Chemical Testing of Drinking Water

Adapted from: An original Creek Connections activity.

Grade Level: all

Duration: 50 minutes

Setting: lab or classroom

Summary: Students will conduct chemistry tests on various water samples.

Objectives: To have students understand some of the common chemistry parameters studied for drinking water.

Vocabulary:

Related Module Resources:

- Books

Materials (Included in Module):

- 2 Hach hardness Test Kit
- 2 Hach iron test kits
- 2 Hach chlorine test kits
- 2 Hach nitrate test kits
- extra glassware is in each of the above kits
- 2 Boxes of pH paper
- 4 Distilled water bottles
- sample bottles
- bottled water
- Brita Filter
- Rain Water
- Iron supplements
- Chlorine bleach

Additional Materials (NOT Included in Module):

- Some additional types of water samples

ACADEMIC STANDARDS:

7th Grade

4.1.B Understand the role of the watershed.

- explain factors that affect water quality and flow through a watershed

10th Grade

4.1.B Explain the relationship among landforms, vegetation and the amount and speed of water.

- describe factors that affect the quality of groundwater.

12th Grade

4.1.C Analyze the parameters of a watershed.

- interpret physical, chemical and biological data as a means of assessing the environmental quality of a watershed

4.3.A Analyze the complexity of environmental health issues.

- identify invisible pollutants and explain their effects on human health

BACKGROUND:

There are a number of water tests that can be done on drinking water, but chemistry parameters that are often associated with drinking water include: hardness (calcium and magnesium), chlorine, nitrates, iron, lead, copper, total dissolved solids, fluoride, and aluminum. Some of these parameters can be studied with the materials supplied in the drinking water module.

HARDNESS:

Hardness is defined as the sum of the polyvalent cations (ions with a charge greater than +1) present in the water. The minerals of calcium (Ca^{+2}) and magnesium (Mg^{+2}) are usually the predominant cations responsible for hardness levels. Other ions, such as iron (Fe^{+2}), manganese (Mn^{+2}), aluminum (Al^{+3}), may contribute to hardness, but in natural waters these other ions are usually found in insignificant amounts. Waters with high hardness values are referred to as "hard", while those with low hardness are "soft". Hard water simply has excessive amounts of the polyvalent cations in them.

Calcium and magnesium may be added to a natural water system as it passes through soil and rock containing large amounts of these elements in mineral deposits. Hard water is usually derived from the drainage through calcareous (calcite-rich) sediments and rock, such as limestones, sandstones, siltstones. Dolomites are rich in magnesium. These rocks are found in Western Pennsylvania, thus affecting the hardness levels in our water. In this area, if water has had the opportunity to interact with bedrock, rock, and soils for a long time (such as groundwater), it will be hard. If the cations responsible for making water hard are not calcium and magnesium, but are iron, sulfate, chloride, manganese, or aluminum, etc. instead, this is considered to be "non-carbonate hardness".

Water that has entered waterways directly without soaking into the ground, will be significantly softer. Collected rainwater is usually soft because it has not interacted with any geological sources of the cations. Soft water is also derived from the drainage of igneous rocks, because these rocks don't weather very easily, don't release many cations, and don't always contain calcium and magnesium.

IRON:

Most natural waters contain some iron, a positive charged metal. In fact, iron is one of the most prevalent elements in the earth's crust – so groundwater usually has some iron in it. Surface waters with excessive amounts of iron may be affected by mining operations. If you find reddish stains on your plumbing fixtures or in your sinks, iron is in your water. When dissolved in water, iron is called ferrous iron or "clear water" iron. This can cause a metallic taste and odor. Exposure to air causes ferrous iron to oxidize and form insoluble rust (reddish brown particles / stain). This rust can cause problems in plumbing systems and in the appearance and taste of water. Colloidal iron is very small particles of oxidized iron suspended in the water. Another problem with associated with iron in water is iron-eating bacteria that can create a sludge-like gel that can clog plumbing. Iron gives water a displeasing taste and appearance, but it is not a major human health concern.

CHLORINE:

Added to water since 1908, chlorine has been an effective and inexpensive way to kill bacteria and other waterborne microorganisms. Chlorine has a distinctive taste and smell and too much chlorine in drinking water is quite noticeable by some people. Too much chlorine in water can also be a health concern. It may contribute to heart disease, destroy vitamin E, be toxic to friendly intestinal bacteria, and maybe even contribute to cancer.

NITRATES

As part of the natural nitrogen cycle, nitrates are needed in water for plants and animals and will be supplied in sufficient amounts in a locally adapted, undisturbed ecosystem. However, when humans alter the nitrogen cycle by disrupting the ecosystem or adding excessive nitrogen to the system, then some problems occur. And since nitrates can be found in both groundwater and surface water, excessive levels can find their way into drinking water supplies. High nitrate content in drinking water can be responsible for infant methemoglobinemia or "blue baby syndrome". The nitrates interfere with the blood's (red blood cell's) ability to carry oxygen. This can occur in humans and other mammals. Shortness of breath, susceptibility to illness, heart attack or even death by asphyxiation can occur. Nitrates also contribute to the formation of nitrites and nitrosamines, which are carcinogens. (SEE THE NITRATES INFORMATION AND FACT SHEET FOR MORE INFORMATION).

OVERVIEW:

Students will conduct water chemistry tests on various types of drinking water samples.

PROCEDURE:

Teacher Preparation: Before doing this experiment, you will need to collect some various water samples. Examples of possible water samples include:

a) tap water from school (know the source of the water – from ground or surface water). (See FACT SHEETS section in the module resource folder for a fact sheet on sources of local drinking water).
b) tap water from various locations or students' homes (ask them to find out the source of the water – well or city water, from ground or surface water).
c) groundwater – from a private home well
d) water from a spring or small stream, perennial stream (that will be mostly groundwater)
e) rainwater (try to collect your own, but if not some bottles are enclosed in module)
f) from a larger stream, creek, French Creek
g) bottled water, spring water
h) purified bottled water
i) water after it has been filtered through Brita Filter
j) water that has been spiked with a few drops of chlorine bleach
k) water that has been spiked with some iron supplements
l) distilled water

1. Discuss background information as needed. Tell students that they will be testing various water samples to determine the amount of various chemical parameters associated with drinking water testing.
2. Have various water test kits separated and placed at stations in the laboratory.
3. Divide class into groups and assign each group to a testing station.
4. Have students conduct the chemical tests for whichever samples you assign them to study. They should record their data on a data sheet you have created or the enclosed data sheet.

OPTIONAL WAY OF RECORDING RESULTS:

Have students design a bottled drinking water label that will reveal various pieces of information about a particular water sample. There is a separate handout with a list of ideas of what could be included on a label. This could be a creative way for students to share their research findings for a particular water sample.

DISCUSSION:

Have students compare differences in their results.

Try to make connections between the source of water samples and the results that they obtained. Were there any that were surprising? Were there any that were above drinking water standards set forth by the EPA?

Were there any big differences in the tap water brought in by students? Have students with metal content in their water find out how old their plumbing is in their house.

EVALUATION:

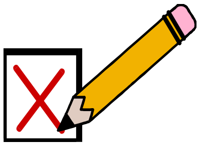
- What are some the chemical parameters that scientists are concerned about when studying drinking water?
- What are the ions that contribute to hardness levels in water?
- What are some metals found in drinking water?

EXTENSIONS AND MODIFICATIONS:

- There are many mini-experiments that can be done using the water chemistry test kits.
  - ❖ Have students test the before and after effects of using the Brita Water Filter system.
  - ❖ Have students compare many different brands of bottled water.
  - ❖ Have students see if the chemical parameter amounts indicated on bottled water labels is accurate.
  - ❖ Compare and contrast tap water samples from various students homes

- Ask a water authority to provide you with a water sample before it goes through the water treatment process and then a sample post treatment. Compare the two using the test kits.
- Conduct other chemistry tests on the drinking water samples – TDS, sulfates, alkalinity would be other good ones to investigate

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):



Bottled Water Label Activity

It is your task to design a bottled drinking water label that will indicate the source of your water sample, report your chemical test results and nutrition facts. Your teachers have copies of real bottled drinking water labels for your reference.

WHAT TO INCLUDE ON YOUR LABEL:

1) Company Name - Product Brand Name
2) Company Address
3) Source of water (name of waterway and/or geographic location)
4) Water Analysis (report your results)
   a) Calcium (mg/L)
   b) Magnesium (mg/L)
   c) Nitrates (mg/L)
   d) Chlorine (mg/L)
   e) pH
   f) Iron (mg/L)
   g) Sulfates (mg/L) *if you did not do this test, make up an appropriate amount*
   h) Lead (mg/L) *if you did not do this test, make up an appropriate amount*
   i) Sodium (mg/L) *if you did not do this test, make up an appropriate amount*
   j) Total Dissolved Solids (mg/L) *if you did not do this test, make up an appropriate amount*

5) Nutrition Facts
   a) Calories
   b) Total Fat
   c) Sodium
   d) Total Carbohydrates
   e) Protein

6) Catchy Slogan
7) Artwork
8) Recycle Symbol and information

Drinking Water Facts

Water Quality Standards

Through the combined efforts of the EPA and local authorities, the government sets drinking water quality standards. These standards are chosen based on the health effects of the contaminant, the commonality of that contaminant, and experimental data describing damaging doses. There are two types of drinking water standards. Primary standards are required and enforced. Secondary standards are not required or enforced and pertain mainly to aesthetic properties. Units are milligrams per Liter (mg/L) unless otherwise noted. (same as parts per million (PPM))

Summary of Important Primary Drinking Water Standards

Contaminants	MCLG (mg/L)	MCL (mg/L)	Health Effects	Source of Contaminant
Vinyl Chloride	Zero	0.002	Cancer	May leach from PVC or be formed by solvent breakdown.
Giardia Lamblia	zero	TT	Gastroenteric disease	Human and animal fecal waste
Legionella	N/A	TT	Legionnaire's disease	Indigenous to natural waters; can grow in water heating systems.
Total Coliform	zero	<5% +	Indicates gastroenteric pathogens	Human and animal fecal waste
Turbidity	N/A	TT	Interferes with disinfection, filtration	Soil runoff
Viruses	zero	TT	Gastroenteric disease	Human and animal fecal waste
Standard Plate Count	N/A	TT	Indicates water quality and effectiveness of treatment.	
Asbestos (>10um)	7MFL	7MFL	Cancer	Natural deposits; asbestos cement in water systems
Cadmium	0.005	0.005	Kidney effects	Galvanized pipe corrosion; natural deposits; batteries, paints
Cyanide	0.2	0..2	Thyroid, nervous system damage	Electroplating, steel, plastics, mining, fertilizer
Mercury	0.002	0.002	Kidney, nervous system disorders	Crop runoff; natural deposits; batteries, electrical switches
Nitrate	10	10	Methemoglobulinemia	Animal waste, fertilizer, natural deposits, septic tanks, sewage
PCBs	zero	0.0005	Cancer	Coolant oils from electrical transformers; plasticizers
Tetrachloroethylene	zero	0.005	Cancer	Improper deposal of dry cleaning and other solvents
Lead	zero	TT +	Kidneys, nervous system damage	Natural/Industrial deposits; plumbing, solder, brass alloy faucets
Copper	1.3	TT	Gastrointestinal irritation	Natural/industrial deposits; wood preservatives, plumbing
Arsenic	0.05	0.05	Skin, nervous system toxicity	Natural deposits, Smelters, glass, electronics wastes; Orchards
Combined Radium 226/228	zero	5pCi/L	Bone cancer	Natural deposits

* Contaminants with interim standards which have been revised. TT = Special treatment techniques required. MFL = Million fibers per liter. + = less than 5% positive samples. Treatment Technique – An Enforceable procedure or level of technical performance which public water systems must follow to ensure control of a contaminant.

MCLG = Maximum Contaminant Level Goal – The maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows for an adequate margin of safety. MCLGs are non-enforceable public health goals.

MCL = Maximum Contaminant Level – The maximum permissible level of a contaminant in water which is delivered to any user of a public water system. MCLs are enforceable standards. The margins of safety in MCLGs ensure that exceeding the MCL slightly does not pose significant risk to public health.

Secondary Drinking Water Standards

Contaminant	National Secondary Drinking Water Regulations
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	Noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor
pH	6.6 – 8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

From EPAs Safe Drinking Water Is In Our Hands.