



Arsenic Testing the Easy Way

Test strip technology advances make difficult arsenic detection a thing of the past.

Arsenic often is remembered as a poison, used since medieval times to eliminate unsuspecting persons. In those days, arsenic was a perfect murder weapon because the symptoms of death mimicked other causes and, therefore, were hard to trace. Severe poisoning and possibly death can occur from just 100 mg of arsenic. Lower frequent doses like those received from contaminated drinking water build up in the body and produce varying side effects. Cancer, diabetes and cardiovascular problems are linked to arsenic poisoning. Some research suggests that as little as 3 parts per billion (ppb) is potentially harmful.

The thought of arsenic being present at any quantity in drinking water is quite alarming to the average consumer. Groundwater contaminated with arsenic has been found in 49 of the 50 states in the United States. Arsenic most often is present in the environment in the form of inorganic arsenic and enters groundwater from the erosion of arsenic-containing rocks and soil. Inorganic arsenic consists of arsenic ions combined with chlorine, oxygen and sulfur ions to form compounds known as arsenite (As⁻³) and arsenate (As⁻⁵). (Arsenite is the more toxic of the two forms.)

Testing for Arsenic

In the past, testing for arsenic in drinking water has been as difficult as removing it. Measuring arsenic concentrations accurately was left to the laboratory and expensive instrumentation such as atomic absorption spectrometers. Time delay and expense are the obvious problems with this approach. A variety of test kits have appeared on the market deriving from the need for easier, cheaper and faster methods. These test kits rival both the accuracy and low detection ability of laboratory instrumentation.

Of the available competing products, the most useful arsenic test kits report quantitatively as well as qualitatively. All of these kits rely on similar chemistry in which inorganic arsenic compounds (As⁻³ and As⁻⁵) are reduced to arsine gas. This is done in a controlled reaction between an acidified water sample and zinc powder. A volume-specific reaction vessel, usually a plastic bottle supplied in the test kit, is used for this reaction. Different kits typically require different sample sizes and usually employ

additional reagents to control interferences from other common elements found in groundwater such as hydrogen sulfide and iron. Once the sample and all of the reagents are combined in the reaction vessel, a test strip is used to measure the arsenic concentration of the water sample. The test strip is not dipped into the sample but rather placed above the sample in a special cap that seals the reaction vessel. As the arsenic converts to arsine gas and comes in contact with the test strip, the mercuric bromide indicator on the test strip changes in color from white to shades of yellow and brown. This chemical reaction varies in time between test kits from 10 to 30 minutes. Once the reaction is completed, the test strip is removed and matched to a color comparator chart to obtain a quantitative measure for arsenic in the tested sample.

These test kits are convenient in that they include all needed materials and reagents. In most cases, even the type of acid has been carefully selected to be of a weaker and less hazardous nature for easier transport and safer use. Arsenic test kits also can be a cost effective alternative or preliminary test to laboratory testing with the average price per test being less than \$2.

Correlation Study

When considering options in arsenic testing, people often ask if a test strip-based test kit really is an accurate way to measure arsenic. Answering "yes" in a positive tone does answer the question. Actual test data from a third party is more convincing proof and often is requested. To help in demonstrating arsenic field test kit accuracy, a non-biased third party was used to conduct a study of the major brands of arsenic test kits available in the United States.

In a study, conducted by Dr. Mark Zabo of Catawba College in Salisbury, N.C., several arsenic standards were prepared using NIST Standard Reference Material 3103a. Four different test kits were used to test each set of standards. (See Chart 1.)

In reviewing the results from the chart, it is important to remember that the test kits studied use test strips. Test strips are colorimetric and the results depend on matching colors by eye. One shortcoming of a colorimetric test like this is the limited number of preselected levels present on a color chart. This limited number of levels,

Chart 1: Arsenic Standard Testing Using Test Kits

HACH Co. Arsenic Test Kit 30-Minute Procedure part number 28000-88

Prepared Sample	Test Result	Sample Temperature	Comments
distilled water #1	0 ppb	23.0 °C	no color change
distilled water #2	0 ppb	22.0 °C	no color change
3 ppb #1	about 3 ppb	22.5 °C	very small color change
3 ppb #2	about 3 ppb	25.9 °C	very small color change
10 ppb #1	10 ppb	23.3 °C	matched the color on the color chart
10 ppb #2	10 ppb	25.7 °C	matched the color on the color chart
50 ppb #1	40–50 ppb	25.5 °C	not quite dark enough to be 0.050 mg/L
50 ppb #2	40–50 ppb	25.5 °C	not quite dark enough to be 0.050 mg/L

Industrial Test Systems, Inc., Arsenic Check 30 Minute Procedure part number 481196

Prepared Sample	Test Result	Sample Temperature	Comments
distilled water #1	0 ppb	25.0 °C	no color change
distilled water #2	0 ppb	24.0 °C	no color change
3 ppb #1	about 2 ppb	26.4 °C	very small color change (barely yellow)
3 ppb #2	about 2 ppb	26.4 °C	very small color change (barely yellow)
10 ppb #1	9–10 ppb	26.9 °C	very close to the color of 0.010 mg/L on chart
10 ppb #2	9–10 ppb	26.9 °C	very close to the color of 0.010 mg/L on chart
50 ppb #1	50–60 ppb	24.5 °C	slightly darker yellow than 0.050 mg/L
50 ppb #2	50–60 ppb	24.5 °C	slightly darker yellow than 0.050 mg/L

Industrial Test Systems, Inc., Low Range Arsenic Check 30 Minute Procedure part number 481296

Prepared Sample	Test Result	Sample Temperature	Comments
distilled water #1	0 ppb	24.0 °C	no color change
distilled water #2	0 ppb	24.2 °C	no color change
3 ppb #1	about 2 ppb	22.0 °C	slight color change (very light yellow)
3 ppb #2	about 2 ppb	22.0 °C	slight color change (very light yellow)
10 ppb #1	about 8 ppb	27.1 °C	not yellow enough to be 0.010 mg/L
10 ppb #2	about 8 ppb	27.1 °C	not yellow enough to be 0.010 mg/L
50 ppb #1	50 ppb	24.8 °C	matched the color on the color chart
50 ppb #2	50 ppb	24.8 °C	matched the color on the color chart

Industrial Test Systems, Inc., Quick Arsenic Test Kit 30 Minute Procedure part number 481396

Prepared Sample	Test Result	Sample Temperature	Comments
distilled water #1	0 ppb	23.0 °C	no color change
distilled water #2	0 ppb	22.0 °C	no color change
3 ppb #1	about 3 ppb	23.0 °C	small color change
3 ppb #2	about 3 ppb	23.0 °C	small color change
10 ppb #1	10 ppb	26.6 °C	matched the color on the color chart
10 ppb #2	10 ppb	26.6 °C	matched the color on the color chart
50 ppb #1	50–60 ppb	24.5 °C	very close to the color of 0.060 mg/L on chart
50 ppb #2	50–60 ppb	24.5 °C	very close to the color of 0.060 mg/L on chart

ppb = parts per billion

Prepared by Dr. Mark Zabo, Catawba College, Salisbury, N.C., using NIST Standard Reference Material 3103a, Arsenic (As) Standard Solution, Lot# 891003

which convert to test results, sometimes requires the reader to estimate a reading that is between available colors. For example, of the four test kits studied only one had color levels available on the color chart below 5 ppb. Yet, the individual running these tests was still able to estimate results of 3 ppb. In another instance, with the Low Range Arsenic Check, there was no 50 ppb level (only 40 and 60 ppb), but an accurate result was estimated. In summary, a strong point of this type of arsenic test kit is test result resolution. Between the mercuric bromide indicator on the test strip and carefully printed color charts, the individual running the test is able to obtain a detailed picture of arsenic concentrations in water—even with only a test strip.

A second point to make with reference to the test data is the obvious reproducibility of these test kits from one test to the next. At each level of arsenic concentration, two samples were tested. When the tests for each kit were completed, results were found to be the same for both samples of the same arsenic concentration. Predictable and reproducible results

are as important as accurate results when considering test methods.

Important Test Kit Features

Although most arsenic test kits use the same basic method and chemistry, each kit is unique. When considering which test kit you will choose, there are some important factors to consider.

- **Ease of use.** A variety of kits is available with varying levels of complexity. Testing for arsenic may not be as easy as testing for many other ions. However, some manufacturers have done a better job than others at making test procedures easy to perform and understand. Fewer steps, easy-to-read instructions and illustrations are key to reducing confusion and human error.

- **Time.** Three of the four test kits included in the study require a 30-minute incubation time while the arsenic in the water sample is reduced to arsine gas. Compared to other test methods, 30 minutes is a great time saving. However, if you have a large number of samples to

test, or just don't like to wait, a 10-minute test may be more desirable. The addition of arsine gas enhancers in a kit's reagents runs tests in a third of the time of other kits.

- **Cost.** Choosing testing kits for measuring water quality often is a balance of cost versus performance especially if many tests are required. With the average price per test between \$1 and \$2.40, all kits evaluated in this article are cost effective alternative when compared to the cost of sending water samples to a laboratory.

- **Sensitivity.** Detection range or sensitivity is a common question regarding arsenic testing methods. With the current arsenic standard of 50 ppb in debate and most water sources in the United States below 100 ppb, additional sensitivity eventually may win out over other test kit benefits. At the same time, water quality professionals who install arsenic remediation devices ask for tests that detect less than 10 ppb. This low detection sensitivity is important for the calibration and efficiency confirmation of the arsenic removal equipment. With

these considerations, a low-range arsenic kit may be your best option with low detection levels at 2, 4, 6, 10, 15, 20 and up to 240 ppb. This is accomplished by a larger sample size (250 ml compared to 50 or 100 ml) and chemical enhancers that produce colors of greater intensity at lower concentrations of arsenic.

Which type of test method is right for your arsenic detection and measurement needs? Improvements in test strip technology make it possible to test water for arsenic easily, quickly, cost effectively, accurately and at useful detection levels. Using the previously stated considerations ease of use, testing time, cost and sensitivity, your arsenic test kit should be easy to select.

About the Author

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