TESTING THE WATERS

HOW GOOD IS THAT BOTTLED WATER AND HOW EFFECTIVE IS YOUR WATER FILTER

TEACHER NOTES

This experiment is designed for students working singly or in groups of two. One run through the series of tests will take most of the laboratory period. Each group is to be responsible for testing ONE TYPE of water using each of the tests available. All data will be shared within the class.

Due to the number of tests and the many reagents needed, this experiment uses Hach water test kits for most of the tests. The Hach kits are designed for environmental tests of both drinking water and surface waters. Except, where noted, disposal does not harm the environment, but normal laboratory disposal methods should be followed.

The Hach water test kits used are:

Total Hardness and Iron Test Kit, Model HA-77
Lead (LeadTrak), Model DR 100
Copper, Free and Total Test Kit, Model Cu-6
Free and Total Chlorine Test Kit, Model CN66
EZ Arsenic Test Kit 28228-00

Students also measure the total dissolved solids in their water sample. This is done by evaporation, by boiling, of 100 mL of water. It is recommended that hot plates be used to heat the water and, if so equipped, the apparatus be placed under a fume hood.

The types of water to be tested are:

Tap water (more than one source can be used)
Filtered tap water using a Brita water filter or equivalent
Contaminated water, made using the “metal ion mixture” which follows
Filtered contaminated water using a Brita water filter or equivalent
Bottled tap water or “purified” water such as Aquafina (Pepsi Co.) and DeSani (Coca Cola Co.)
Bottled spring water. Various brands labeled as “natural” and “spring water”
Bottled, “natural” sparkling water such as Perrier (Note: Any sparkling water must be totally defizzed before testing so carbon dioxide will not interfere with any tests.)
Well water – supplied by student

All bottled water must be in its original container so students have access to label information.

Students will need approximately 500 mL of water for testing.

Room set up

To run this experiment efficiently, the room should be set up with lab tables, or sections of laboratory benches, used as testing stations. One station should be set up for testing hardness and iron, one for testing pH, one for testing chlorine, one for testing lead, and so forth. The area for evaporating water to determine dissolved solids should be set up under a hood, to help speed evaporation. Microscopes should be set up on a laboratory table,

Students should rotate between stations to complete their tests. Do not allow students to move materials needed for any test from one station to another.

If testing “stations” are not maintained, students will have difficulty in completing all the required water tests and there will be a great deal of confusion in the laboratory.

The lead test takes about 15 minutes and the arsenic test takes about 20 minutes. Some students should start these tests immediately.

There should be two sets of plastic testing bottles, but only ONE set of reagents, available for the lead test. Two groups of students should be able to run this test, slightly staggered, at the same time. Due to the number of reagents used, a second set of reagents will make this test confusing.

There should be at least two arsenic testing bottles available for the arsenic test. There should be only one package of each of the two arsenic test pillows and one bottle of test strips.

Metal Ion Mixture:

The detection range for materials in the water are:

Total Hardness and Iron Test Kit, Model HA-77	1drop = 1 gpg (17 mg/L) $CaCO_3$
	0-5 mg/L Fe
Lead (LeadTrak), Model DR 100	0-150 µg/L Pb
Copper, Free and Total Test Kit, Model CU-6	0-5 mg/L Cu
Free and Total Chlorine Test Kit, Model CN66	0-3.5 mg/L Cl_2
Arsenic	0-500 ppb

This is an experiment where a successful test reports a **low** concentration of material in the water.

The total dissolved solids will vary with the water used. Be sure that students are instructed to use a clean dry beaker and to use the same balance for all mass determinations. Students should make sure the balances are level and zeroed before weighing the beaker. Beakers should be labeled for identification using a pencil and marking the white labeling area on the beaker – they must not use tape or any other externally applied identification method. Occasionally, the beaker containing the water residue will show a loss in mass compared to the empty beaker. If this occurs, record the mass of the beaker containing the residue, then clean out the beaker, dry it and reweigh it.

Depending on the source of the water, the examination of the total dissolved solids may show nothing more than dried mineral residue, or in some cases, may contain small crystals or diatoms.

To prepare 2 L of "contaminated" water for a single class testing use:

- 0.056 g $CaCl_2$ this results in a concentration of 10 mg/L Ca^{2+}
- 0.043 g $Fe(NO_3)_3{\cdot}9H_2O$ this results in a concentration of 3 mg/L Fe^{3+}
- 0.00032 g $Pb(NO_3)_2$ this results in a concentration of 100 µg/L Pb^{2+}
- 0.023 g $Cu(NO_3)_2{\cdot}3H_2O$ this results in a concentration of 3 mg/L Cu^{2+}
- 0.18 mL Chlorox Bleach this results in a concentration of 3 mg/L Cl_2 Note: Do not add the Chlorox bleach until shortly before the "contaminated" water is to be tested.

NOTE: The contaminated water will deplete a Brita water filter in one pass.

To prepare larger quantities of "contaminated" water for multi-section lab classes use a concentrated metal ion mixture:

- 0.56 g $CaCl_2$ this results in a concentration of 10 mg/L Ca^{2+}
- 0.43 g $Fe(NO_3)_3{\cdot}9H_2O$ this results in a concentration of 3 mg/L Fe^{3+}
- 0.0032 g $Pb(NO_3)_2$ this results in a concentration of 100 µg/L Pb^{2+}
- 0.23 g $Cu(NO_3)_2{\cdot}3H_2O$ this results in a concentration of 3 mg/L Cu^{2+}

to prepare 100 mL of metal concentrate solution.

To use the concentrated metal ion mixture, add approximately 1.5 L of water to a clean 2 l volumetric flask, add 10 mL of this mixture, 0.18 mL Chlorox bleach, and then dilute to 2 liters. Mix well before use.

Preparation of samples (Instructor's procedure)

This procedure should be done shortly before or at the beginning of the laboratory class.

Place approximately 1.5 L of fresh tap into a clean, rinsed 2 L volumetric flask. Add the metal ion mixture and Chlorox bleach. Rinse any residue from the metal ion mixture container and add to the volumetric flask. Stopper and shake to dissolve the solid. Add water to the 2 L mark and mix well. This is the **chemically contaminated water** for this experiment.

Empty any water from the water filter pitchers. If necessary, prepare new filters for the pitchers according to the manufacturer's directions. NOTE: **Brita water filters must be soaked for approximately 15 minutes in fresh water before use.**

Do not allow water filters in the water filter pitchers to dry out. There must be sufficient water in the pitcher so that the filter remains in contact with some liquid water. A dry filter will not effectively remove contaminants from a water sample.

Add approximately one liter of chemically contaminated water to the upper reservoir of the filter pitcher reserved for contaminated water. A new filter must be used each time. The contaminated water will deplete the water filter in one pass.

Add fresh tap water to the pitcher reserved for tap water to fill the upper reservoir. Keep this pitcher in an area where it will be away from laboratory chemical contamination.

Water tasting

Water tasting is an important part of water testing. If water has any off-taste, then individuals will not drink it and will look for alternate sources. Tap, filtered, purified, and spring waters do have slight differences in taste.

Because this is a laboratory environment, a number of precautions must be observed for water tasting. There should be no compromises on these precautions.

All glassware and apparatus used for tasting must be clean and free from laboratory chemicals. Use only special glassware and equipment that has been stored away from all sources of laboratory chemical contamination and reserved only for food experiments.

Individuals must wash their hands with soap and water before tasting any water.

All work surfaces where tasting materials are located must be clean and free from laboratory chemicals. It is advised to cover the cleaned work area with aluminum foil or a food-grade paper covering. All water for tasting must come from fresh water sources and should be isolated from all areas where laboratory chemicals have been used.

Use new paper or plastic drinking cups for water tasting. Store all cups away from any sources of chemical contamination.

Use only new bottles of bottled water specifically labeled, and kept from the chemical testing area, for tasting.

During testing, never return any water to the container from which it was obtained as it will contaminate the entire container of water. Dispose of excess water in the sink or as directed.

Taste water from a water filtration pitcher that has been reserved for, and labeled for tap water only.

Do not taste any water that was chemically treated for laboratory testing purposes, even if it has been filtered to remove contaminants.

Conclusion and Clean-up

At the conclusion of the experiment, empty the water from the water filter pitchers and fill the upper reservoir of each pitcher with tap water. (Do not store the pitchers with the water filters dry.)

Any container used for tasting water should be stored in a protected area, away from any possible contamination by foreign materials or laboratory chemicals.

Bottled water used for testing should be discarded and the container disposed of or recycled.

Bottled water used only for tasting can be removed from the laboratory for later consumption.

All testing containers should be rinsed with distilled or deionized water before storage.

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DATA and RESULTS

Name (s) ____ Date_________________

Water Information:

Complete the information below for the type of water you tested in this experiment.

Locality where tests are being performed: ____

What is the source of the water? ____
(Note: You may have to contact the water company to find the water source.)

Brand(s) of bottled water used: ____

Brand of water filtration pitcher used: ____

NOTE: All water data will be shared with the class. In addition to writing your results on these data pages, you will also write your data on the chalk board/white board in the laboratory. A summary chart appears on page 15 of this experiment.

Dissolved solids: (Add your data to this table for the type(s) of water you tested. Also, add your data to the summary table on the chalk board/white board in the laboratory and the summary chart on page 15.)

Type(s) of water used	Mass of empty beaker, g	Mass of beaker and residue, g	Mass of dissolved solids, g	Dissolved solids in mg/L

Results of the microscopic examination of the dissolved solids. What did you observe?

Depending on the source of the water, students may observe dried mineral residue, crystallized minerals, or diatoms.

Federal guidelines for *total dissolved solids* and *maximum contaminant level* in tap water is 500 mg/L. How do the samples compare?

pH

Record the pH of each type of water using your data and class data: (Add your data to this table for the type(s) of water you tested. Also, add your data to the summary table on the chalk board/white board in the laboratory and the summary chart on page 15.)

Type(s) of water			
pH			

Hardness

Record the total hardness of each type of water in mg/L as calcium carbonate. (Add your data to this table for the type(s) of water you tested. Also, add your data to the summary table on the chalk board/white board in the laboratory and the summary chart on page 15.)

Type(s) of water			
Total hardness as $CaCO_3$			

Iron

Record the iron concentration in mg/L for each type of water: (Add your data to this table for the type(s) of water you tested. Also, add your data to the summary table on the chalk board/white board in the laboratory and the summary chart on page 15.)

Type(s) of water			
Iron concentration In mg/L			

Chlorine

Record the concentration of total and free chlorine for each type of water in mg/L and calculate the concentration of combined chlorine. (Add your data to this table for the type(s) of water you tested. Also, add your data to the summary table on the chalk board/white board in the laboratory and the summary chart on page 15.)

Type(s) of water			
Free chlorine in mg/L			
Total chlorine in mg/L			
Combined chlorine in mg/L			

Lead

Record the lead concentration in μg/L for each type of water. (Add your data to this table for the type(s) of water you tested. Also, add your data to the summary table on the chalk board/white board in the laboratory and the summary chart on page 15.)

Type(s) of water			
Lead concentration In μg/L			

Copper

Record the concentration of total and free copper for each type of water in mg/L and calculate the concentration of combined copper. (Add your data to this table for the type(s) of water you tested. Also, add your data to the summary table on the chalk board/white board in the laboratory and the summary chart on page 15.)

Type(s) of water			
Free copper in mg/L			
Total copper in mg/L			
Combined copper in mg/L			

Arsenic

Record the arsenic concentration in ppb for each type of water. (Add your data to this table for the type(s) of water you tested. Also, add your data to the summary table on the chalk board/white board in the laboratory and the summary chart on page 15.)

Type(s) of water			
Arsenic concentration in ppb			

Water Tasting

Describe the taste of the tap water:

Tastes will vary with location and source. Students often note presence of chlorine.

Describe the taste of the filtered tap water:

The ion exchange resin in the filter usually add some H^+ ions to the water. There is often a slight aftertaste.

Describe the taste of the bottled water(s):

Taste will vary with different waters. Some may be described as "sweet".

Which water do you prefer in order of preference? Why?

Testing The Waters – Class Summary of Results

Complete this table using class data

Type(s) of water tested	Dissolved Solids, g/100 mL	pH	Total Hardness mg/L	Iron mg/L	Chlorine			Lead µg/L	Copper			Arsenic ppb
					Free mg/L	Total mg/L	Combined mg/L		Free mg/L	Total mg/L	Combined mg/L	
Tap water												
Filtered tap water												
Contaminated water												
Filtered contaminated water												

Questions:

1. When tasting water, why must the different waters be at the same temperature?

   Tastes will be not be evident in chilled water.

2. Does the water filter pitcher remove the contaminants as it claims? Explain.

   The water filters do remove contaminants.

3. Is the bottled water as pure as you thought it was before doing this experiment? Explain.

   Bottled waters, except for filtered tap water, are not "pure", they contain dissolved minerals.

4. What is the difference between purified water, spring water, and natural spring water?

   Purified water is often tap water that has been passed through a reverse osmosis filter and/or ion exchange filters, sometimes with a charcoal (activated carbon) filter.

   Spring water may be pretreated and filtered before bottling.

   Natural spring water is usually not treated before bottling.

5. If the value of any measurement for the water tested was very high, what would you do?

   Retest to verify results, then contact company or web site to verify concentration and to report your findings. It is advised that retesting be done on a fresh sample of the water.

6. Calculate the cost of tap water for one year. (Calculate the amount of water, in quarts, you would drink in one day, multiply by 365 days, multiply by the cost of a quart of tap water. (You will have to call the local water company to get the cost of the water.)

   No calculations are done here, but tap water is inexpensive.

7. Calculate the cost of using a water filter pitcher for one year. The pitcher, with one filter, costs an average of $20.00. A filter will process about 140 quarts of water. A replacement filter costs $7.00 (Calculate the amount of water, in quarts, you would drink in one day and multiply by 365 days. Divide by 140, subtract 1, and multiply by $7.00/filter. Add $20.00 for the cost of the pitcher and original filter.)

   No calculations are done here, but filtered water is cheaper than bottled water.

8. Assuming a one-Liter bottle of water costs $1.00. How much would you spend on bottled water over the course of one year? (Calculate the amount of water, in Liters, you would drink in one day and multiply by 365 days and by $1.00/Liter)

   No calculations are done here, but bottled water is expensive.

9. Taking into account the taste, the purity of the water and the cost for one year, which is your choice of water? Explain.