EXPERIMENT: What's in Your Water?

Grade level: 6-12

National Science Content Standards:
A: Science as Inquiry
E: Science and Technology

OBJECTIVE:

To develop an understanding of water quality monitoring and an appreciation of the methods used to keep water safe and clean. Additionally, students will learn the chemical and physical properties of water, and apply the methods and terminology related to filtration and water purification through demonstrations.

DESCRIPTION:

Students will learn to perform some of the essential tests required for drinking water analysis. In small groups, students will collect water and measure pH, chlorine and nitrate concentrations, and dissolved oxygen levels. They will share and compare data, and respond to questions that encourage them to apply their knowledge to a wider context.

MATERIALS:

- Surface water or tap water **
- 1 liter plastic collection bottles
- 1 package of small Dixie cups with enough cups so each group has at least five
- Pens to label cups
- Thermometer
- *pH testing kit or strips
- *Chlorine colorimetric meter for total and residual chlorine or testing kit or strips to measure free chlorine (Eliminate *parameter if sampling from a water body.)
- *Nitrate testing kit or strips
- *Dissolved Oxygen meter or testing kit

*Note: All testing kit items can be purchased at a science supply store as a complete water testing kit or as individual strips or experiments. pH strips and nitrates and dissolved oxygen testing kits are sold at pet and aquarium stores as well.

**This experiment can be conducted near a local water body or can be done using tap water from one faucet or a variety of different tap sources.

BACKGROUND:

Sources for drinking water are at risk of pollution from both anthropogenic (human-related) activities

and natural processes. Pollutants can enter a watershed through point (direct) or non-point (indirect) sources, some examples of which are: (point) discharge from farms, mines, and garbage dumps; and (nonpoint) fertilizer and pesticide runoff.

In the United States, public water supplies are tested and regulated to keep water as free from unsafe levels of contamination as possible, as determined by parameters issued by the Environmental Protection Agency (EPA). Scientists test the quality of a body of water by measuring the chemical and physical characteristics to determine if it is healthy for humans, animals, bacteria and plant life. Observation of life surrounding water is also an important form of testing. An aquatic ecosystem full of diverse life, thriving wildlife populations and abundant fish species is an indicator of good water quality.

Whether your drinking water comes from groundwater or surface water, samples are taken in the field and analyzed in the laboratory for microbial, chemical and physical measures of quality. Before water enters our pipes and comes out our tap, it is treated at a water treatment facility. Water treatment ensures that harmful chemicals and human and animal wastes do not enter our drinking water supply.

There are a few different processes to treat drinking water:

- Flocculation/ Sedimentation: Where alum and iron salts are used to bind small particles in the water together into one big mass of particles that settles down to the bottom and can be removed.
- Filtration: This method is used to remove all of the particles from water. It is similar to a strainer that might hold your cooked pasta while the water drains. Filtering water ensures that it is clear so the next step can take place.
- Ion exchange: This method uses an electronic charge between positive and negative ions to remove inorganic compounds, such as metals.
- Absorption: Traits like color and odor are absorbed by sticking to an activated carbon surface.
- Disinfection: Chemicals are added to remove microbiologic contaminants. The levels of chemicals added are closely monitored to make sure that there are low concentrations used and that there is no residual leftover after processing.
- Chemical treatment: The main treatment chemicals used are chlorine, fluoride orthophosphate, and sodium hydroxide. Chlorine is added to disinfect the water. Fluoride is added to prevent tooth decay and cavities. Orthophosphate is added to create a protective film on pipes, which reduces the release of metals, such as lead and copper from household plumbing. Sodium hydroxide is added when the water coming from the source is too acidic, to lower the pH and reduce the ability of the water to corrode the pipes and leach these same harmful metals.

WATER QUALITY PROBLEMS - TESTING PARAMETERS:

- Physical parameters: color, odor, turbidity, taste
- Chemical qualities: iron, hardness, pH, nitrate, fluoride, sulfate, nitrite, manganese, CO_2, TDS
- Microbiological concerns: total coliforms, E. coli, giardia, Amoebae

PROCEDURE:

Students will make physical and chemical measurements, recording their data. Finally, they will analyze the data and discuss their observations.

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Students should work in groups of 3-4 depending on the size of the class. They will rotate the jobs of measuring and recording the data. Students will first record data, then complete questions and present their data as a group to the rest of the class. Students will determine whether or not their sample contains good water quality.

Each group will collect a water sample in the 1 liter bottle. If there is no access to an outdoor water source, teachers or students should collect samples prior to class and distribute. If students are testing tap water, each group will collect the water from a different source (i.e.: drinking water fountain, bathroom, cafeteria sink, lab sink). Groups should label a new Dixie cup for each test.

Once groups have been assembled and the 1 liter sample acquired, they will immediately indicate name, date and sample source on data sheet. To test each parameter, students will pour approximately ½ cup of the water from the liter bottle into a labeled Dixie cup. Provide all groups with a waste bucket to pour all used samples into. This waste bottle should be discarded by flushing with water down the tap or toilet or bring to your local wastewater treatment facility.

WATER QUALITY PARAMETERS AND SIGNIFICANCE:

1) **Temperature:** First measure the water temperature. Temperature is important because it influences water chemistry. Water temperature helps determines how much oxygen can be dissolved in the water, which impacts the organisms living there. Warm water holds less oxygen than cold water.
    - Temperature can be taken directly from the 1 liter bottle, if full enough, or pour a small amount in the Dixie cup. Hold the thermometer in the water for 60 seconds. Record all temperature data in degrees Celsius on the data sheet. The average water room temperature is about 20-25 degrees Celsius.

2) **pH:** Human activities such as agriculture and industry can affect the pH of water bodies. pH (potential hydrogen) is a measure of how acidic or basic (alkaline) a solution is. Atoms of water disassociate to form H^+ and OH^- ions. ($H2O = H^+ + OH^-$). pH levels reflect the total concentration of hydrogen ions, and increase by a factor of ten for each number on the scale. (For example, a solution with a pH of 2 is 10x more acidic than a solution with a pH of 3, and 100x more acidic than a solution with a pH of 4). A low pH indicates an acidic solution, while a high pH indicates a basic solution. Many fish and vertebrate species are unable to tolerate very basic or acidic water. Changes in water pH can also affect aquatic organisms indirectly by changing other aspects of the water chemistry. For example metals trapped in sediments are released into the water at lower pH level, increasing the concentration of that metal in the water.
    - Fill ½ Dixie cup with water from the 1 liter bottle. Use this water and follow directions on either the test kit or outside of the strip package to measure pH. Most kits or strips come with a color indicator to determine the pH level. There are NO UNITS used with pH. Pure water has a pH of 7.0, neutral.

3) **Chlorine:** Chlorine is used to disinfect drinking water, but excess or residual (leftover) chlorine can be harmful to our health. Its purpose is to kill pathogens. Treatment facilities closely monitor the levels of chlorine to make sure there is not too much in our water.
    - Fill ½ labeled Dixie cup with water from the 1 liter bottle. Use this water as your sample with the chlorine monitor to measure total and free (residual) chlorine or testing kit/strips to measure free chlorine. Chlorine measurements are given in parts per million (ppm). One part per million is equal to one drop of water in a large swimming pool. The federal standard for Chlorine in drinking water is 4 ppm.

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4) **Nitrates:** Nitrates are naturally occurring nutrients that are used by plants and animals. Too much nitrogen in the water can cause algal blooms, which can negatively impact the amount of dissolved oxygen available to aquatic life. When the algae populations are widespread the water temperature is affected which impacts the health of the ecosystem. Excess nitrates in the water result from human activities; when fertilizers and animal waste runoff from agricultural areas, or when sewers or storm drains that hold human and other waste overflow during heavy rain storms. The drinking water standard for Nitrates is 10 ppm. In natural bodies of water, concentrations greater than 4 ppm can cause negative health effects on the aquatic life.
    - Fill ½ labeled Dixie cup with water from the 1 liter bottle. Use this water as your sample. Have students follow instructions on the kit or test strips and record on the data sheet.

5) **Dissolved Oxygen (DO):** Oxygen is one of the most important indicators for the quality of water for life. Too little dissolved oxygen can harm the health of a water ecosystem and indicates an imbalance and means there is less oxygen available to fish and wildlife. The saturation level of DO (or the ability for water to contain oxygen) is dependent on the temperature of the water. As temperature increases, the ability of water to hold oxygen decreases. Oxygen levels in water can also be reduced if aquatic plants are over-fertilized by run-off from farm fields containing phosphates and nitrates (the ingredients in fertilizers). The plants will grow rapidly, and if the weather becomes cloudy for several days (i.e. the sun is not present for photosynthesis), respiring plants will use most of the available DO. When these plants die, they become food for bacteria, which in turn multiply and consume large amounts of oxygen, depleting it for other species.

    DO measurements are given in milligrams per liter of water (mg/L) or parts per million (ppm). These measurements are used interchangeably and measure the same thing, the density of water. DO measurements range from 0-16 ppm. In order to sustain life, water must have at least 4ppm of DO.
    - Use the DO meter or follow instructions on the testing kit to record DO. Then record the temperature and the DO to determine % saturation. Use the nonogram on the data sheet to record the % of saturation. 100% saturation means that the water cannot hold any more oxygen at that temperature.

VARIATIONS:

- Collect water from the upper layer and the bottommost layer of the same body of water. Compare and contrast the different parameters.
- Include more extensive water quality parameters, such as phosphates, alkalinity and hardness to gain a greater understanding of water quality.

EXTENSIONS:

- Research regulations in place to protect drinking water. http://water.epa.gov/lawsregs/rulesregs/sdwa/index.cfm
- Visit local water treatment plant. (Ask experts there the difference between a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) for regulated contaminants.)
- Research other methods used for treatment such as UV disinfection and natural treatment methods such as using wetlands as a filter.

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Student Data Sheet

Name: _____ Date: _____

Sampling location and source: _____ (indicate body of water or type of water)

I. Physical parameters:

Water Appearance: Describe what the water looks like. Is it clear or cloudy? What does it smell like? (*If you are collecting water from outside also answer:* Is the water flowing fast? What is surrounding the body of water? Is there anything floating in the water?)

_____

_____

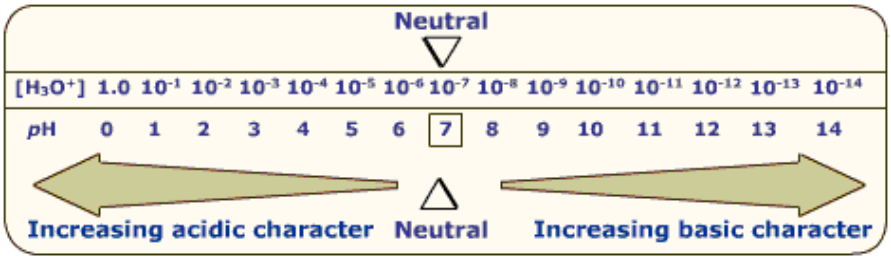
_____

_____

Temperature: _____ (in degrees Celsius)

II. Chemical parameters

1) **pH**_____
   Are there more Oxygen or Hydrogen Ions in this sample?

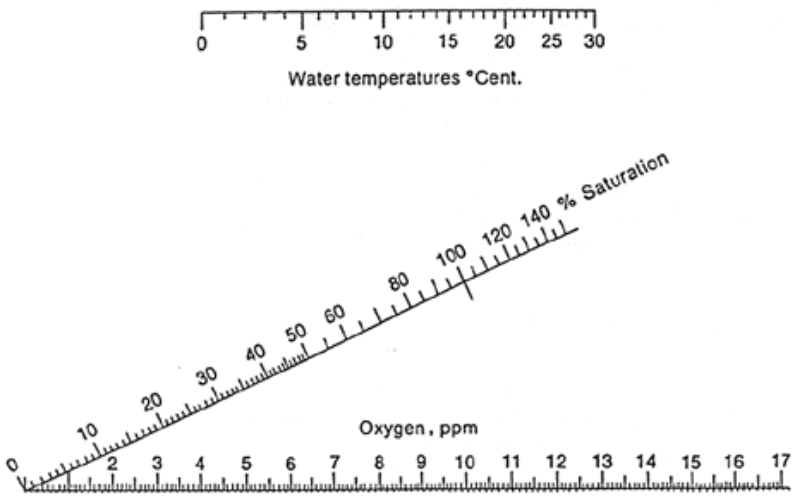


2) **Chlorine:** _____ parts per million (ppm)
3) **Nitrates:** _____
4) **Dissolved Oxygen:** _____ (mg/l) or PPM

Use the following graph (a nomogram) to determine the % of saturation in the water:

Water temperature in ºC _____; DO (mg/l) or PPM: _____%; saturation _____

Locate and mark your DO reading on the scale (ppm equals mg/L). Locate and mark the temperature of the water in degrees C on the top scale. Draw a straight line between the temperature and DO. The % saturation is the value where the line intercepts the saturation scale. (Healthy Expected Range 90% or above)



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Concluding Questions

Name: _____ **Date:** _____

1) Would you drink the water from your sample water source? Is it good or poor quality water?

2) If the water quality is poor, what might be some of the reasons this? What might have caused the results?

3) Why is water quality important to us and other living things?

4) Why is water quality important to ecosystems, both aquatic and terrestrial?

5) Why should we disinfect the drinking water supplies?

6) If you are concerned about your tap water at home, what should you do?

7) What are some problems (if any) that could result from drinking or using your water.

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