LESSON 4 - QUALITATIVE WATER ANALYSIS

Overview:
In a laboratory activity, students learn about water quality indicators and perform a series of qualitative chemical tests on a sample of water that they have collected.

Suggested Timeline: 1.5 hours

Materials:
- Water Quality Indicators for Lakes and Ponds (Teacher Support Material)
- Qualitative Water Analysis (Student Handout)
- Boreal-Northwest Qualitative Water Analysis Lab – 66701M50 ($117) (Refill kit also available – 66701M55 - $78)

OR
- the following lab materials per group:
  - lab goggles
  - small (50 mL) plastic container with lid to capture a water sample.
  - 9 microfuge tubes (or small clear containers with lids to do individual tests)
  - microfuge tray
  - disposable pipet
  - scoop (0.1 g)
  - wax marking pencil
  - cadmium powder
  - 0.1 M sulfanilic acid
  - 0.1 M chromotropic acid
  - 1.0 M sulfuric acid
  - Ammonium thiocyanate crystals
  - 0.1 M ammonium molybdate
  - 1% ascorbic acid
  - 0.1 M silver nitrate
  - 0.1 M potassium hydroxide
  - Nessler reagent
  - 0.1 M ammonium hydroxide
  - Eriochrome Black T indicator solution
  - 0.10% EDTA Disodium
  - 0.1 M barium chloride
  - O-Tolidine
  - Universal indicator solution

Method:
1. Arrange for students to bring in water from a source of their choice (and in a sterile container) on the day of the lab.
2. Review material learned in the last lesson on water treatment, such as elements found in water and their importance.
3. Excite students with the opportunity to learn about what kinds of elements are in the water that they have brought! Introduce them to water quality indicators by discussing the notes on

Qualitative Water Analysis (Student Handout) and by using the Water Quality Indicators for Lakes and Ponds (Teacher Support Material)**.**

4. Review lab safety protocol and procedures for handling chemicals.
5. Facilitate students' completion of the lab. Have them hand in their lab sheet for grading.

Assessment:
Student grade on lab

Extension:

6. Have students that live on farms (or in an area where well water is used) find out how often their water is tested and what it is tested for. Have students who have access to the municipal water supply research more about the testing that goes on at their local treatment plant.
7. Discuss the debate surrounding the fluorination of water.

Water Quality Indicators for Lakes and Ponds

1. **Temperature:** Each organism has its own preferred temperature. For example, carp prefer 32°C water, perch prefer 24°C water and trout prefer water at 15°C. Organisms can handle a small change in temperature, but if the change is too much, the organism will move to another place or die. As water gets warmer, cold-blooded organisms require more oxygen, although less oxygen is actually available at higher temperatures.

2. **Turbidity:** Solids in the water may cause it to be cloudy. These solids may be living things such as phytoplankton (plants) or zooplankton (animals). They also include non-living things like small pieces of dead organisms, sewage, silt or clay.

3. **Transparency:** A measure of how well light passes through the water. It is an indication of the amount of solids floating in the water.

4. **Speed:** A measure of how fast the water travels. Fast water tends to contain more oxygen and lose more carbon dioxide. Fast water is also cooler as it bounces over rocks and evaporates. The speed of the water can help scientists to determine what the bottom of the body of water looks like.

5. **Oxygen:** Oxygen does not dissolve very well in water, although enough of it does to be able to support life. Most aquatic organisms need a definite amount of oxygen to survive (e.g., trout need 10 mg of oxygen per gram of water carp need 2 mg of oxygen per gram of water). Cold water contains more oxygen than warm water. Most oxygen comes from the air or from plants and algae. Organisms living in the water remove the oxygen when they respire. If there are a lot of dead organisms and sewage in the water, there will be many decomposers (like bacteria and fungi). They will use up much of the oxygen, leaving little for other organisms.

6. **Carbon Dioxide:** a clear, colorless, tasteless gas that enters from the air or from the respiration of other organisms. Water near the surface usually contains less carbon dioxide than water at the bottom (where many decomposers exist). Water typically can have up to 10 mg of carbon dioxide per gram before it becomes unhealthy.

7. **pH:** a measure of how acidic or basic the water is. The pH scale ranges from 0 (most acidic) to 14 (most basic) with 7 being neutral. The pH scale is logarithmic, meaning that a change of 1 is actually a change of 10 and a change of 2 is actually a change of 100. A pH range of 6.7 – 8.6 supports most aquatic life. Acid spills and sewage can affect the pH of a lake. As it ages, a lake usually becomes more acidic. Respiration by living things makes a lake more alkaline.

8. **Hardness:** caused mainly by the presence of calcium and magnesium ions. These are released into the water when the water runs over rock such as limestone (calcium carbonate) or dolomite (magnesium calcium carbonate). Acid rain can dissolve these ions from buildings and streets too. Drinking water is best if it has a total hardness of 250 mg per gram. If levels are too high, one’s digestive system is disrupted and diarrhea can result.

Hard water also reacts with soap to form curds and can cause build-up in pipes to clog household plumbing.

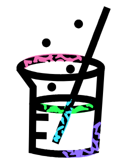
9. **<u>Nitrogen</u>:** an element found in the proteins of all living things. It is therefore an essential part of ecosystems. Nitrogen exists in the form of ammonia and nitrate. Ammonia is found in pond and marsh water de to the decay of dead matter or from fertilizer runoff. Ammonia is changed to nitrite and then nitrate. Over 0.5 mg per gram of ammonia can be directly harmful to aquatic life. Nitrates are also found in fertilizers. A lake should not have over 0.30 mg per gram of nitrogen or an algal bloom could result. An algal bloom results in a large number of algae existing in a lake. Initially, the lake is healthy, but once the algae die, decomposers cause an oxygen shortage. Drinking water should contain less than 10 mg per gram of nitrogen. 45 mg per gram can be hazardous to humans, especially infants. A condition called methemoglobinemia (blue baby) can result in humans that live in areas where fertilizer and animal wastes have reached the groundwater and have entered the drinking supply.

10. **<u>Phosphorus</u>:** an important element in the molecules that make up our cells. Phosphorus enters the water supply during the natural decay of matter or through detergents. Over 0.015 mg per gram of phosphorus could cause an algal bloom to occur.

11. **<u>Chloride</u>:** most common in the form of sodium chloride (table salt). Sea water can contain 27 000 mg per gram of chloride. Some chlorine is needed (250 mg per gram in drinking water), but excess amounts can harm freshwater organisms or cause high blood pressure in humans.

Adapted from *Investigating Aquatic Ecosystems*, Prentice-Hall Canada Inc.

Qualitative Water Analysis Lab



Background:
The water that comes from our taps and that we drink as bottled water is usually not pure water. The presence of elements in water, even when they are present in small amounts, changes the properties of that solution so that it is not longer pure water.

Water that contains enough magnesium and calcium will prevent soap from forming bubbles in it. Instead, soap forms a white substance that floats at the top, making cleaning with such water difficult! In some older house, pipes may be made of lead. This lead enters the water and can be poisonous since it builds up in our body tissues.

Many sources of water contain harmful or unwanted substances. Therefore, it is important for water treatment facilities to test water and closely monitor it.

There are a number of properties of water that are considered when lake or pond water is tested:

1. Temperature: Each organism has its own preferred temperature. For example, carp prefer 32°C water, perch prefer 24°C water and trout prefer water at 15°C. Organisms can handle a small change in temperature, but if the change is too much, the organism will move to another place or die. As water gets warmer, cold-blooded organisms require more oxygen, although less oxygen is actually available at higher temperatures.

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3. Hardness: caused mainly by the presence of calcium and magnesium ions. These are released into the water when the water runs over rock such as limestone (calcium carbonate) or dolomite (magnesium calcium carbonate). Acid rain can dissolve these ions from buildings and streets too. Drinking water is best if it has a total hardness of 250 mg per gram. If levels are too high, one's digestive system is disrupted and diarrhea can result. Hard water also reacts with soap to form curds and can cause build-up in pipes to clog household plumbing.

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Instructions:
This lab consists of nine tests that you will perform using a portion of a water sample you collected and the chemicals provided. Shake all water samples before adding chemicals to ensure a homogeneous solution. Record all results in the data table and answer the questions that follow.

NOTE*:* Put on your lab goggles now and wear them for the duration of the lab.

Materials: (per group)
- lab goggles
- Boreal-Northwest Qualitative Water Analysis Lab OR the following supplies:
    - small (50 mL) plastic container with lid to capture a water sample.
    - 9 microfuge tubes (or small clear containers with lids to do individual tests)
    - microfuge tray
    - disposable pipet
    - scoop (0.1 g)
    - wax marking pencil
    - cadmium powder
    - 0.1 M sulfanilic acid
    - 0.1 M chromotropic acid
    - 1.0 M sulfuric acid
    - Ammonium thiocyanate crystals
    - 0.1 M ammonium molybdate
    - 1% ascorbic acid
    - 0.1 M silver nitrate
    - 0.1 M potassium hydroxide
    - Nessler reagent
    - 0.1 M ammonium hydroxide
    - Eriochrome Black T indicator solution
    - 0.10% EDTA Disodium
    - 0.1 M barium chloride
    - O-Tolidine
    - Universal indicator solution

Nitrate Station

1. Use your wax pencil to label a clean, dry microfuge tube "nitrate" or "NO_3".
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using the 0.1 g scoop, place a half filled scoop of cadmium powder in the microfuge tube containing 0.5 mL of your water sample. Close the lid of the tube and shake well.
4. Add 0.5 mL sulfanilic acid to your water sample in the microfuge tube containing cadmium powder. Close the lid and shake well.
5. Using a clean pipet, add 5 drops of chromotropic acid to the water sample containing the other two reagents. Close the lid of the vial and shake well. Set this sample aside and record your results at the end of the class period. The formation of a dark red complex is a positive test result for the presence of nitrate. In your data table, indicate the presence of nitrate with a (+) and the absence with a (-).

Iron Station

1. Label a clean, dry microfuge tube "iron" or "Fe".
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using a clean pipet, add 5 drops of sulfuric acid to the water in the microfuge tube. Close the lid and shake well.
4. Using the 0.1 g scoop, place a scoop of ammonium thiocyanate crystals into the microfuge tube containing the water sample and sulfuric acid. Close the lid and shake well. The formation of an orange or dark purple solution is a positive indicator for the presence of iron. Record your results in the data table with a (+) to indicate the presence of iron and the absence with a (-).

Phosphate Station

1. Label a clean, dry microfuge tube "phosphate" or "PO_4".
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using a clean pipet, add 5 drops of sulfuric acid to the water in the microfuge tube. Close the lid and shake well.
4. Using a clean pipet, add 5 drops of ammonium molybdate to the water in the microfuge tube. Close the lid and shake well.
5. Using a clean pipet, add 5 drops of ascorbic acid to the water sample containing the other two reagents. Close the lid of the vial and shake well. Wait several minutes for the reaction to take place. The formation of a blue solution is a positive indicator for the presence of phosphate. Record your results in the data table, using a (+) to indicate the presence of phosphate and a (-) for the absence.

Chloride Station

1. Label a clean, dry microfuge tube "chloride" or "Cl".
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using a clean pipet, add 0.5 mL of silver nitrate to your water sample in the microfuge tube. Close the lid but **DO NOT SHAKE THE TUBE**. The formation of a white precipitate (solid) is a positive indicator for the presence of the chloride ions. Record the presence with a (+) and the absence with a (-) in your data table.

Ammonia Station

1. Label a clean, dry microfuge tube "ammonia" or "NH_4".
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using a clean pipet, add 5 drops of potassium hydroxide to the water in the microfuge tube. Close the lid and shake well.
4. Using a clean pipet, add 3 drops Nessler agent to your water sample in the microfuge tube. Close the lid but **DO NOT SHAKE THE TUBE**. The formation of a dark orange precipitate (solid) is a positive indicator for the presence of ammonia. Record the presence with a (+) and the absence with a (-) in your data table.

Hard water station

1. Label a clean, dry microfuge tube “hard water” or “HW”.
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using a clean pipet, add 5 drops of ammonium hydroxide to the water in the microfuge tube. Close the lid and shake well.
4. Using a clean pipet, add 1 drop of the indicator solution, Eriochrome Black T to the water sample containing the ammonium hydroxide. Close the lid of the vial and shake well. The solution should be purple in color at this point.
5. Using the pipet provided, add EDTA Disodium until the volume of the tube is 1.0 mL. The formation of a blue solution is a positive indicator for the presence of hard water. Record the presence with a (+) and the absence with a (-) in your data table.

Sulfate Solution

1. Label a clean, dry microfuge tube “sulfate” or SO_4”.
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using a clean pipet, add 3 drops barium chloride to your water sample in the microfuge tube. Close the lid but **DO NOT SHAKE THE TUBE**. The formation of a white precipitate (solid) is a positive indicator for the presence of sulfate. Record the presence with a (+) and the absence with a (-) in your data table.

Chlorine Station

1. Label a clean, dry microfuge tube “chlorine” or “Cl”.
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using a clean pipet, add 0.5 mL o-Tolidine to the water sample in the microfuge tube. Close the lid of the vial and shake well. The formation of a yellow colored solution is a positive indicator for the presence of chlorine. Record the presence with a (+) and the absence with a (-) in your data table.

pH Station

1. Label a clean, dry microfuge tube “pH”.
2. Pipet 0.5 mL of water from your sample vial into the clearly labeled microfuge tube.
3. Using a clean pipet, add 2 drops universal indicator solution to the water sample in the microfuge tube. Close the lid of the vial and shake well. Use the information provided below to record the approximate pH of your water sample in the data table.

pH	Color transitions
2	Red
3	Red/orange
4	Orange/red
5	Orange
6	Yellow
7	Yellow/green
8	Green
9	Green/blue
10	Blue

Student Handout

Name: ________________ Partner(s): ______________________ Date: ________________
Period: ____

Qualitative Water Analysis – Lab Worksheet

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Record your results in the following data table:

Solution Test	(+) Control color	(-) Control color	Your water sample
Nitrate	Dark red complex	Yellow solution	
Iron	Dark orange or purple	Clear Solution	
Phosphate	Blue solution	Yellow solution	
Chloride	White precipitate	Clear solution	
Ammonia	Dark orange precipitate	No precipitate	
Hard water	Blue solution	Purple solution	
Sulfate	White precipitate	No precipitate	
Chlorine	Yellow solution	Clear solution	
pH			

5 marks

Questions:

1. Describe the source of your water sample (eg. Local stream, pond, tap water, etc.) – 1 mark

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2. Describe the smell of your water sample (eg. Chlorine, rotten eggs, musty, etc.) – 1 mark

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3. Describe the local conditions from which your water sample was taken (eg. wooded area, industrialized area, park setting, etc.) – 1 mark

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4. If your water sample was clear, would it be safe for you to drink? Explain your answer, including information that you have learned in this unit about water. – 3 marks

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