Operation Water Drop - Testing the Water We Drink! Elementary

Subject: Science, Biology, Chemistry, Health

Topic: Testing the water we drink!

Time Frame: Approximately 40 minutes

Objectives: There are 8 tests to be run in this kit, teachers will demonstrate 2 different tests, and these tests are: Alkalinity and Sulphate. The students can do the other 6 tests with a minimal amount of help, these tests are: Ammonia, pH, Colour, Copper, Total Chlorine, and Total Hardness. Provided with the Operation Water Drop kit are supplies to run tests on the local drinking water source, and on a Canadian Drinking Water Guideline sample. The guideline sample is for quality control purposes (was the test performed properly?). This will also be a reference to see what a sample would look like if it meets the Canadian Drinking Water Guideline, students are then expected to gather their own water samples for the Local Treated Water. They will then be able to compare their own community drinking water to the Canadian Drinking Water Guideline. It is recommended that teachers assign a Class Captain student who will track student and teacher opinions of OWD and complete the required Evaluation form and submit it to SDWF along with the community analysis sheet and any pertinent suggestions.

Methodology: The tests will include: precipitation, colourimetric, visual, bacteriological, and test strips. All procedures, instructions, and reference material are available online for easy reference and reporting. It is suggested you print out the individual test instructions for quick reference and follow instructions closely. It is also recommended that you print the materials list to ensure you have all materials.

Materials: Each Operation Water Drop Test Kit contains 8 test supply bags with all requirements for testing your drinking water, and the Canadian Drinking Water Guideline Limit sample; for each analyte tested all supplies required are packaged in one bag for your convenience. You will find a list of all materials sent in the OWD kit; please cross-reference your list with material received to ensure you have all of the material required.

A Note About Disposal: After the testing has been completed, everything can be poured down the tap as everything is within limits of safety. However, if you are concerned and are able to do so, you could take the solutions to a local waste disposal facility or university chemistry department.

Please check to make sure that you have received all of the material listed below.
All of the test materials will be packaged in separate bags for each determination (Test).

Materials List For Elementary Operation Water Drop Kit

Total # of Beakers, Glasses, and Water Sample Bottles

Drink Glasses	7
10 mL Disposable Beakers	8

2 - 250 mL Bottles: Deionized Water, and 1 empty bottle for your **Local** Treated Water that will be tested. All of the test materials except for the drink glasses and the disposable beakers will be packaged in separate bags for each test. The teacher will need to distribute the drink glasses and the disposable beakers.

Test	Vial size (mL)	# In Kit
Alkalinity	**Vial / Container**	**Quantity**
Alkalinity (Low Limit Sample)	50	1
0.02N H_2SO_4	15	2
Methyl purple indicator	1.5	1
Disposable pipette	1.2	1
Drink glass		2
Ammonium		
Ammonium (AEUL)	5	1
Test strips in tube		2
Colour chart		1
Disposable beaker	10	1
Colour		
Colour standard (CGLS) (tube)	50	1
Plastic test tubes	29x115 mm	3
Copper		
Copper (CGLS)	10	1
Test strip packets		2
Disposable beakers	10	2
pH		
pH buffer 7 (tube)	5	1
pH indicator strips (in tube)	10	4
pH scale card		1
Disposable beakers	10	3

Test	Vial size (mL)	# In Kit
	Vial / Container	**Quantity**
Sulphate		
Sulphate (CGLS) (tube)	2	1
Sulphate reagent # 1 (tube)	5	3
Sulphate reagent # 2 (tube)	5	3
Disposable pipettes	2	2
Drink glass		3
Total Chlorine		
Test strip packets		2
Drink glass		2
Total Hardness Total		
Hardness (SGLS)	10	1
Test strip packets		2
Disposable beakers	10	2

Additional materials:

Although the OWD kit is complete, there are a few things that will be needed to ensure analyses are performed with ease and accuracy.

Each group should have:

- A permanent marker for test tube labeling
- Masking tape for labeling pipettes
- A 25 mL and a 50 mL measuring device (preferably a graduated cylinder)
- A test tube rack
- Coke and bleach or other acidic and basic liquids for the pH tests

Space Requirements: Students should be in a room with sufficient bench or desk space to work comfortably in small groups to conduct their tests.

Directions:

The Teacher and students will be testing water for the following parameters:
Approximate Time for all tests to be completed (40 minutes)

1. Copper	2. Alkalinity	3. Sulphate	4. Ammonium
5. Colour	6. pH	7. Total Chlorine	8. Total Hardness

Teacher Demonstration: Alkalinity, and Sulphate.
Student Tests: 6 groups with each group doing a different test (Colour, Copper, Ammonium, pH, Total Chlorine, and Total Hardness) on the water sample and the Canadian Guideline Limit Sample.
The teacher should do the demonstration on the two tests (15 minutes), then split the class up, the classroom should be divided into 6 separate groups; each group will be running tests on their own drinking water plus a Canadian Guideline Limit Sample (or in the case of ammonia, a European Union Limit Sample) that is supplied for all analytes.

It cannot be overstated how important it is to be clean and careful while doing all of these tests. Please remember that although the tests are designed to be safe for students to use, whenever working with any amount of chemicals lab safety precautions must be taken into consideration. For best safety practices, please ensure that your students wear lab coats, goggles and gloves when handling the kit materials and samples.

Results:

After the tests have all been completed, the teacher should lead a discussion on the results that were found and enter in the water quality results online in the Operation Water Drop Test Results Submission Website.
The class and teacher are also encouraged to complete and submit the online Program Evaluation on the Safe Drinking Water Foundation website. The success of the Operation Water Drop program depends on this feedback and reporting. The Safe Drinking Water Foundation thanks everybody in advance for their cooperation in the reporting of their results.

Possible Presentation Questions/Topics:

► Does it concern you that Canada has no national regulations (just guidelines) for drinking water?

► Do you feel rural (including Aboriginal and non-Aboriginal) people should be concerned about their drinking water?

► Is your water treatment plant modernized?

► Are your water treatment plant operators certified?

► Are you comfortable/satisfied that your community water is safe?

► For more questions and possible solutions please refer to the fact sheets that are attached to the methods.

Requirements	Yes	No
Did the group prepare a summary sheet of information for the rest of the class?		
Did the group demonstrate their knowledge about their topic?		
Was the presentation approximately 3-5 minutes in length?		
Did the group come up with a creative way to present the information?		
Did the group complete a poster to demonstrate what they have learned?		

Evaluation: Presentation Checklist

Resources:

Visit the Safe Drinking Water Foundation Website www.safewater.org to learn more about issues affecting safe drinking water. Once at www.safewater.org go to public education and then fact sheets to find more information about several of the tests that you have or will run.

You will find links to many Educational Fact Sheets and various articles published pertaining to the different analysis which students conduct as part of Operation Water Drop.

For more information on health risks and possible contributors of all chemicals you can go to the following website: http://www.lenntech.com/WHO-EU-water-standards.htm you will also find the drinking water standards for the World Health Organization, and the European Union at this site.

Alkalinity Analysis (Elementary School)

Purpose: To determine how much alkalinity a sample contains using a colourimetric method. Testing will be done on a Local Community Treated Water sample; the teacher will do this as a demonstration.

There is no Canadian Drinking Water Guideline for Alkalinity in drinking water, but it is an important characteristic of the water and if your local community water is less than the Low Limit Sample (LLS) then the water may be quite corrosive, which may result in increased levels of copper and lead leached out from household plumbing.

Materials:

- 1 - 50 mL tube containing 50 mL of Alkalinity Low Limit Sample (LLS)
- 2 - 15 mL tube with 12.5 mL of 0.02N H_2SO_4 (Sulphuric Acid)
- 1 - 1.5mL tube with Methyl Purple Indicator
- 1 - Small 1.2 mL plastic pipette
- 2 - Plastic cups
- 50 mL graduated cylinder (not supplied with kit – teacher must supply)

Method:

1. Cover the area that you are working on with paper and use gloves as the Methyl Purple Indicator that you will be using may stain.
2. Label the 2 plastic cups as follows; label one cup Alkalinity LLS and the other cup Local Community Treated Water.
3. Pour the 50 mL of Alkalinity LLS into the cup labeled Alkalinity LLS.
4. Add 7 drops of Methyl Purple Indicator to the cup by using the small plastic pipette. This causes the water to turn green. Be careful when using the Methyl Purple Indicator as it may stain.
5. While swirling the water in the cup, add the 0.02 N H_2SO_4 slowly until the water turns purple, the LLS should take around 2.5 mL, record your reading (the volume you used is initial – the next reading, say 12.5 – 10.0 = 2.5) after you see the colour change. The other samples may take more or less than the LLS. Record

amount of H_2SO_4 used. Then add the remaining Sulphuric acid to see the colour changes (there should be a slightly darker colour after you add all of the acid).

6. Using the graduated cylinder, measure 50 mL of the Local Community Treated Water sample and pour it into the cup labeled Local Community Treated Water sample.

7. Repeat steps 4 & 5.

8. Calculate the amount of alkalinity in the different water sources. You can do that by knowing that the LLS is 50 mg/L and it required around 2.5 mL of acid.

Operation Water Drop: Data Sheet (Elementary)

Date:_____

Please be as precise as possible! You can write numbers other than those that are on the colour charts.

Water Sample	**Alkalinity (mg/L)** Guideline: 50 mg/L (Lower Limit)
Local	
Control	
Did the local water pass the guideline? (yes/no) If not, brainstorm why that might be.	

Results:

If the water sample requires less than 2.5 mL of 0.02 N H_2SO_4 to change colour then the water may be quite corrosive (read more about alkalinity below). You can multiply the amount of acid added by 20 and change the units to ppm in order to get the result in parts per million. For example, if 2.5 mL of acid is added then 2.5 x 20 = 50 ppm.

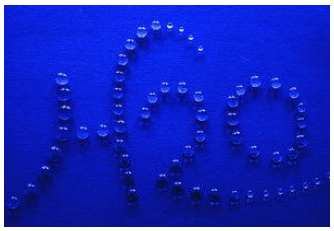
Safe Handling of Materials

Caution must be taken at all times when handling any chemicals. Although this test is safe to use in any area, please be cautious with the materials supplied.

Visit the Safe Drinking Water Foundation Website www.safewater.org

Alkalinity:

What is alkalinity and why do we test our water for it?



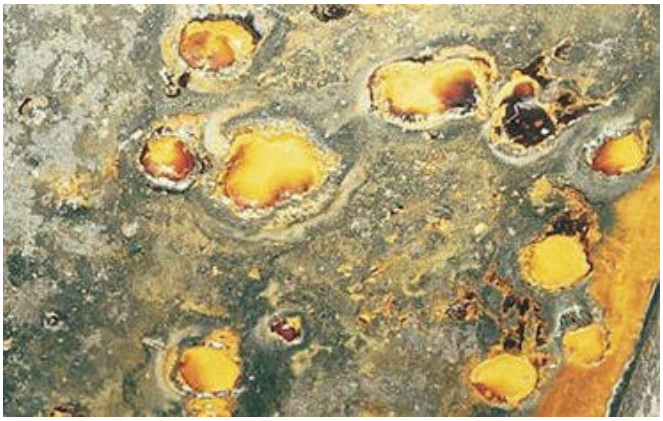
Alkalinity is a measure of the ability of your water to resist changes in pH, which would tend to make the water more acidic. The pH is a value given to indicate how acidic or how basic a substance is. It is important that there is a good balance to the alkalinity of our water. In Canada, the recommended range of alkalinity is 80- 120 ppm or parts per million. If the levels are higher or lower than this, there can be problems with water quality. However, alkalinity levels are usually looked at together with pH levels to get a better idea of the complete water quality.

Where does alkalinity in water come from?

Alkalinity of water is due to the presence of certain ions: carbonates, bicarbonates, and hydroxides (often referred to as alkaline salts). Bicarbonates are the most common cause of alkalinity and are found in almost all natural water sources, as are carbonates. Hydroxides are found less often in natural water but concentrations may increase after certain treatments.

What happens if alkalinity is too low or too high?

If the alkalinity is too low, the ability of your water to resist pH changes decreases. This means that the pH will yo-yo up and down, changing from acidic to basic fairly rapidly. Water with low alkalinity can also be corrosive which can result in copper and lead leaching out of household plumbing. It can also irritate the eyes. Water with high alkalinity has a soda-like taste, can dry out skin and can cause scaling on fixtures and throughout water distribution systems. This scaling is undesirable because it begins to decrease the efficiency of plumbing systems, which results in greater power consumption and increased costs. There do not appear to be serious adverse health effects from drinking water with alkalinity above or below the suggested levels. However, many public water utilities try to maintain an acceptable alkalinity level in order to prevent low pH (acidic) water from damaging pipelines and other distribution equipment.



Metal water pipes can become corroded due to water with low alkalinity and pH.

What do I do if the level of alkalinity in my water is too low or too high?

Some simple household compounds can bring the alkalinity within the suggested range. In order to increase the alkalinity, baking soda (Sodium bicarbonate) can be used. To decrease the alkalinity, muriatic acid (Hydrochloric acid) can be added. We don't recommend that you do this as alkalinity problems should be dealt with in a water treatment plant.

Ammonia Analysis (Elementary)

Purpose: To determine the Ammonia concentration of a sample. Testing will be done on a Local Community Treated Water sample and a European Union limit sample for quality control purposes.

Determination will be done by using a test strip method. The major source of ammonia is runoff from fertilizers used in the farming community. The health risks are low, the major concern with ammonia is if the concentration is elevated then it will start to negate the effectiveness of the chlorination process as well as begin to form harmful Chloramines. A 0.5 mg/L standard is supplied for quality control purposes; this is also the limit that the European Union imposes.

Materials:

- 1 - Tube with 4 mL of 0.5 mg/L Ammonia European Union limit (AEUL).
- 2 - Test strips in a tube
- 1 - Colour chart for determining Ammonia concentration.
- 1 - Disposable beaker

Method:

1. Fill disposable beaker with Local Community Treated Water sample.
2. Dip ammonia test strip into water for five seconds, remove with pad face up and hold level for 60 seconds. **Do not shake off excess water.**
3. Compare the colour on the test strip to the colours on the colour chart after the 60 seconds have elapsed in order to determine the ammonia concentration.
4. Dip ammonia test strip into the 4 mL of AEUL in its vial for five seconds, remove with pad face up and hold level for 60 seconds. **Do not shake off excess water.**
5. Compare the colour on the test strip to the colours on the colour chart after the 60 seconds have elapsed in order to determine the ammonia concentration.

Operation Water Drop: Data Sheet (Elementary)

Date:_____

Please be as precise as possible! You can write numbers other than those that are on the colour charts.

Water Sample	**Ammonia (mg/L)** Guideline: 0.5 mg/L (EU)
Local	
Control	
Did the local water pass the guideline? (yes/no) If not, brainstorm why that might be.	

Results: Since there is no Canadian Drinking Water Guideline for ammonia you will compare results to the European Union limit. The standard should give a result very close to 0.5 mg/L; if the colour is darker then it **DOES NOT** meet the guidelines.

Safe Handling of Materials Caution must be taken at all times when handling any chemicals. Although this test is safe to use in any area, please be cautious with the materials supplied.

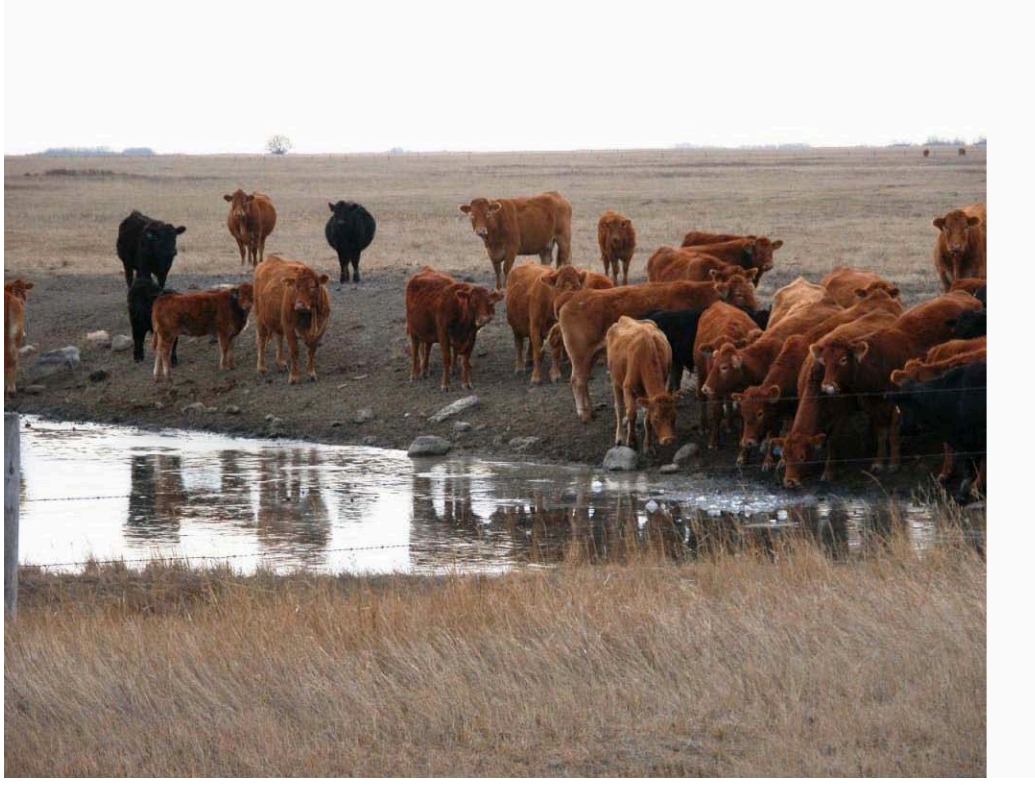
Ammonium:

What is ammonia and why do we test our water for it?

Ammonium is a reduced form of nitrogen (NH_4^+) and together with the non-ionized form (NH_3) they compose ammonia. Ammonia is frequently present in groundwater sources where there is no oxygen present. **Ammonia ions play a key part in water treatment because they need to be removed before breakpoint chlorination can be achieved. Breakpoint needs to be reached to comply with Canada's primary disinfection requirements.**

Where does ammonia in water come from?

Ammonia comes from the breakdown of plants and animals, agricultural (application of large quantities of ammonia fertilizer), and industrial processes. The use of ammonia-containing groundwater and chloramination can also contribute to the ammonia levels. Groundwater that is anaerobic (no oxygen) can contain large quantities of ammonia (>2 mg/L) while surface water sources generally contain levels ten times lower. During specific events in a lake, such as the death of an algal bloom, or spring and fall turnover (when bottom waters get mixed in with the surface water layer), the ammonia levels can increase although it is typically decreased quite rapidly. Also, intensive livestock operations can contribute large quantities of ammonia to surface water sources. High levels of ammonia in surface waters can therefore be an indicator of pollution by various sources.



Picture 1. Cattle grazing around a water source. What contaminants do you think will end up in the water under these circumstances? Do you think this is healthy for the cattle?

What are the current drinking water quality guidelines for ammonium?

There is no guideline for ammonia in the U.S. or Canada, but the European Union recommends that ammonia levels should be lower than 5 mg/L. However, as discussed here, such high levels would basically exclude the use of chlorine as a primary disinfectant. Unfortunately, many communities don't realize this and are not adequately disinfecting their water.

What happens if ammonia levels are too high?

There are no health based guidelines for ammonia in drinking water, but its removal is recommended as ammonia can compromise disinfection, it can cause taste, odour and the formation of nitrite as well as interfering with the removal of manganese. Strong oxidizing reagents, such as ozone, chlorine dioxide, chloramines and potassium permanganate cannot remove ammonia ions while chlorine will remove the ammonia by forming less toxic compounds, the chloramines. However, for every mg of ammonia removed, the chlorine demand is 10-15 mg.

The use of chlorine for ammonia removal can only be recommended for water sources with less than 1 mg/L of ammonia (preferably less than 0.2 mg/L). If breakpoint chlorination is not achieved then the water treatment plant is using what is called secondary disinfection, which should only be used after primary disinfection has been carried out.

An ideal and inexpensive way of oxidizing the ammonia to nitrate is achieved by biological treatment where bacteria (nitrifiers) gain energy from the conversion of ammonia to nitrate. Initial problems of biologically removing ammonia at low temperatures (bacteria generally like warmer temperatures) have been overcome as shown by Yellow Quill First Nation where the oxidation of 4 mg/L of ammonium down to levels less than 0.05 mg/L is achieved at 6°C using a rapid filtration process (see www.safewater.org for more information on biological filtration).

What do I do if the level of ammonium in my water is too high?

We don't recommend that action is taken in individual homes as these are issues that should be dealt with in the water treatment plant.

Colour Analysis (Elementary)

Purpose: To determine if the water sample meets Canadian Drinking Water Guidelines for Colour. Testing will be done on Local community treated water. The Canadian Drinking Water Guidelines has an aesthetic objective of 15 TCU (True Colour Units) for drinking water; you will test and compare your result to see if it meets these guidelines.

Materials:

- 1 - Canadian Guideline Limit Sample for Colour(CGLS)
- 3 - Large plastic test tubes

Method:

1. Label the test tubes; Control, Canadian Guideline, and Local community sample.
2. Pour the 50ml of Canadian Guideline Limit Sample into the Canadian Guideline test tube.
3. Fill the Control test tube with the deionized water to the same level as the Canadian Guideline test tube.
4. Fill the Sample test tube with Local community water to the same level as the Canadian Guideline test tube.
5. Hold the Local community test tube side by side with the Control and Canadian Guideline tubes over a white piece of paper
6. View the test tubes from above: Is the colour of the Sample lighter or darker than the colour of the Canadian Guideline tube?
7. Record the results

Operation Water Drop: Data Sheet (Elementary)

Date:_____

Please be as precise as possible! You can write numbers other than those that are on the colour charts.

Water Sample	**Colour Analysis** Guideline: 15 True Colour Units (TCU)
Local	
Control	
Did the local water pass the guideline? (yes/no) If not, brainstorm why that might be.	

Results:

If the water sample has a colour lighter or equal to that of the Canadian Guideline then it passes the Canadian Drinking Water Guideline for Colour.
If the water sample is darker in colour than that of the Canadian Guideline, it fails the Canadian Drinking Water Guideline of 15 TCU (True Colour Units).

Colour:

Where does the colour of the water come from?

When water has a visible tint to it, it is usually due to the presence of decaying organic material or inorganic contaminants such as iron, copper, or manganese. Limits for colour in drinking water are usually set based on aesthetic considerations. The Canadian guidelines are set at 15 TCU (True Colour Units), as most people can easily detect colour exceeding this level. Generally, colour is classified into two types: true and apparent colour. The most common ca use of true colour is decaying organic material such as dead leaves and grass. This type of colour is usually found in surface water. Apparent colour is caused by inorganic materials, usually iron, copper or manganese. The true colour of water can be distinguished from the apparent colour by filtering the sample to remove the larger organic particles. The following table lists some frequent colours that may be detected in drinking water and their most common causes.

Colour	Cause	Health Hazards/Other Problems
Red or Brown	Generally indicative of iron or manganese in water	Stains sinks and discolours laundry
Yellow	Suspended organic particles	No adverse health risks (unless chlorinated; see below)
Blue or Green	Generally due to copper in water supply or corrosion of copper pipes leading into water supply	Can cause staining of fixtures and laundry; high copper content (30ppm) can cause vomiting, diarrhoea, and general gastrointestinal symptoms

Cloudy, White, or Foamy	Usually due to turbidity (finely divided particles in water, either organic or inorganic)	No adverse health risks but can cause abrasions to pipes and staining of fixtures

What are the health risks associated with drinking coloured water?

Generally speaking, the colour in water does not pose any health risks. However, there are some exceptions. If the colour is due to a metal contaminant, such as copper, mild gastrointestinal symptoms may result. Therefore, Canadian guidelines stipulate certain recommended limits to many inorganic materials. Also, when chlorinated, any organic material that is present in the water can combine with the chlorine to form compounds called trihalomethanes (THMs). Chloroform is a common THM and is considered potentially carcinogenic (cancer causing). Therefore THMs in drinking water supplies that are routinely chlorinated are closely monitored and also have recommended limits.

What do I do if my water exceeds colour limits?

Colour in water can easily be removed using activated carbon filters (charcoal). However, these filters need to be replaced periodically to maintain colour absorption activity. In larger plants, a common treatment method called coagulation and sedimentation is used. This method utilizes alum and other chemicals to remove the materials that cause colouration of drinking water, before being pumped out to people's homes.

Copper Analysis (Elementary)

Purpose: To determine the Copper concentration of a sample. Testing will be done on a Local Community Treated Water sample and a Canadian Guideline Limit Sample for quality control purposes:
Determination will be done by using a test strip method. You will see if the Local Community Treated Water meets the Canadian Drinking Water Guidelines. Copper is naturally present in the environment, but the levels of contamination can be increased around agricultural land (manure spreading), near smelting facilities, and phosphate fertilizer plants, there is also significant amounts of copper released from wastewater treatment plants. The copper piping in most buildings that we consume water from also can contribute to our intake, depending on the corrosiveness of the water. Copper is essential to good human health but we don't have to concern ourselves with not getting enough copper, it is present in the food we eat, the air we breathe (more so around large manufacturing plants and industries), and the water we drink. We can, however, consume too much copper and some of the possible negative health effects of excess copper are dizziness, vomiting, diarrhea, upset stomachs, and headaches. A 1 mg/L Canadian Guideline Limit sample will be included for quality control purposes; this is also the limit for copper according to the Canadian Drinking Water Guidelines.

Materials:

- 1 - 1 mg/L Canadian Guideline Limit sample (Copper Standard).
- 2 - Test strip packets, with colour charts printed on them.
- 2 - 10 mL disposable beakers.

Method:

1. Label the two beakers CGLS and Local.
2. Put 10 mL of sample in their respective beakers.
3. Dip one test strip in sample or (CGLS) beaker for 30 seconds with constant back and forth motion.
4. Remove and match colour after 2 minutes to determine the Copper concentration in mg/L or parts per million (ppm).

Operation Water Drop: Data Sheet (Elementary)

Date:_____

Please be as precise as possible! You can write numbers other than those that are on the colour charts.

Water Sample	**Copper (mg/L)** Guideline: 1 mg/L
Local	
Control	
Did the local water pass the guideline? (yes/no) If not, brainstorm why that might be.	

Results: Compare results to the Canadian Drinking Water Guidelines. The Canadian Guideline should give a result very close to the 1 mg/L guideline; a darker colour means that the water **Does Not** meet Canadian Drinking Water Guidelines.

Copper Fact Sheet

What is Copper and why do we test for it?

Copper is a metal that is naturally present in the environment, but the levels of contamination can be increased around agricultural land (manure spreading), near smelting facilities, and phosphate fertilizer plants. There are also significant amounts of copper released from waste water treatment plants, which could lead to problems downstream for a community that uses this water as their source water. Farmers and others that rely on small water reservoirs for their water supplies may at times try to control algal blooms with copper sulphate (bluestone), which can increase the copper levels in their water supplies but as copper is taken up by the algae its levels should decline rapidly.

However, the main source of copper comes from household plumbing especially when the water is corrosive. As the copper levels in the water treatment plant is generally acceptable compliance with the Copper Guideline is generally achieved by controlling the corrosiveness of the water in the treatment plant. The corrosiveness of water towards copper is generally highest when the water is acidic (pH less than 7, see pH Test), the Alkalinity is low (see Alkalinity Test), and the Hardness is low (see Hardness Test).

What are the Canadian Drinking Water Guidelines for Copper?

The guidelines state that the level should not exceed 1 mg/L copper. The U.S. Environmental Protection Regulation for copper is 1.3 mg/L. The World Health Organization has established a 2.0 mg/L guidance level.

What are some of the health risks associated with Copper?

Copper is an essential nutrient, required by the body in very small amounts. However, health affects may occur when people are exposed to it above the guideline level. The National Academy of Sciences' Food and Nutrition Board recommends that children need at least 0.34 mg Copper/day and adults need 0.9 mg copper/day. It also recommends that consumption should not exceed 9 mg copper/day.

The most common health effects of the excessive consumption of copper bearing water would be: nausea, vomiting, diarrhea, upset stomach, and dizziness. If extreme intake of Copper occurs, kidney and liver damage is possible.

What do I do if my water exceeds the Canadian Drinking Water Guidelines?
Since the major contributor to copper in drinking water is the corrosion of the copper pipes, the best way to minimize the problem is to raise the pH of the water to greater than 7.0 so that the piping is not being attacked. Another possibility is the source water may be contaminated by one of the sources previously stated; in that case a more aggressive approach may be needed by the water treatment facility. Actions to ensure that we are not exposed to high levels of copper should all be taken at the drinking water treatment plant.

If the water is corrosive, higher levels of copper can occur when the water sits in plumbing pipes for longer periods, such as overnight. Flushing of the tap water for 30 seconds or more can reduce the copper levels.

In the U.S. if a water system fails to comply with the U.S. Environmental Protection Agency Regulation it must notify the public through newspapers, TV etc. Failure to provide a water meeting the Copper Standard may mean that the water supplier needs to supply alternate drinking water supplies.

pH Analysis (Elementary)

Purpose: To determine if the water sample meets the Canadian Drinking Water Guideline for pH by determining its level of pH. Testing will be done on Local community treated water. There will be a pH 7 buffer solution included for quality control purposes.
There is a 7.0-10.5 range in the Canadian Drinking Water Guideline for pH in drinking water; you will test and compare your result to see if it meets these guidelines. For demonstration purposes get two other samples like Coke and bleach to show the pH levels of these compared to the drinking water.

Materials:

- 1 – 10 mL vial containing 4 pH test strips
- 1 – 5 mL vial containing pH 7 buffer
- 1 - pH scale card
- 3 – 10 mL disposable beakers

Method:

1. Label the three beakers Local and what the other two samples are (such as Coke and Bleach) (do not include the buffer; this can be tested in the tube).
2. Fill the beakers with their respective samples.
3. Place the pH strip into the beakers/ vial
4. Leave for 2 minutes
5. Remove the pH strip and lay it across the beaker, coloured side up. Wait 30 seconds
6. Determine the pH of the strip by comparing it to the pH scale card
7. Record your results

Operation Water Drop: Data Sheet (Elementary)

Date:_____

Please be as precise as possible! You can write numbers other than those that are on the colour charts.

Water Sample	pH Guideline: 7.0-10.5
Local	
Control	
Did the local water pass the guideline? (yes/no) If not, brainstorm why that might be.	

Results:

Sample water with a pH between 7.0 and 10.5 meets the Canadian Drinking Water Guideline for pH. The buffer should give a result very close to 7.

pH:

What is pH and why do we test our water for it?

pH is an index of the amount of hydrogen ions (H^+) are in a substance. The pH scale runs from 0-14, with 7.0 being neutral. Substances with a pH higher than 7.0 (7.1-14.0) are considered alkaline or basic. Substances with a pH less than 7.0 (0 - 6.9) are considered acidic. We consume many different foods and beverages with a large range of pH. For example, citrus fruits like oranges, lemons and limes are quite acidic (pH = 2.0 - 4.0). On the other hand, egg whites are a little basic, with a pH of 8.0. The ideal pH range for water is between 7.2 and 7.6. This means that the water is slightly basic. By maintaining the proper alkalinity of water, the pH will stay around the ideal levels. However, if the alkalinity gets too low, the pH can start to deviate and can begin to cause water quality problems.

What happens if the pH of my water is too low or too high?

There are no health risks associated with consuming water that is slightly acidic or basic. After all, we can eat lemons, drink soft drinks, and eat eggs. However, when water has a pH that is too low, it will lead to corrosion an d pitting of pipes in plumbing and distribution systems. This can lead to health problems if metal particles are leached into the water supply from the corroded pipes. The water

also has a slightly bitter and metallic taste that some may find objectionable. If the pH of your water is too high, it will have a taste similar to baking soda and will have a slippery feel to it. It will also begin to leave scale deposits on plumbing and fixtures, which will decrease the efficiency of the plumbing systems.

Type of Substance	*pH Range*
Battery Acid	1.1-1.7
Lemon Juice	1.9-2.8
Vinegar	3.2-3.6
Orange Juice	3.7-4.2
Cola	4.0-4.5
Normal Rainwater	5.1-5.6
Distilled Water	7.0
Blood	7.4-8.1
Baking Soda	8.3-8.8
Milk of Magnesia	9.8-10.2
Ammonia	10.7-11.5
Bleach	12.4-13.0
Household Lye	13.6-14.0

pH of several different substances
Source: http://bear_creek.tripod.com/water.htm

How do I increase or decrease the pH of my water?

Acidic water can be corrected using one of the following two methods:

1. Neutralizing filters increase the pH by passing water through a filter bed of Calcium Carbonate ($CaCO_3$). This neutralizes the acid and increases the pH.
2. Soda Ash (Sodium Carbonate) solution is fed through a tube into the pumping intake and is automatically injected whenever the water pump is running.

NOTE: Both Sodium and Calcium Carbonate are the most common compounds used to increase pH in drinking water.

Basic water can be corrected by either adding a specific volume of Muriatic acid (hydrochloric acid) or a commercially prepared chemical designed to decrease the

pH. It is always best to check with water treatment experts when deciding on the products and the volumes to use when adjusting pH.

Sulphate Analysis (Elementary)

Purpose: To determine if the water sample meets Canadian Drinking Water Guideline for Sulphate making a visual comparison of precipitate present. Testing will be done on Local community treated water; the teacher will do this as a demonstration. There is a 500 mg/L Canadian Drinking Water Guideline for sulphate in drinking water; you will test and compare your result to see if it meets these guidelines.

Materials:

- 3 - Plastic cups
- 2 – 2 mL plastic pipettes
- 1 – 2 mL Canadian Guideline for Sulphate sample (CGLS) (500 mg/L)

- 3 – 5 mL vial containing 2 mL of Sulphate Reagent 1
- 3 – 5 mL vial containing 3 mL of Sulphate Reagent 2
- 50 mL graduated cylinder (not supplied with kit – teacher must supply)

Method:

1. Label the 3 plastic cups with appropriate number, and name:
   #1 - Control
   #2 - Canadian Guideline (CGLS)
   #3 - Local Community Treated Water
2. Label the 2 pipettes: DI (for Deionized Water), LTW (for Local Community Treated Water).
3. Using a graduated cylinder, measure out 25mL of Deionized Water to each of the 3 cups.
4. To the #1 Control cup, add 2ml of the Deionized Water using the pipette labeled DI.
5. To the #1 Control cup, add contents of one of the Sulphate Reagent 1 tubes.
6. To the #1 Control cup while swirling, add contents of one of the Sulphate Reagent 2 tubes. Continue swirling for 1 minute and then set the cup aside.
7. To the #2 cup (Canadian Guideline (CGLS)), add contents of tube labeled Canadian Guideline (CGLS).

8. To the #2 cup, add contents of one of the Sulphate Reagent 1 tubes.
9. To the #2 cup while swirling, add contents of one of the Sulphate Reagent 2 tubes. Continue swirling for 1 minute and then set the cup aside.
10. To the #3 cup, using the pipette labeled LTW, add 2 mL of the Local Community Treated Water.
11. To the #3 cup, add contents of the Sulphate Reagent 1 tube.
12. To the #3 cup while swirling, add contents of the Sulphate Reagent 2 tube. Continue swirling for 1 minute and then set the cup aside.
13. Determine the cloudiness of the cups **Relative to the** Canadian Guideline for Sulphate sample (CGLS) (more or less cloudy) and record the results.

Operation Water Drop: Data Sheet (Elementary)

Date:_____

Please be as precise as possible! You can write numbers other than those that are on the colour charts.

Water Sample	**Sulphate (mg/L)** Guideline: 500 mg/L
Local	
Control	
Did the local water pass the guideline? (yes/no) If not, brainstorm why that might be.	

Results:

The Canadian Guideline sample should be cloudy. The local community treated water sample may or may not be cloudy. If the water sample is less cloudy than the Canadian Guideline, then it passes the Canadian Drinking Water Guideline for Sulphate, which is 500 mg/L. The Control should not have any cloudiness present.

Safe Handling of Materials

Caution must be taken at all times when handling any chemicals. Although this test is safe to use in any area, please be cautious with the materials supplied.

Sulphate:

What is sulphate and why do we test for it?

Sulphur is a non-metallic element that is widely used for commercial and industrial purposes. Sulphur combines with oxygen to form the sulphate ion, SO_4. Sulphate products are used in the manufacture of many chemicals, dyes, soaps, glass, paper, fungicides, insecticides, and several other things. They are also used in the mining, pulp, sewage treatment and leather processing industries. Aluminum sulphate (alum) is used in water treatment as a sedimentation agent, and copper sulphate has been used to control blue-green algae in raw and public water supplies.

Drinking water with excess sulphate concentrations often has a bitter taste and a strong 'rotten-egg' odour. Sulphate can also interfere with disinfection efficiency by scavenging residual chlorine in distribution systems. Sulphate salts are capable of increasing corrosion on metal pipes in the delivery system and sulphate-reducing bacteria may produce hydrogen sulphate which can give the water an unpleasant odour and taste and may increase corrosion of metal and concrete pipes.

What are the current Canadian limits for sulphate?

The current limits for sulphate in drinking water are based on aesthetic objectives and are set at <500mg/L, which is the taste threshold level.

What are the health risks associated with high or low sulphate levels?

There are no symptoms associated with sulphate deficiency. However, most people get the majority of their dietary sulphates through food and not from the water. High sulphate levels (1000 mg/L) have been shown to have a laxative effect on humans and can cause mild gastrointestinal irritation. Therefore, excessively high sulphate levels are usually investigated by water treatment authorities.

What do I do if my water exceeds the recommended sulphate limit?

Unfortunately, sulphate is not easily removed from drinking water as it is often in a form that is quite soluble in water. The most effective removal methods include distillation, reverse osmosis or electrodialysis. For home treatment reverse osmosis and distillation are most common.

Total Chlorine Analysis (Elementary)

- **Purpose:** To determine the total chlorine concentration in your local drinking water. Find two different locations (drinking water fountain, tap water from the gym etc.) and sample the water into cups provided, label the cups from where the water came before you sample.

The determination will be done by using a test strip method. You will compare the different results, and you will also see if the water meets the United States Environmental Protection Agency's maximum residual disinfectant level goal for chlorine of 4 ppm.

Materials:

- 2 - Test strip packets with colour chart printed on packet for determining Total Chlorine concentration.
- 2 - Drinking glasses.

Method:

1. Label the two glasses with the names of the locations from which you got the water.
2. Put about 50 mL of sample in respective glasses (volume is really not critical).
3. Dip one test strip in glass for 5 seconds with constant back and forth motion, so that water passes through the small aperture in the test strip.
4. Remove and shake the test strip once, briskly, to remove any excess water on the strip. Allow the test strip to dry for 30 seconds by lying across glass.
5. Match with the best colour to determine the Total Chlorine concentration in mg/L or parts per million (ppm). Complete the colour matching within 15 seconds. Do one sample at a time.
6. Write up your results.

Operation Water Drop: Data Sheet (Elementary)

Date: _____

Please be as precise as possible! You can write numbers other than those that are on the colour charts.

Water Sample	**Total Chlorine (mg/L)** MRDLG: 4 mg/L
Local	
Control	
Did the local water pass the guideline? (yes/no) If not, brainstorm why that might be.	

Results: Compare results to the United States Environmental Protection Agency's maximum residual disinfectant level goal for chlorine of 4 ppm; a darker colour of green means that the water sample **Does Not** meet the United States Environmental Protection Agency's maximum residual disinfectant level goal for chlorine.

Safe Handling of Materials:

Caution must be taken at all times when handling any chemicals. Although this test is safe to use in any area, please be cautious with the materials supplied.

Total Chlorine:

What is Total Chlorine and why do we test for it?

Chlorine is a chemical that is used to disinfect water prior to it being discharged into the distribution system. It is used to ensure water quality is maintained from the water source to the point of consumption. When chlorine is fed into the water, it reacts with any iron, manganese, or hydrogen sulphide that may be present. If any chlorine remains (residual), it will then react with organic materials, including bacteria. In order to ensure that water is sufficiently treated through the whole distribution system, an excess of chlorine is usually added. This amount is usually adjusted to make sure there is enough chlorine available to completely react with all organics present.

The chlorine will decrease in concentration with distance from the source, until it reaches the point where the chlorine level can become ineffective as a disinfectant. Bacteria growth will occur in distribution systems when very low levels of chlorine are encountered. Therefore, it is important to make sure there is enough chlorine to efficiently disinfect even at the far ends of the distribution system. Chlorination can kill many pathogenic (disease causing) microorganisms such as *E.coli,* but others, like *Cryptosporidium* and *Giardia,* are very resistant to chlorine and require other measures to properly remove them.

There are some important chlorination trends found in drinking water treatment:

- As chlorination increases, the time required to disinfect decreases.
- Chlorination is more effective as the temperature increases.
- Chlorination is less effective as pH increases (becomes more alkaline).
- Chlorination is less effective in turbid water.

Residual chlorine may have a taste and/or odour that some people may find disagreeable. However, most would prefer that to drinking water that contains potentially harmful inorganic and organic materials.

What are the current recommendations for total chlorine?

There are two ways in which residual chlorine is measured. Free Chlorine is the chlorine that remains in the water that has not reacted with anything (organic or inorganic). Total Chlorine is the chlorine that remains in the water that is both free and reacted.

The United States Environmental Protection Agency's maximum residual disinfectant level goal (MRDLG) for chlorine is 4 ppm (4 mg/L). The United States Environmental Protection Agency's maximum residual disinfectant level (MRDL) (which is enforceable in the United States) is 4.0 mg/L or 4 ppm as an annual average.

What are the health risks associated with low total chlorine?

Studies have shown that when total chlorine levels drop below recommendations, several water quality problems can occur. With regard to public health, bacteria and selected viruses, called bacteriophages, are able to multiply in water that is not properly disinfected and, depending on the species, could potentially cause waterborne illnesses.

It is important to note that, although chlorination has been the most common method of disinfection for over 100 years, there have been recent studies that have shown that chlorine in water can react with otherwise innocent organic material in drinking water and form chemicals called Trihalomethanes (THMs), such as Chloroform. THMs have been shown to be potentially carcinogenic (cancer causing) and are, therefore, carefully monitored in water systems that are routinely chlorinated. While recommendations only state minimum total chlorine levels, it is important that a careful balance is maintained in drinking water. There needs to be enough chlorine to make sure everything is properly disinfected. However, an extreme excess of chlorine is not necessary and may lead to high levels of THMs and the adverse health risks described previously.

What do I do if my water does not meet total chlorine recommendations?

In municipal water systems, the drinking water is chlorinated prior to being distributed and chlorine totals should be measured at the far end of the distribution line. This ensures that the house located furthest from the plant still receives water that is adequately disinfected. If your water does not have appropriate chlorine residual levels, contact your local treatment facility and have them conduct further tests to make sure enough disinfectant is added to the water at the plant. For homes that get their water from wells, either commercial disinfectants or diluted household bleach may be used to adequately treat drinking water. Usually, gaseous chlorine is added to the water at large treatment facilities. However, this form of chlorine is too dangerous to be used for home use and other disinfectants such as those mentioned above are recommended. Contact a local water treatment authority to determine the recommended levels for your well system.

Total Hardness Analysis (Elementary School)

Purpose: To determine the Total Hardness concentration in drinking water on a Local Community treated water and a Saskatchewan Guideline Limit Sample (SGLS) for quality control purposes.

Determination will be done by using a test strip method. You will compare the result with the enclosed quality control sample.

Total hardness is a measurement of calcium and magnesium, and is expressed as calcium carbonate; our body needs both Ca and Mg to remain healthy. In some countries minimum levels of calcium have been advocated (levels should be greater than 20 mg/L for calcium). The major concern with elevated levels of hardness is scale depositing on piping and drains making them less efficient. If water is too hard it will also decrease the washing ability of many soaps and detergents (the soap may not clean properly), as well as affect the taste of the water.

Materials:

- 1 – An 800 mg/L Total Hardness (SGLS)
- 2 - Test strip packets (with colour charts printed on them)
- 2 - 10 mL disposable beakers.

Method:

1. Label the two beakers SGLS and Local.
2. Put 10 mL of sample in the beakers.
3. Dip one test strip in sample beaker for 3 seconds**.**
4. Remove and immediately match to the closest colour on the colour chart that is located on the test strip packet. Colour is **only stable** for **1 minute.**
5. Read and record the results as mg/L (parts per million), match with the best colour to determine the Total Hardness concentration.
6. Repeat for the Guideline Limit Sample.

Operation Water Drop: Data Sheet (Elementary)

Date:_____

Please be as precise as possible! You can write numbers other than those that are on the colour charts.

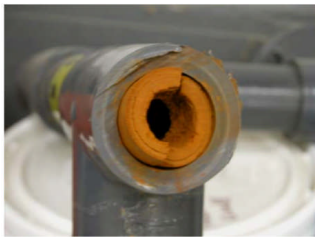
Water Sample	**Total Hardness (mg/L)** Guideline: 800 mg/L (SK)
Local	
Control	
Did the local water pass the guideline? (yes/no) If not, brainstorm why that might be.	

Results:

The Saskatchewan Guideline Limit Sample (SGLS) for Total Hardness should give a result very close to the 800 mg/L guideline; this is a very high level of hardness and should only be encountered in untreated well water sources.

Total hardness:

What is total hardness and why do we test our water for it?



The guidelines for hardness are based on aesthetic, rather than health concerns. Hard water causes scale to form in water pipes, plumbing fixtures and kitchen appliances (see photo). Scale build-up in hot water tanks and boilers increases heating costs and can lead to premature failure of heating equipment. Scale deposited in clothing during washing will cause increased wear and tear on fabrics. Soap reacts with hard water to form a curd and can also cause skin flaking and irritation. In addition, when washing or doing laundry with hard water, more soap or detergent is needed.

Where does hardness in water come from?

Hardness is primarily caused by the dissolved mineral compounds calcium and magnesium although smaller contributions to hardness will also come from some other ions including iron and manganese. The amount of hardness is expressed in milligrams per litre (mg/L) or grains per gallon (gpg) as calcium carbonate.

Hardness is calculated from the equation $Hardness = 2.497\,(Ca) + 4.118\,(Mg)$. Therefore, fluctuations in the magnesium pool affect hardness stronger than do calcium fluctuations.

The main components of hardness, calcium and magnesium, are actually of benefit to people. There are no Canadian guidelines for calcium in water and when present in drinking water, calcium may be considered to be of nutritional benefit (if levels around 50 mg/L were consumed, drinking water would provide around 5 to 10% of the daily calcium requirements). The European Community has set

a guideline level of 100 mg/L with no maximum acceptable upper concentration. The European Union has also stated that water intended for human consumption should contain a minimum of 20 mg Ca/L.

Magnesium is an essential nutrient for humans, with adults requiring around 350 mg per day. Moderate levels of magnesium may provide a nutritional benefit to individuals consuming a magnesium deficient diet. There are no Canadian recommendations in regard to magnesium, but the European Community suggests a guideline of 30 mg/L, with a maximum acceptable level of 50 mg/L, which may be related to magnesium's strong effect on hardness and has no health significance.

What do guidelines say about hardness?

The Guidelines for Canadian Drinking Water Quality notes the following:

1) public acceptance of hardness varies considerably. Generally, hardness levels between 80 and 100 mg/L as $CaCO_3$ are considered acceptable;
2) levels greater than 200 mg/L are considered poor but can be tolerated;
3) levels in excess of 500 mg/L are normally considered unacceptable;
4) where water is softened by sodium-ion exchange, it is recommended that a separate unsoftened supply be retained for culinary and drinking purposes.

The Saskatchewan Government has set an upper acceptable limit for hardness to 800 mg/L. Such high levels will, however, impart a taste to the water and will cause problems with clothes washing, minerals will be deposited on dishes, tubs and showers and water heaters will become less efficient.

What happens if the hardness is too low or too high?

If the hardness is too low the water can be quite corrosive leaching copper and lead out of plumbing pipes. With very low hardness there would also be low levels of beneficial ions in the water, especially calcium and magnesium. If hardness is too high it can have an unpleasant taste, can dry out skin and cause scaling on fixtures and throughout the water distribution system. This scaling is undesirable because it begins to decrease the efficiency of plumbing systems, which results in greater power consumption and increased costs.

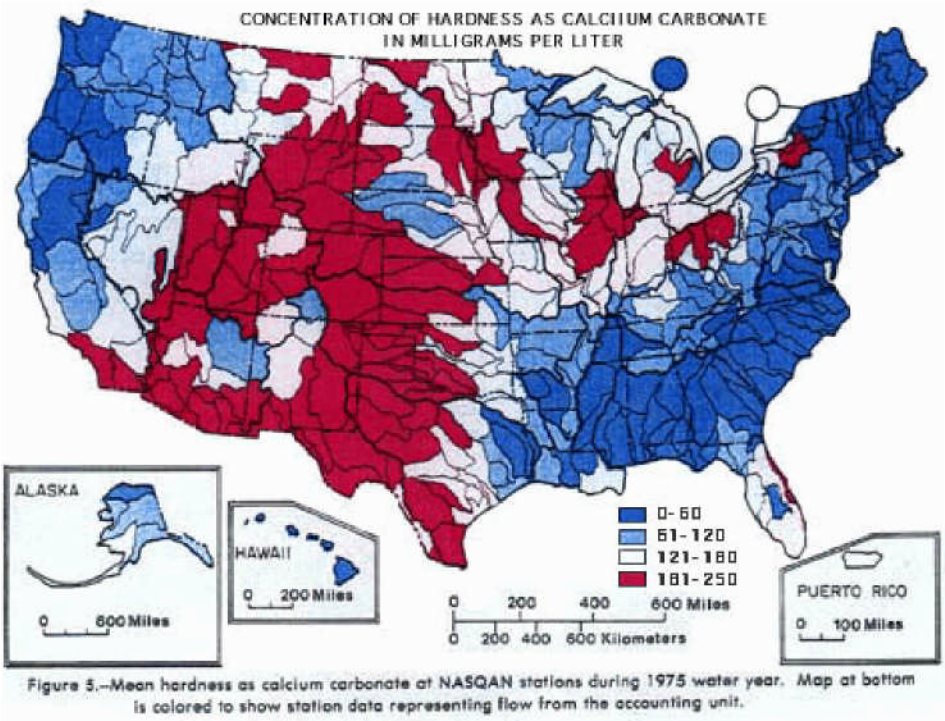


Figure 5.--Mean hardness as calcium carbonate at NASQAN stations during 1975 water year. Map at bottom is colored to show station data representing flow from the accounting unit.

Map of total hardness in water across the United States. It is expected that the shown trends continue into Canada

Source: http://water.usgs.gov/owq/map1.jpeg

What do I do if the level of hardness in my water is too low or too high?

Public water utilities with high hardness levels may not be able to lower these levels as it is difficult to do this before an increased use of membrane technologies become common in the future. These membranes, such as nanofiltration membranes and reverse osmosis membranes can effectively remove both calcium and magnesium ions from the water (the main causes of hardness). However, when using Reverse Osmosis (which removes virtually all calcium and magnesium ions) it should be borne in mind that the European Union has stated that water intended for human consumption should contain a minimum of 20 mg Ca/L. RO treated water frequently fail to meet this guideline unless calcium is added back to the water. In homes the use of softeners is more common where calcium and magnesium ions are replaced by sodium or potassium, although many homes are now installing under the sink reverse osmosis membranes to provide drinking water.

Student Evaluation

Name: _____

Knowledge/Understanding

Knowledge of issue and depth of analysis.	/ 10
Sufficient information presented.	/ 10

Thinking/Inquiry

Material is well-integrated.	/ 5
Original and creative.	/ 5
Effective selection of information.	/ 5
Ideas are relevant to topic.	/ 5

Communication

A/V resources supplement & enhance information.	/ 5
Delivered in a well-modulated & distinct voice.	/ 10
Inconspicuous use of notes and outlines. (Maintained eye contact with audience.)	/ 5

Learning Skills - Organization

Well prepared to present.	/ 5
Information follows a logical sequence.	/ 5
Follows agenda and manages time well.	/ 5

Learning Skills - Teamwork

Group members are organized, prepared & cohesive.	/ 5
Clear introduction of topic(s) and activity.	/ 5
Active role taken by each group member.	/ 5
Time is well-managed.	/ 5
Able to handle questions, manage audience & initiate meaningful activity/discussion.	/ 5

Total score out of possible 100

Comments: