75 million people of Bangladesh are at risk of arsenic poisoning in drinking water.

This life threatening element was first detected in the groundwater of Bangladesh in 1993. Since that time both governmental and non-governmental agencies have conducted arsenic analyses in various parts of the country.

GPL test kit

Different analytical devices are being used to detect arsenic content in water. Among them AAN/NIPSOM (Ahmad, S. A. *et al.*, 1997) and GPL (MODEL UI, made for UNICEF supported projects) kits are so far available in Bangladesh for field level extensive testing work. These two kits give quantitative data as well with some limitations. Actually GPL kit is slightly modification of NIPSOM kit and can detect from 10 ppb to 1500 ppb of arsenic in water (1 mg = 1000 ppb). In GPL kit there are 10 color grades in the color chart to match the color produced in the disc paper from the respective water sample in each test. This kit needs an assessment of its suitability for field level detection of arsenic in tubewell water.

BRAC's arsenic activities

BRAC-the world's largest national non-government development organization has been contributing to combat this serious problem of Bangladesh. A total of 802 tubewells installed in BRAC's area offices were tested in 1996. In 1997 all tubewells of Hajigonj thana, Chandpur were tested and painted red if found upper permissible limit (>50ppb) and green if below permissible limit (=/<50ppb). In 1998 it has completed successfully a project on testing for arsenic in approximately 18000 tubewells installed by DPHE in collaboration with DPHE and UNICEF. In these projects BRAC has used NIPSOM field test kits for detection of arsenic in water.

Recently BRAC has initiated a community based arsenic mitigation project in Jhikorgachha thana under Jessore district and Sonargaon thana of Narayanganj district in collaboration with DPHE and UNICEF. As part of the project activities, in Jhikorgachha thana, testing of tubewell work has been started with BRAC's 77 VHWs who would carryout the field level testing work.

After completing a 2 days training successfully on arsenic testing by GPL field kit they were involved in the testing work. Four well trained field supervisors were responsible for the testing work by the VHWs throughout the period required. In this testing work GPL kits were used to conduct the field level testing work.

This study was an attempt to find out problems and the extent and sources of variation in results of tests for arsenic in water by GPL kit.

OBJECTIVES

The broad objective of the present work was to asses the suitability of GPL kit as a device for detection of arsenic in tubewell water.
The specific objectives were to

i) find out sources of variation in test results done by GPL kits
ii) determine the range of variation in test results due to apparatus , reagents used and person to person handling
iii) point out the complains against the kit during the field level testing work

METHODOLOGY

In this experiment the tests for arsenic in tubewell water were carried out by using GPL kit in the Jhikorgachha RDP office, Jessore. Some of the tests were done by NIPSOM kit. Complains against the GPL kit were collected from the field level testing conducted by the supervisors during their regular field works. Then these complains were justified and discussed with them in the office.

EXTENT AND SOURCES OF VARIATION IN TEST RESULTS

To find out the extent and sources of variation in results of tests for arsenic by GPL kit water samples were collected from four different tubewells located in different places. It was tried to find out the sources of variation in results of tests given below.

Table 1: Results of tests for arsenic in the same sample water done by different persons with different kits.

Sl.	Person	GPL kit	Conc. of As in ppb	Sd.
1	1	1	400	
2	2	2	300	
3	3	3	300	74.833
4	4	4	200	
5	5	5	200	

Table 1 shows the results of tests for arsenic concentration in the same water sample which varied from 200 ppb to 400 ppb. The possible sources of such variation of results may be both use of different kits and person to person handling as well as chemicals used.

Table 2: Results of tests for arsenic in the same sample water done by different persons with same kit.

SL.	Person	Conc. of As in ppb	Sd.
1	1	300	
2	2	300	
3	3	200	40
4	4	300	
5	5	250	

As the results shown in Table 2 are of the same sample done by different persons with the same kit the variation is obviously due to person to person handling of the kit.

Table 3: Results of tests for arsenic in the same sample water done by the same person with the same kit.

SL.	Replicate	Conc. of As in ppb	Sd.
1	1	300	
2	2	300	
3	3	300	48.989
4	4	200	
5	5	200	

Test results shown in Table 3 varied from 200 ppb to 300 ppb. As the sample, person and kit used here are constant the possible sources of variation in test results may be timing of the test, amount of reagents added, fixing of the flange, and setting the disc paper to trap the arsine gas properly.

Table 4: Results of tests for arsenic in the same sample water done by the same person with different GPL kits.

SL.	GPL kit	Conc. of As in ppb	Sd.
1	1	200	
2	2	10	
3	3	200	76.524
4	4	200	
5	5	100	

Table 4 shows the results of tests for arsenic in the same sample water done by the same person with different sets of GPL kit. The variation of results ranged from 10 ppb to 200 ppb which is most probably due to difference in apparatus of the different sets of kit if the quality of the reagent is considered same. In this experiment the lower value 10 ppb given by GPL kit-2 may be due to any provisions of gas pass through any route between test-tube and the cork of the flange.

From the observation of the test results it is clear that quantitative variation exists in these results although there is no qualitative effect except in case of test no. 2 shown in Table 4. Because all these values are above the upper permissible limit (50 ppb) for arsenic in drinking water. But if the difference is 200 ppb then it will affect the result when the exact concentration of arsenic in any water is close to 50 ppb. Because in such case the water will be treated either safe or unsafe.

The range of variation from 200 ppb to 300 ppb has been found in both Table 2 and Table 3. So, if the sample water and the GPL kit are constant the variation in test results due to handling of GPL kits by different persons and by the same person is nearly same. Thus, these two sources of variation has no prominent role in test results.

The results of tests given in Table 4 ranged from 10 ppb to 200 ppb. This results given by the GPL kit is still to be a question of quality testing for arsenic. Except the test result given by GPL kit 2 the others are qualitatively same. According to the result given by this GPL kit 2 water is suitable for drinking or cooking. On the other hand, water with 200 ppb arsenic is highly contaminated. This lower value of 10 ppb is most probably due to gas pass through the joint between two parts of the flange joined by the clip.

COMPARISON BETWEEN NIPSOM AND GPL KIT RESULTS

Tests for arsenic concentration in six water samples were done to compare the variation of the results.

Table 5: Results of tests for arsenic in water determined by NIPSOM and GPL kits.

SL.	Sample	NIPSOM kit (in mg/L)	GPL kit (in ppb)
1	1	0.05 (50 ppb)	30
2	2	0.05 (50 ppb)	30
3	3	0.05 (50 ppb)	30
4	4	0.5 (500 ppb)	300
5	5	0.5 (500 ppb)	1500
6	6	0.5 (500 ppb)	100

According to NIPSOM kit results (Table 5) three water samples are unsafe and the rest are safe as per drinking water quality standard and the same qualitative results have been given by the GPL kit. So, GPL kit did not differ in results of tests for arsenic from the results given by NIPSOM kit.

SOME COMPLAINS AGAINST GPL FIELD KIT

Complains against GPL apparatus

(1) One of the directions for using this field kit is to keep this at temperature between 20°C to 25°C. But at the month of June when testing work was conducted temperature was recorded from 35°C to 37°C in the region of Jessore district. Beside this, field level workers for testing work have to move rural areas. So, it is quite impossible for them to keep this kit at the range of temperature as instructed.

(2) In some cases the size of disc paper was not uniform. When it was larger than the cavity of the flange where to be placed it became folded at the time of placing it in the cavity. This might have influence in gas pass produced by the reaction in the test-tube.

(3) It's difficult to pluck the disc paper from the cavity of the flange with the help of disc paper. Beside this, use of such forceps causes disc paper folded.

(4) Cork attached at the lower portion of the flange has been found two types. The soft one has been found to fit well with the test-tube. The hard cork does not fit well with the test-tube which may cause gas pass from the test-tube during reaction. Another type of transparent and glassy cork most probably made of plastic has been found in some kits. After fixing this with the test-tube it has been found that this type gets out of the test tube slowly and automatically.

(5) After several days of using the forceps it shows rust production. This causes color production in the disc paper when it gets contact with that.

(6) Sometimes lead acetate cotton placed inside the cavity of the flange has been found black in color at the lower portion.

(7) In some kits the inside wall of the cavity of the flange where lead acetate cotton is placed has been found irregular in shape. Some times it is swollen causing the reduction of the interior volume.

Complains against the reagents

(1) As per the instruction of using the GPL kit 100 tests should be completed with the reagents contained by each bottle in a refill pack. But except HCl_2 and Zn other two reagents KI and $SnCl_2$ run short quickly. One bottle of KI can complete at best 80 tests and $SnCl_2$ can 60 only even though these salts are not melted.

(2) Comparatively $SnCl_2$ is melted more quickly than KI. As a result one bottle of $SnCl_2$ can carryout at best 50 tests. Due to it's moisture absorbing nature it becomes liquid in nature and consequently the volume is reduced. So, the amount of $SnCl_2$ in a set can not complete the number of tests as per instruction.

(3) During the period of testing of a sample water, after addition of Zn in the solution the whole amount of Zn forms clog and floats over the solution and blocks the test tube. This clog formation creates a barrier for gas pass upwardly through the test tube and the flange. This clog moves upward.

A relationship between such clog formation and physical properties of $SnCl_2$ have been found. Only 2 bottles out of 100 were different where $SnCl_2$ salt was powdery and white in color. The rest of the $SnCl_2$ salts were all hygroscopic and granular. The powdery white $SnCl_2$ salt did not absorb moisture and was never melted. On the other hand, the transparent granular $SnCl_2$ salt absorbed moisture and was melted quickly. During the reaction, the powdery white $SnCl_2$ did not produce clog inside the test-tube whereas the hygroscopic granular $SnCl_2$ salt produced clog in the test-tube.

Table 6: Effects of properties of $SnCl_2$ in reaction.

SL.	Types of $SnCl_2$	Total tests for arsenic content in water	No. of tests where clog formation occurred
1	Powdery white $SnCl_2$	60	0
2	Hygroscopic granular $SnCl_2$	>150	>150

(4) After addition of Zn sometimes excess bubbles are produced. These bubbles move upwards and touch the lead acetate cotton placed in the cavity of the flange.

CONCLUSION AND RECOMMENDATIONS

- Sources of variation in results of tests for arsenic determined by GPL kit were apparatus, reagents and person to person handling of the kit.
- Variation in results of tests due to use of different apparatus of the GPL kit is more prominent than that of the reagents used and person to person handling. Among the three sources of variation person to person handling of the kits has the least effect on the test results.
- Results given by GPL and NIPSOM kits did not differ qualitatively although differed quantitatively.
- Quality of the reagents seemed to be questioned.
- Apparatus should be uniform in structure.

LIM ITATIONS

There were some limitations in this study which have been mentioned below-

1. Results were not cross-checked by AAS/Spectrophotometer.
2. Number of samples of tests was smaller.
3. Tests were done only in duplicate due to lack of sufficient reagents.

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REFERENCES

Ahmad, S. A., M. H. Salim Ullah Sayed, Sk. Abdul Hadi and Abdul Wadud Khan. Modified Arsenic field Test Kit: A cheap and easy device for detection of arsenic in water. *Journal of Preventive & Social Medicine*, 1997; **16(2)**: 143-150.

Department of Environment, Bangladesh (1991). Environmental Water Quality Standards for Bangladesh.

ABBREVIATION

AAN	Asian Arsenic Network
As	Arsenic
Conc.	Concentration
DPHE	Department of Public Health Engineering
GPL	General Pharmaceuticals Limited
GOB	Government Of Bangladesh
mg	milligram
NIPSOM	National Institute of Preventive and Social Medicine
L	Litre
ppb	parts per billion
RDP	Rural Development Program
VHW	Village Health Worker