Water Quality Testing Preparation

Virginia Science SOLs

6.1, 6.5, 6.7, 6.9, LS.1, LS.4, LS.11, LS.12

Key Concepts

chemical water quality monitoring, impact of environmental factors on aquatic organisms

Setting

classroom

Summary

A basic introduction to water quality parameters including the units of measure, range and regulatory standards for temperature, pH and dissolved oxygen. This lab provides experience in using World Water Monitoring Day test kits and other common equipment.

Learning Objectives

Students will:

1. understand the basic concepts of temperature, pH and dissolved oxygen, including how the parameters relate to one another.
2. learn the acceptable water quality standards in Virginia for these three parameters.

Background Information

The instructor can cover this material in approximately 45 minutes depending on the student aptitude and preparation. The background information on each water quality parameter can be inter-woven with the students familiarizing themselves with basic water test kits and generating data on tap water and other liquids. Most water test kits contain the supplies needed to perform a variety of additional tests such as turbidity, salinity and nitrate level, however for introductory training purposes the following critical parameters will be highlighted:

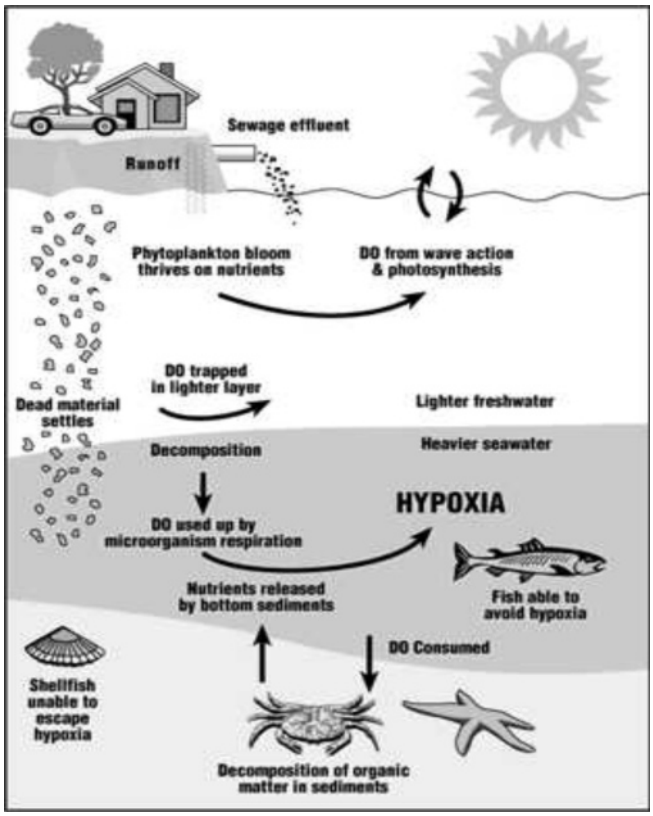
Temperature – Definition: The measurement of how hot or cold a substance is.

1. Scientists measure temperature in degrees Celsius.
   a. The instructor will give a brief explanation of the differences between Fahrenheit and Celsius (water freezes at 32°F, 0°C and boils at 212°F, 100°C).
   b. Celsius was developed to measure the properties of water when it goes through different phases (solid, liquid, gas).
2. Temperature affects many physical, chemical, and biological processes.
   a. Affects dissolved oxygen to a major degree and pH, salinity to a lesser degree.
   b. Water at different temperatures will not mix easily (warm water will tend to stay on the surface while cooler water is near the bottom).

In Virginia, trout waters must never exceed a temperature of 20°C due to the high amounts of oxygen that the fish need to survive. For most other waters, the temperature must not exceed 32°C.

Dissolved Oxygen – Definition: Measurement of the amount of oxygen that is dissolved in water.

1. Just like animals and plants on land, aquatic animals and plants need oxygen to breathe.
2. Unlike the air (~21% oxygen in the air), water can hold only a tiny amount of oxygen (~0.001% oxygen in water).
   a. Aquatic animals use gills to breathe underwater while land animals with lungs cannot.
   b. Dissolved oxygen is measured in the units of milligrams per liter (mg/L) or parts per million (ppm). Both mg/L and ppm are the same.
      i.e. 5 mg/L dissolved oxygen is equal to 5 ppm dissolved oxygen, etc.
   c. Water typically cannot hold more than 15 ppm of oxygen. Air holds about 210,000 ppm oxygen (21% O_2 in the air x1,000,000)
3. Both water temperature and salinity affect how much dissolved oxygen water can hold.
   a. The higher the temperature or salinity, the less ability water molecules have to hold onto oxygen molecules.
   b. The colder or less salty the water, the more ability water molecules have to hold onto oxygen.
4. Oxygen is absorbed in water in several ways.
   a. **Diffusion** of oxygen from the surface is a major method. Diffusion is a net transport of molecules from a region of higher concentration to one of lower concentration.
   b. **Photosynthesis** from aquatic plants is another way oxygen is introduced into water and is why algae and aquatic plants are important to aquatic organisms.
5. Excess pollution such as sewage and nutrients can lead to lower oxygen levels due to bacteria breaking down organic (carbon containing) materials such as dead algae and other organisms. This breakdown process uses oxygen.
6. In most Virginia waters, dissolved oxygen must not drop below 4.0 mg/L. In trout waters, the dissolved oxygen must not drop below 6.0 mg/L. Doing so will result in fish dying.
7. Certain species of aquatic animals need specific levels of dissolved oxygen. The charts to the right and below show the dissolved oxygen cycle and how varying dissolved oxygen levels affect aquatic life.



From EPA Volunteer Estuary Monitoring: A Methods Manual, second edition

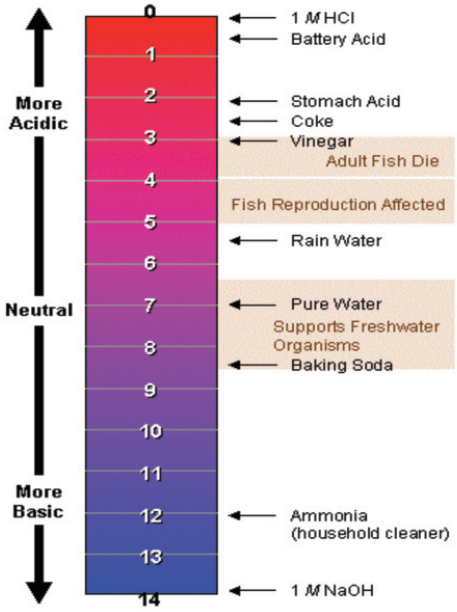
Levels of Dissolved Oxygen

> 5 mg/L	Between 3-5 mg/L	<3 mg/L – Hypoxia Occurs *(low dissolved oxygen levels)*	<0.5 mg/L – Anoxia Occurs *(lack of dissolved oxygen)*
Level needed to support most aquatic life.	Aquatic organisms may become stressed.	Mobile organisms will move to areas of higher dissolved oxygen and immobile species may die.	Waters cannot support most aquatic life.

Background, continued

pH – Definition: Is the measure of how acidic or basic a material is.

1. The pH scale goes from 0 to 14 with 7 being neutral.
   a. pH <7 is considered an acid and a pH >7 is a base.
   b. For every number from this midpoint (7), acid and base concentrations increase 10x.
      i.e. Example, a pH of 5 is 100x more acidic than a pH of 7.
2. pH is important to aquatic life as it affects many biological and chemical processes.
   i.e. Example, pH values nearing 9.00 units converts ammonium (NH4) to Ammonia (NH3+) which is toxic to fish and other aquatic life.
3. In Virginia, the acceptable pH for most waters is a pH between 6.00 and 8.5
4. Below is a chart denoting the pH scale and how it affects aquatic life along with typical household materials pH values.



Materials

Temperature

- Thermometer capable of reading temperatures from 0°C to 30°C or greater. Mercury free or electronic thermometer preferred.
- 2 or more cups (clear plastic preferred) per student or group of participating students
- Water at two different temperatures (at least 5°C different). Use two 2L soda bottles and fill to the halfway point)

pH

- pH measuring equipment such as a pH meter (Oakton pH30 or similar), field test kit such as World Water Monitoring Day or LaMotte pH kit #5858, or litmus paper capable of measuring pH from 3 to 10 pH units. (Note: pH meters usually have a thermometer as part of the unit.)
- 3 or more cups (clear plastic preferred) per student or group of participating students
- Baking soda (1 lb box for class, 1-2 tablespoons per baking soda cup filled with 8 oz water)
- White vinegar (16 oz or more for class) 2 oz per cup and 6 oz of water)

Dissolved Oxygen

- Dissolved Oxygen equipment such as a DO meter (YSI Ecosense DO200 meter), or Winkler titration test kit such as the LaMotte kit #5860
  Note: DO meters usually have a thermometer as part of the unit
- Water used during the temperature experiment. If using the 2 L soda bottles, make sure students vigorously shake the bottles for two minutes to ensure enough oxygen is added to the water.
- 2 or more cups (same ones used for the temperature exercise would be fine) per student or group of participating students

General

- Waste container per group to pour out any used chemicals
- Paper towels
- Log or data sheet designed by classroom teacher depending upon available equipment

Procedure

Temperature

Using two, 2 L soda bottles (for the classroom) or measuring a sunny and shaded portion of a waterbody (field trip), students will measure temperature using a thermometer and record the results on a log sheet. If using soda bottles, the instructor will fill the bottles half way with warm tap water in one bottle and cold tap water in the other. Students will shake both bottles at the same rate to prep for the dissolved oxygen exercise.

Dissolved Oxygen

Using a dissolved oxygen meter or Winkler titration kit, students (or the instructor) will measure dissolved oxygen from water samples collected during the temperature measurement. If temperature readings are different by more than 5°C and the water is from the same source (same waterbody, or from the tap), the difference in dissolved oxygen levels should be noticeable. The warmer water should have lower dissolved oxygen than the colder sample. World Water Monitoring Day or LaMotte Low Cost test kits can be used to practice taking a DO reading, however these are relative DO tests and results do not vary considerably.

pH

Using the same samples for the temperature and dissolved oxygen tests, students will use a pH meter, test kit, or litmus paper to measure pH of the two samples. Since the water from both samples comes from the same source, the pH values will likely be nearly identical (within 0.05 pH units).

As an additional exercise to show the pH scale, students will receive three containers prepared in advance by the instructor. Each container will hold one of the following substances (white vinegar, tap or distilled water, and water mixed with baking soda). Looking at the cups, the samples will look the same but have very different pH values (pH 2-3 for vinegar (acid), 6.5-7.5 for water (neutral), and 8.5-9 for baking soda (base)). Students (or the instructor) will use the pH sensing equipment to sort the cups according to where they would be found on the pH scale. Students will use the pH chart to try to identify the substances based on the pH reading.

At the conclusion of the measurements, the instructor will combine roughly equal amounts of the baking soda and vinegar samples to show how they react with one another (can be messy so do over a sink or area that is easy to clean up). Once the reaction has taken place (fizzing stops) the instructor or students will measure the pH. This pH value should now be somewhere between the vinegar and baking soda values and close to a pH of 7. This shows that by combining acids and bases together, you get a pH value closer to neutral.

Extension

To download comprehensive student activity booklets on pH and dissolved oxygen from the New Jersey Marine Science Consortium go to: www.njmsc.org/Education/Lesson_Plans/pH_Booklet.pdf and www.njmsc.org/Education/Lesson_Plans/DO_Booklet.pdf.

Assessment

Individual student assessment can be made through observation during the exercise, collecting science notebooks or data sheets generated during the lab, a water quality parameter quiz or the use of the booklets listed above.