Operation Water Drop – Testing the Water We Drink!	Grade 9-12

Subject: Science, Biology, Chemistry

Topic: Testing the water we drink!

Time Frame: Roughly 60 minutes

Objectives: To allow students to run tests on five different sources of water. Students are expected to collect three samples of water: Urban and Rural (includes Aboriginal and non-Aboriginal communities) treated waters, and a Raw Source Water. A Drinking Water Guideline sample will be provided with the OWD Kit. 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 Guidelines for Canadian Drinking Water Quality. The only exception to this will be the Ammonium test where Canada does not have a guideline, and in this case the comparison will be to the European Union Limit.

Methodology: 12 different tests will be conducted on water from the five different sources so that the students can compare the different drinking water qualities. 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 each test instruction sheet to give to respective students/groups to follow procedures carefully. It is also recommended that you carefully review the materials list included in your kit, to ensure you have all materials.

Materials: Each Operation Water Drop Test Kit contains 12 test supply bags with all requirements for testing five different samples; your community water sample, Drinking Water Guideline sample and three other water samples. We recommend you test rural (includes Aboriginal and non-Aboriginal communities) water, urban water, and raw untreated source water. For each analyte tested all supplies required are packaged in one bag to be given to the responsible group. The following is a list of all materials sent in the OWD kit for High Schools. Please ensure all of the required materials are included in your kit.

A Note About Disposal: After the testing has been completed, everything can be poured down the tap as even the arsenic test 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 test.

Materials List For High School Operation Water Drop Kit

Total # of Beakers, Glasses, and Water Sample Bottles
Drink Glasses 16
10 mL Disposable Beakers 27
5 – 500 mL Bottles: Deionized Water**, Rural** Treated Water, **Urban** Treated Water, **Raw** Untreated Water, **Local** Treated Water.
All of the materials are packaged in separate bags for each test.

Test	Vial size (mL)	# In Kit	Test	Vial size (mL)	# In Kit
Alkalinity			**Ammonium**		
Alkalinity (Low Limit Sample)	50	1	Ammonium (AEUL)	5	1
0.02N H_2SO_4	15	5	Test Strips in Tube		5
Methyl Purple Indicator	1.5	1	Colour Chart		1
Disposable Pipette	1.2	1	Disposable Beakers	10	4
Drink glass		5	**Copper**		
Colour			Copper (CGLS)	10	1
Colour Standard (CGLS) (Tube)	50	1	Test Strip Packets		5
Plastic test tubes	29X115 mm	6	Disposable Beaker	10	5
pH			**Iron**		
pH Buffer 7 (Tube)	5	1	Iron (CGLS)	10	1
pH Indicator Strip	10	5	Aluminum Pouches		5
pH Scale Card		1	Disposable Beaker	10	5
Disposable Beaker	10	4	**Manganese**		
Sulphate			Manganese (CGLS)	10	1
Sulphate (CGLS) (Tube)	2	1	Manganese #1 strip		5
Sulphate Reagent #1 (Tube)	5	6	Manganese #2 strip		5
Sulphate Reagent #2 (Tube)	5	6	Manganese #3 strip		5
Disposable Pipette	2	5	Colour Chart		1
Drink glass		6	Free Standing Vial	10	4
Arsenic			**Nitrate**		
Plastic Bottles (1 Containing Proposed CGLS)	100	2	Nitrate (CGLS)	10	1
Caps (Flip Top)		2	Test Strip Packets		5
Arsenic Reagent #1 Packets		5	Disposable Beaker	10	4
Arsenic Reagent #2 Packets		5	**Total Chlorine**		
Arsenic Reagent #3 Packets		5	Test Strip Packets		5
Arsenic Indicator Strips		5	Drink glass		5
Colour chart		1	**Total Hardness**		
			Total Hardness (SGLS)	10	1
			Test Strip Packets		5
			Disposable Beaker	10	5

Additional materials:
Although the 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
- Fume hood or well ventilated area for arsenic test
- Protective gloves, goggles, and apron for arsenic test

Space Requirements: Students should be in a room with sufficient bench or desk space to work comfortably in small groups to conduct their tests, the arsenic and alkalinity test should be done in either a fume hood or in a well ventilated area.

Directions:
The students will be testing water for the following parameters:
Approximate Time for each test to be completed (minutes)

1. Alkalinity (20)	2. Ammonium (5)	3. Arsenic (40)
4. Colour (10)	5. Copper (10)	6. Total hardness (5)
7. Iron (5)	8. Manganese (5)	9. Nitrate (5)
10. pH (5)	11. Total Chlorine (5)	12. Sulphate (20)

The students should be divided into 4 separate groups; each group will be running tests on all five water samples including a Canadian Guideline Limit Sample that is supplied for all analytes. The following distribution of the tests among the students will consume approximately 60 minutes:
Group 1: Will do Arsenic alone.
Group 2: Will do Alkalinity, Copper, and Manganese.
Group 3: Will do Ammonium, Sulphate, and Total Hardness.
Group 4: Will do Colour, Nitrate, Total Chlorine, Iron, and pH.

The arsenic test is the biggest time consumer; these tests have been set up so that students can get exposure to doing laboratory work, testing their water, comparing different water qualities to the Canadian Drinking Water Guidelines. The optimum size for Group 1 would probably be 4, and the other groups could be as large as 6-8.

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.

After the tests have all been completed, the teacher should lead a discussion on the results that were found.

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.

Results:

After the tests have all been completed, the teacher should lead a discussion on the results that were found and enter the students' results into 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.

Evaluation: Presentation Checklist

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?		

Resources:

Visit the Safe Drinking Water Foundation Website www.safewater.org to learn more about issues affecting safe drinking water.

You will find links to many Educational Fact Sheets and various articles published pertaining to the different analyses 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.

Following student presentations on their test results, it is suggested that the class have a discussion and formulate a Community Action Plan.

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Alkalinity Analysis (High School)

Purpose: To determine how much alkalinity a sample contains using a colourimetric method.
Testing will be done on 4 different water sources, plus a Low Limit Sample (LLS):

- Urban treated water
- Rural (Aboriginal and/or non-Aboriginal community) treated water
- Untreated raw source water
- Local community treated water
- Alkalinity Low Limit Sample (LLS)

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 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
- 5 - 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
- 5 - 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 5 plastic cups as follows:

    #1 Alkalinity LLS
    #2 Urban Treated Water
    #3 Rural Treated Water
    #4 Untreated Raw Water
    #5 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 Urban Treated Water sample and pour it into the cup labeled Local Urban Treated Water sample.
7. Repeat steps 4 & 5.
8. Measure out 50 mL of the remainder of the water samples into their appropriately labeled cups and repeat steps 4 & 5.
9. 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 (High School)

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)
Control	

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. You can multiply the amount of acid added by 20 and change the units to ppm to get the result in parts per million. For example, if 2.5 mL of acid is added then the calculation is 2.5 x 20 = 50 ppm.

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.

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Ammonia Analysis (High School)

Purpose: To determine the Ammonia concentration in drinking water from 4 different sources, plus a European Union limit sample for quality control purposes:

- Urban treated water
- Rural (Aboriginal and/or non-Aboriginal community) treated water
- Untreated raw source water
- Local community treated water
- Ammonia European Union limit (AEUL)

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).
- 5 - Test strips in a tube
- 1 - Colour chart for determining Ammonia concentration.
- 4 - Disposable beakers

Method:

1. Label the 4 plastic beakers as follows: Urban Treated Water, Rural Treated Water, Untreated Raw Water, and Local Community Treated Water. The ammonia AEUL sample can be tested in its tube.
2. Fill the disposable beakers with the appropriate water samples.
3. Dip ammonia test strips into the water samples for five seconds, remove with pad face up and hold level for 60 seconds. **Do not shake off excess water.**
4. Compare the colour pads on the test strips to the colours on the colour chart after the 60 seconds have elapsed in order to determine the ammonia concentrations.

Operation Water Drop: Data Sheet (High School)

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)
Control	

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 the 0.5 mg/L AEUL; if the colour is darker then it **DOES NOT** meet the guidelines.

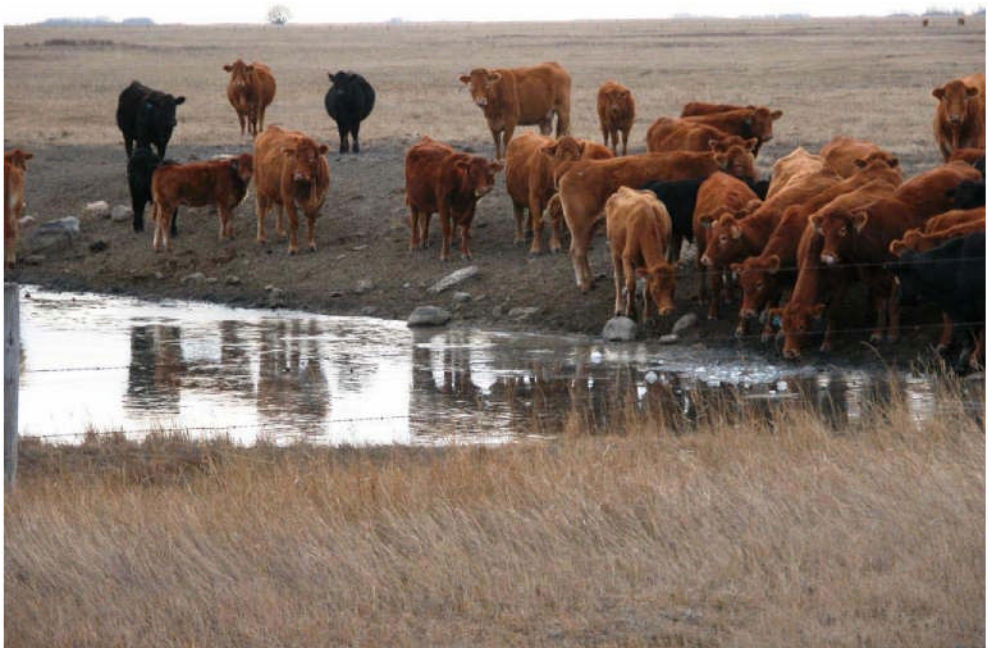
Ammonium:

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.

Arsenic Analysis (High School)

Purpose: To determine the arsenic concentration in drinking water from 4 different sources, plus a Proposed Canadian Guideline sample for quality control purposes:

- Urban treated water
- Rural (Aboriginal and/or non-Aboriginal community) treated water
- Untreated raw source water
- Local community treated water
- Possible Future Canadian Guideline for arsenic

Determination will be done by using a test strip method. You will compare the different results, you will also see if the water meets a future stringent guideline that may be implemented by Health Canada (5 micrograms arsenic/L). Arsenic in the form of arsenate is very similar to phosphate, an essential nutrient in the human body, and is incorporated into many compounds causing many different diseases including cancer. This is the reason why Health Canada's guideline ten years ago was, 50 micrograms/L, was decreased to 25 micrograms/L and then to 10 micrograms/L with a possible future decrease to 5 micrograms/L.

Materials

- 2 - Plastic bottles (1 will contain 5 ppb arsenic sample).
- 4 - Caps (2 screw caps and 2 with flip tops).
- 5 - Packets with arsenic reagent 1.
- 5 - Packets with arsenic reagent 2.
- 5 - Packets with arsenic reagent 3.
- 5 -Packets with indicator strips.
- 1 - Colour Chart

Method

1. One bottle contains 5 micrograms/L arsenic. Put 100 mL of water sample in second plastic bottle with lid (not the flip top type). Water should be room temperature (20-25 degrees Celsius).
2. Add one reagent #1 packet to each bottle, cap securely and shake vigorously with bottle upright for 15 seconds.

3. Uncap the reaction bottles, add one reagent #2 packet to each bottle, cap securely and shake vigorously with bottle upright for 15 seconds.
4. Allow the reaction bottles to stand undisturbed for 2 minutes (this will ensure that there is no Hydrogen Sulfide interference).
5. While waiting, prepare reagent strips by inserting into flip top caps. (**Do not touch the small pads on the test strip).** Insert the strip into the turret pad end first, until the red line is even with the top of the turret, and now close (flip down) the turret, which will hold the test strip in place. Make sure that the test strip is positioned in the middle of the cap, so that it is hanging straight down from the cap, do this by bending the test strip but be careful NOT to touch the test pad.


6. Uncap the reaction bottles and add one reagent #3 packet to each reaction bottle, cap securely with the yellow cap and shake vigorously with bottle upright for 15 seconds.
7. Uncap; now recap securely using the flip top cap with the strip in it. Ensure that the test strip is hanging straight down from the cap.
8. After 10 minutes, carefully remove indicator strip from cap and compare colour to that of *colour chart.
9. Rinse bottles twice with Deionized Water, and twice with new sample water. Fill the bottles with 100 mL of the next water samples to be tested. Repeat steps 2-8 with the 2 remaining water samples.
10. Put indicator strips back in Ziploc bag and dispose of in garbage.

Operation Water Drop: Data Sheet (High School)

Date:____________________________

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

Water Sample	Arsenic (ug/L) Guideline: 10 ug/L
Control	

Results:

The 5 microgram/L sample should be similar to the 5 ug/L (or 5 ppb) colour (the lightest colour) on the colour chart, which is a potential future limit for the Guidelines for Canadian Drinking Water Quality. If the sample is darker in colour than this, then the drinking water will NOT meet this potential future Guideline for Canadian Drinking Water Quality. Communities with levels higher than 5 micrograms/L need to carefully optimize their treatment plant processes or look at alternate processes to achieve the potential lower guideline level. The current arsenic limits for the European Union and the United States are set at 10 micrograms per litre with possible changes going to 5 or less micrograms per litre. When Simon Kapaj M.D. worked for Safe Drinking Water Foundation, he argued that arsenic levels above 5 are not sufficiently protective of human health (article published by Journal of Environmental Science and Health, October 2006).

Arsenic:

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

Arsenic occurs naturally often together with other chemicals in soils and minerals. Arsenic and all of its compounds are poisonous, but the toxicity varies. Inorganic arsenic is thought to be most toxic; it can occur as trivalent arsenite (As3+) or pentavalent arsenate (As5+). These are the types of arsenic present in drinking water. Organic arsenic is mainly found in seafood and is much less harmful to human health. The guideline for arsenic has decreased from 50 micrograms per L to 25 and this year it has decreased further to 10 micrograms/L. As we know more about the ill effects of arsenic it is expected that it will decrease further. The Safe Drinking Water Foundation recommends that efforts should be made to keep treated water levels below 5 micrograms/L.

Arsenical keratosis on the palm, Santiago del Estero

Where does arsenic in water come from?

In Canada arsenic concentrations in underground water sources (well water, aquifer water) are higher than surface water supplies, which is common to most locations around the world suffering from arsenic problems. If you live in an area that is known to have high arsenic levels then you should have the water tested.

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

For people on municipal water supplies the arsenic levels should normally be tested regularly and efforts are generally made to improve and optimize water treatment methods so that arsenic levels remain below Guideline levels. However, as the acceptable level of arsenic is decreasing, it is becoming increasingly difficult to remove arsenic to trace levels without the use of some form of advanced treatment systems. The introduction of Reverse Osmosis membranes can remove high levels of arsenic (>75 micrograms/L) to levels below 2 micrograms/L. If the arsenic is in the form of arsenite (As+3) it will not be effectively removed even by RO membranes. It is therefore necessary in high arsenic water sources to make sure that the arsenite is converted to arsenate before the water is treated by RO.

Colour Analysis (High School)

Purpose: To determine if the water sample meets Canadian Drinking Water Guidelines for Colour, by doing a visual comparison of 4 different sources:

- Urban Treated water
- Rural (Aboriginal and/or non-Aboriginal community) treated water
- Untreated raw source water
- Local community treated water

The Canadian Drinking Water Guidelines has an aesthetic objective of 15 TCU (True Colour Units) for drinking water; you will see and compare the different water sources. The 15 TCU (True Colour Units) is the concentration of the Canadian Guideline sample.

Materials:

- 1 - 50ml tubes containing Canadian Guideline Limit Sample for Colour
- 6 - Large plastic test tubes

Method:

1. Label the test tubes with their number, and appropriate name; #1 Control, #2 Canadian Guideline, and #3, #4, #5, #6.
2. Pour the 50ml of Canadian Guideline into the #2 test tube.
3. Fill the #1 Control test tube with the deionized water to the same level as the #2 test tube.
4. Fill the #3 Sample test tube with sample water to the same level as the #2 Canadian Guideline test tube.
5. Hold the #3 sample test tube between the #1 and #2 tubes over a white piece of paper
6. View the test tubes from above: Is the colour of the #3 Sample lighter or darker then the colour of the #2 Canadian Guideline sample?
7. Record the results
8. Repeat steps 4-6 with the remaining samples (#4, 5, and 6).

Operation Water Drop: Data Sheet (High School)

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)
Control	

Results:
If the water sample has a colour lighter or equal to that of the Canadian Guideline test tube then it meets the Guideline for Canadian Drinking Water Quality for colour.
If the water sample is darker in colour than that of the Canadian Guideline tube, it does not meet the Guideline for Canadian Drinking Water Quality for colour 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(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 cause 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 contents of copper (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 treatment 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 (High School)

Purpose: To determine the Copper concentration in drinking water from 4 different sources, plus a Canadian Guideline Limit Sample for copper that will be done for quality control purposes:

- Urban treated water
- Rural (Aboriginal and/or non-Aboriginal community) treated water
- Untreated raw source water
- Local community treated water
- Canadian Guideline for Copper

Determination will be done by using a test strip method. You will compare the different results, you will also see if the 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 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).
- 5 - Test strip packets, with colour charts printed on them.
- 5 - 10 mL disposable beakers.

Method:

1. Label the five beakers with their appropriate water sample names.
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 (High School)

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
Control	

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 wastewater 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).

Copper leaching out from household plumbing is the main cause of concern

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 effects 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.

Iron Analysis (High School)

Purpose: To determine the Iron concentration in drinking water from 4 different sources, plus a Canadian Guideline Limit Sample for Iron sample (Aesthetic Limit), this will be done for quality control purposes:

- Urban treated water
- Rural (aboriginal and/or non- aboriginal community) treated water
- Untreated raw source water
- Local community treated water
- Canadian Guideline Limit Sample for Iron (CGLS)

Determination will be done by adding a chemical reagent to the water. You will compare the different results, you will also see if the water meets the Canadian Drinking Water Guidelines.

Naturally occurring Iron is present in meat and meat products, as well as potatoes and vegetables. Iron is absorbed by the body, and is an essential part of hemoglobin which gives our blood its red colour and it transports oxygen through our bodies.

The direct health implications of iron are very limited, there are however indirect problems some of which are: colour, which comes from iron in a particulate form which is too small to filter so you get "coloured water" (see the Raw Untreated Water supplied in some kits), iron bacteria, this is when bacteria and iron form a slime which can lead to poor pipe flow, this can occur when the iron concentration exceeds 0.3 mg/L, the Canadian Drinking Water Guideline (CGLS).

A 0.3 mg/L Canadian Guideline for Iron is included for quality control purposes; this is the limit for Iron, according to the Canadian Drinking Water Guidelines.

Materials:

- 1 - 0.3 mg/L Canadian Guideline Limit Sample for Iron (CGLS).
- 5 – Aluminum pouches containing chemical reagents that react with iron.
- 5 - 10 mL disposable beakers.

Method:

1. Label five beakers with their respective names: Urban Treated Water, Rural Treated Water, Untreated Raw Water, Local Community Treated Water, Canadian Guideline Limit Sample for Iron (CGLS).
2. Put 10 mL of a water sample or (CGLS) in their respective labeled beakers.
3. With a scissor cut the top of each aluminum pouch, then squeeze pouch (opens it) and add the contents of one pouch into each beaker.
4. Wait for 3 minutes, and then compare the colour (look at the beaker from the top) with the CGLS (giving CGLS a rating of 10), estimate what the other beakers contain, the lighter the colour, the lower your rating. Write down the ratings that you got for each sample.

Operation Water Drop: Data Sheet (High School)

Date:______________________________

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

Water Sample	**Iron (mg/L)** Guideline: 0.3 mg/L
Control	

Results:

The Canadian Guideline Limit Sample for iron of 0.3 mg/L was rated 10; a lower rating (lighter colour) means that the water meets the guideline; a higher than 10 rating means that the water **Does Not** meet Canadian Drinking Water Guidelines.

Iron Fact Sheet

What is Iron and why do we test for it?

Iron is the fourth most abundant element in the earth's crust. Iron is a very common problem in drinking water, and has a strong relationship with water hardness (see Harness tests) typically with both hardness and iron increasing at the same time. Iron can cause staining (laundry and plumbing), unpleasant taste, colour and promotion of growth by iron bacteria. Iron can also precipitate in distribution systems and household plumbing thereby causing additional problems.

When there is no oxygen in the water then the iron is present in a reduced, dissolved form (Fe^{2+}), which is frequently present in well water. This form of iron is dissolved and has no colour. When this iron is exposed to oxygen it will oxidize and this iron (Fe^{3+}) is not very soluble and instead forms small particles or colloids. These rust particles are red in colour and are quite small making it a challenge to remove them. Both sedimentation and filtration are commonly used methods to remove oxidized iron.

Bacteria can use reduced iron as an energy source by converting it to oxidized iron. The biologically oxidized iron is then incorporated into compounds around or in the bacterial cells. This can cause problems in restricting water pipes as can be seen in the picture below.

Picture1: A thick layer of iron bacteria growing inside a water pipe

However, this bacterial growth can also be used in the water treatment plant to remove iron from the water. This is called biological filtration where bacteria are sitting on a surface (can be sand or different forms of material that have been designed with high surface areas). Bacteria attached to a material used for drinking water treatment are shown in the picture below.

Picture2: Electron microscope photograph of bacteria cells attached to expanded clay (Filtralite).

What are the Canadian Drinking Water Guidelines for Iron?

Based on aesthetic reasons the *Guidelines for Canadian Drinking Water Quality* recommends that the iron levels should be kept below 0.3 mg/L. However, levels as low as 0.100 mg/L can cause problems with microbial growth within Reverse Osmosis and other types of membrane systems as well as in the distribution systems. The U.S. Environmental Protection Agency's Maximum Contaminant Level (MCL) is also 0.3 mg/L. The major source of iron is food (around 10 mg/day), while drinking water typically contributes less than 0.5 mg/day.

What are some of the health risks associated with Iron?

Iron is an essential element for humans with food providing the majority of the iron requirements. There should be no direct health effects with iron in drinking water, but iron can be linked to excessive bacterial activity. The end result of this action is water that is not pleasant to drink (smell and taste), cooking with this water can also lead to a very unpleasant experience, as will using it to do laundry or wash with.

What do I do if my water exceeds the Canadian Drinking Water Guidelines?

Iron can be removed by biological filtration as shown above (chemical-free iron removal) or various forms of oxidants including air, potassium permanganate and chlorine can be use to form oxidized iron, which can then be filtered from the water. If the iron is generated in the distribution system then the corrosiveness of the water (see Alkalinity and Hardness tests) may have to be decreased (that is alkalinity and hardness increased). Iron removal water treatment processes are frequently used for groundwater treatment while particulate oxidized iron sometimes present in surface water will be removed by coagulation processes (bunching up small particles that can be removed when particle size increases).

SDWF
Safe Drinking Water Foundation

Manganese Analysis (High School)

Purpose: To determine the manganese concentration in drinking water from 4 different sources, plus a Canadian Guideline Limit Sample for Manganese, this will be done for quality control purposes:

- Urban treated water
- Rural (Aboriginal and/or non-Aboriginal community) treated water
- Untreated raw source water
- Local community treated water
- Canadian Guideline Limit for Manganese sample

Determination will be done by using a test strip method. You will compare the different results, you will also see if the water meets the Canadian Drinking Water Guidelines.

Manganese occurs naturally in the environment, and even if humans can add to these levels most manganese is naturally occurring. Some foods contain manganese including grains, rice, nuts, eggs, soya beans, and green beans. Surface waters typically contain low levels of manganese while groundwater aquifers can contain levels that in some cases are more than ten times higher than the Canadian Drinking Water Quality Guidelines. Groundwater treatment plants are therefore more frequently monitoring for and trying to remove manganese.

Manganese is an essential element that our body requires to function properly. But, if the manganese concentration becomes too high in our body, it can have negative health effects.

A 0.02 mg/L aesthetic objective (AO) Canadian Guideline Limit Sample is included for quality control purposes. This is the AO for manganese according to the Canadian Drinking Water Guidelines. The maximum acceptable concentration (MAC) for total manganese in drinking water is 0.12 mg/L.

Materials:

- 1 – 0.02 mg/L Canadian Guideline Limit Sample for Manganese.
- 5 - #1 test strip packets
- 5 - #2 test strip packets
- 5 - #3 test strip packets
- 1 – Colour chart to determine manganese concentration.
- 4 – 10 ml clear plastic vials.

Method:

1. Label the four clear plastic vials with the names of the water samples to be tested.
2. Test the Manganese CGLS sample first.
3. Support the CGLS vial with one hand and with the other hand, dip one **Manganese #1 strip** into the sample and move it back and forth in a gentle motion. Do this for 20 seconds. Remove the strip and throw it away.
4. Dip one **Manganese #2 strip** into the sample and move it back and forth in a gentle motion. Do this for 20 seconds. Remove the strip and throw it away.
5. Dip one **Manganese #3 strip** into the sample and move it back and forth in a gentle motion for 30 seconds. Remove the strip from the sample and shake it once to remove any excess sample.
6. To determine the manganese concentration in mg/L (same as parts per million, ppm), wait **90 seconds** and match the colour of the test strip to the nearest colour on the chart. To best match the strip to the colour chart, fold the strip in half, so that the aperture is against a white background.
7. Record the results for the sample.
8. Fill up the 10 ml clear plastic vials with their respective samples. Repeat steps 3 to 7 with the four other water samples.

Operation Water Drop: Data Sheet (High School)

Date:____________________________

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

Water Sample	Manganese (mg/L) Guidelines: 0.02 mg/L (AO) and 0.12 mg/L (MAC)
Control	

Results: Compare results to the Guidelines for Canadian Drinking Water Quality. The CGLS for manganese should give a result very close to the 0.02 mg/L guideline; a darker colour means that the water does not meet the aesthetic objective for manganese in the Guidelines for Canadian Drinking Water Quality.

Manganese:

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

Manganese is a grayish hard white metal resembling iron. Drinking water guidelines for manganese are set for aesthetic reasons as manganese can stain plumbing and laundry as well as imparting taste and odour to the water. Manganese-containing water can react with coffee, tea and even alcoholic beverages producing a black sludge affecting both taste and appearance. In addition, commonly occurring dissolved manganese (Mn^{2+}) can be oxidized (Mn^{4+}) by bacteria encouraging microbial slime formation in both distribution and household pipes.

Picture: Manganese containing microbial slime

Where does manganese in water come from?

Manganese is leached out of rocks and minerals as well as man-made materials, such as iron and steel pipes. Groundwater supplies having been in contact with rocks for long periods of time generally have much higher levels of manganese than surface water sources. Sometimes discharge of acidic industrial wastes or mine drainage can increase manganese problems in affected surface water sources. Manganese can also be found in many food items, including grains and cereals as well as being quite high in tea.

What are the current drinking water quality guidelines for manganese?

The Guideline for Canadian Drinking Water Quality states that staining of plumbing and laundry occurs above 0.15 mg/L manganese; for most individuals 0.02 mg/L of manganese is objectionable in terms of taste and this level, 0.02 mg/L, has been set as the aesthetic objective (AO) for total manganese in drinking water in Canada. The Canadian maximum acceptable concentration (MAC) for total manganese in drinking water is 0.12 mg/L. Some drinking water supplies in North America contain 10-100 times the current guideline value.

What happens if manganese levels are too high?

Some of the most common water treatment processes for groundwater are designed to remove manganese to below guideline levels. In conventional treatment reduced manganese (Mn^{2+}), which is soluble, is oxidized to Mn^{4+}, which is insoluble, and the Mn^{4+} is then filtered out (Mn^{3+} may also be formed). The oxidation of Mn can take place with oxygen (pure or air), chlorine, ozone, potassium permanganate etc. It is also possible to oxidize the manganese with bacteria in biological filters. If the raw water contains a lot of organic material, ammonium and other interfering compounds, then the oxidation may be incomplete and manganese may still be present in high levels in the treated water. Under these conditions bacteria are encouraged to grow within distribution lines and household plumbing forming microbial slimes.

What do I do if the level of manganese 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.

Nitrate Analysis (High School)

Purpose: To determine the Nitrate concentration in drinking water from 4 different sources, plus a Canadian Guideline Limit Sample (CGLS) for quality control purposes:

- Urban treated water
- Rural (aboriginal and/or non- aboriginal community) treated water
- Untreated raw source water
- Local community treated water
- Canadian Guideline Limit Sample for Nitrate

Determination will be done by using a test strip method. You will compare the different results, you will also see if the water meets the Canadian Drinking Water Guidelines.

Industrial emissions are extensively responsible for the Nitrogen in the environment, which in turn breaks down to contribute to contamination that we have to deal with, the farming community also contributes by adding nitrate-containing manures and chemical fertilizers, which gets picked up in runoff (rain, snow melt) and can contaminate water sources.

There are many negative health effects related to Nitrate, some of which include blood deficiencies, thyroid problems, decreased vitamin A, and cancer. It is, however, rare that nitrate levels are above the Canadian Water Quality Guideline for drinking water. Contaminated private wells are likely the most common place where high levels of nitrate are found.

Materials:

- 1 - 50 mg/L (parts per million) Canadian Guideline Limit Sample for Nitrate.
- 5 - Test strip packets to determine Nitrate.
- 4- 10 mL disposable beakers.

Method:

1. Label the four beakers with their respective names (no CGLS).
2. Put 10 mL of sample in their respective beakers; use the vial for the Canadian Guideline Limit Sample test.
3. Dip one test strip in water for 2 seconds with no motion.

4. Remove the test strip and allow colors to develop for 1 minute, by lying across top of beaker or vial.
5. Match the colour reading (pink number) and record. Please note: The end pad of the test strip measures Nitrate; whereas the other pad on the test strip measures Nitrite. With this test, we are more concerned with the Nitrate reading.

Operation Water Drop: Data Sheet (High School)

Date:________________________________

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

Water Sample	Nitrate (mg/L) Guideline: 45 mg/L
Control	

Results
The Canadian Guideline and those for the U.S. and the World Health Organization range between 45-50 mg nitrate/L. The Canadian Guideline Limit Sample for Nitrate should give a result very close to the 50 ppm Nitrate limit; there should be no nitrite in the Canadian Guideline Limit Sample. A darker colour means that the water **Does Not** meet the Canadian Drinking Water 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.

Nitrate:

What is nitrate and why do we test for it?

Nitrate (NO_3) is a compound of nitrogen and oxygen that is found in many everyday food items such as spinach, lettuce, beets, and carrots. There are usually low levels of nitrates that occur naturally in water but the majority of dietary nitrate intake is from food rather than water. Nitrates can come from a variety of sources: fertilizer and manure run-off, animal feedlots, wastewater and sludge, septic systems, and nitrogen fixation from the atmosphere by legumes, bacteria, and lightning. Nitrate in water is colourless, tasteless, and odourless. Therefore, it can only be detected using chemical analysis.

What are the current Canadian limits for nitrate?

The current Canadian limit is 45mg NO3/L (10.2 mg NO3-N/L). Above this level, an alternate source of water should be available for infants under 6 months of age.

What are the health risks associated with high nitrate levels?

There are a few potentially serious health risks associated with drinking water high in nitrates. The most serious is Methemoglobinemia (Blue-Baby Syndrome), which occurs most often in infants under 6 months of age. Nitrate becomes toxic when it is reduced to nitrite. This process can happen both in the saliva and in the stomach. The stomach acid of infants is less acidic than in adults and is, therefore more conducive to the growth of nitrate-reducing bacteria. The nitrate is reduced to nitrite in the blood and then combines with haemoglobin to form a compound called methemoglobin.

Methemoglobin is not as efficient as haemoglobin at carrying oxygen to body tissues so oxygen deprivation results. If an infant is affected by Methemoglobinemia, the skin around the mouth and on the extremities will turn blue and the child will experience shortness of breath. Severe Methemoblobinemia can result in brain damage and death. However, if the symptoms are recognized and medical help is sought immediately, the condition can be easily treated with an injection of methylene blue. The majority of Blue Baby Syndrome cases have occurred at nitrate levels over 100mg/L.
Healthy adults can consume large amounts of nitrate without suffering adverse health effects. The nitrate consumed daily in the diet is readily absorbed and is excreted as urine. However, prolonged ingestion of high levels of nitrate has been linked to stomach problems and may increase risk of bladder cancer.

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

Boiling drinking water will not decrease its nitrate concentration. In fact, the nitrate concentration will actually increase because of the evaporation of the water. Water that exceeds the recommended nitrate levels should not be consumed, in any way, by infants under 6 months old. Charcoal filters and water softeners are also not adequate treatment methods for elevated levels of nitrate in drinking water. Several treatment options do exist and these include the following:

- Distillation
- Reverse osmosis
- Ion-Exchange (Nitrate ions are exchanged for something else, such as chlorine)

Contact your local water treatment authorities to find out which method would be right for your water system.

Visit the Safe Drinking Water Foundation Website www.safewater.org to learn more about issues affecting safe drinking water.

pH Analysis (High School)

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 4 different water sources: There will also be a pH 7 buffer solution included for quality control purposes.

- Urban treated water
- Rural (aboriginal and/or non- aboriginal community) treated water
- Untreated raw source water
- Local community treated water

Materials:

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

Method:

1. Label the four beakers with their respective sample names (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 beaker/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 (High School)

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
Control	

Results: Sample water with a pH between 7.0 and 10.5 meets the Guideline for Canadian Drinking Water Quality 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 and 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 hte volumes to use when adjusting pH.

Sulphate Analysis (High School)

Purpose: To determine if the water samples meet Canadian Drinking Water Guideline for Sulphate making a visual comparison of precipitate present. Testing will be done on 4 different water sources, plus a Canadian Guideline Limit.

Materials:

- 1 – 2 mL Canadian Guideline for Sulphate sample (CGLS) (500 mg/L)
- 6 – 5 mL vial containing 2 mL of Sulphate Reagent 1
- 6 – 5 mL vial containing 3 mL of Sulphate Reagent 2
- 6 - Plastic cups
- 5 – 2 mL plastic pipettes
- 50 mL graduated cylinder (not supplied with kit – teacher must supply)

Method:

1. Label the 6 plastic cups with appropriate number, and name:
   #1- Control (Deionized Water or DI)
   #2- Canadian Guideline Limit Sample (CGLS)
   #3- Urban treated water
   #4- Rural (Aboriginal and/or non-Aboriginal community) treated water
   #5- Untreated raw source water
   #6- Local community treated water
2. Label the 5 pipettes as follows:
   #1- Control (Deionized Water or DI)
   #2- Urban treated water
   #3- Rural treated water
   #4- Untreated raw water
   #5- Local community treated water
3. Using a graduated cylinder, measure out 25 mL of Deionized Water to each of the 6 cups.
4. To the #1 cup, add 2 mL of Deionized Water using the pipette labeled #1 or DI.
5. To the #1 cup, add contents of one of the Sulphate Reagent 1 tubes.

6. To the #1 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, add the 2 mL tube of Sulphate 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. Repeat steps 4-6 for cups #3 to #6. Make sure to add the appropriate 2 mL water sample with the appropriate labeled pipette to the matching cup (for example: you will add 2 mL of Urban treated water with the pipette labeled #2 to the cup labeled #3- Urban treated water; and so on.)
11. Determine the cloudiness of the cups relative to the **CGLS** and record the results. I.e. Is it less or more cloudy than?

Operation Water Drop: Data Sheet (High School)

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
Control	

Results:
The **CGLS** should be cloudy. The water sample may or may not be cloudy. If the water sample is less cloudy than the **CGLS cup**, 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 have 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 (High School)

- **Purpose:** To determine the total chlorine concentration in your local drinking water. Find a few 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:

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

Method:

1. Label the five glasses with their respective names.
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 (High School)

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
Control	

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.

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) micro organisms such as *E.coli,* but others, like *Cryptosporidium* and *Giardia,* are very resistant to chlorine and require other measures to properly remove them.

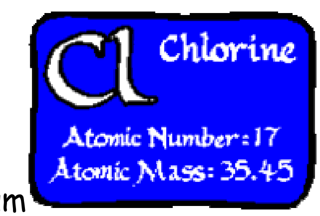
There are some important chlorination trends found in drinking water treatment:

- 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 residual 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 total chlorine 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.

SDWF Safe Drinking Water Foundation

Total Hardness Analysis (High School)

Purpose: To determine the total hardness concentration in drinking water from 4 different sources, plus a Saskatchewan Guideline Limit Sample (SGLS) for quality control purposes:

- Urban treated water
- Rural (Aboriginal and/or non-Aboriginal community) treated water
- Untreated raw source water
- Local community treated water
- Saskatchewan Guideline Limit Sample (SGLS) for total hardness

Determination will be done by using a test strip method. You will compare the different results, you will also see if the water meets the Saskatchewan Guideline Limit Sample (SGLS).

Total hardness is a measurement of calcium, magnesium, and is expressed as calcium carbonate; our body needs both Ca and Mg to remain healthy. The direct health effects are unknown because very little research has been done on the effects of hard water consumption. The major concern with elevated levels of hardness is scale depositing on piping, and drains which makes 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)
- 5 - Test strip packets (with colour charts printed on them)
- 5 - 10 mL disposable beakers.

Method:

1. Label five beakers with their respective names.
2. Put 10 mL of sample in their respective 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 results as mg/L (parts per million), match with the best colour to determine the total hardness concentration.

Operation Water Drop: Data Sheet (High School)

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)
Control	

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/L 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 of 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.

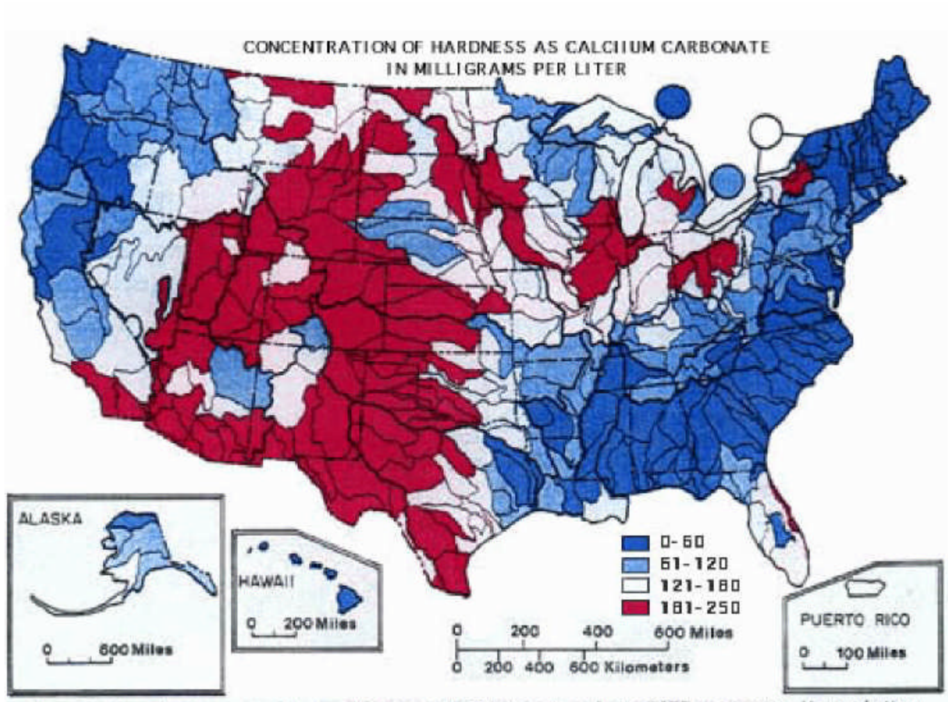


Figure 5.—Mean hardness as calcium carbonate at NASQAN stations during 1975 water year. Map at bottom is colored to show station data representing flow from the accounting unit.

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 and an increased use of membrane technologies will 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 fails 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: