How Healthy is our Watershed?

Testing for DO and pH

Target Grade: 4th– 8th
Incidences

Overview:

Students will learn about two important measurements of water quality—dissolved oxygen, and pH — and why these are important to humans and other organisms. This activity is a portion of a larger curriculum module with the objective of an encompassing understanding of a students' local watershed and greater understanding of earth science related to water. However it can be utilized as a hands-on complement to wider ranging curriculum in a variety of disciplines including, but not limited to, physical and earth science.

Objectives (what students will know or be able to do):

1. Students will perform simple experiments to test the health of a water sample.
2. Students will define pH and explain how it is important to the health of a body of water.
3. Students will define dissolved oxygen and explain how it is important to the health of a body of water.

Background:

See Appendix I

Materials: WATER TESTING KITS ARE AVAILABLE FOR CHECKOUT FROM SIERRA NEVADA JOURNEYS, CALL US AT (775) 355 -1688

- 2 or 3 large buckets filled with water from different sources
- Loop Lake maps (see Appendix III)
- Hydrogen, hydroxide, and electron cards (see Handouts)
- pH test kits
- Dissolved oxygen test kits
- Instructions for each kit
- Student Data Sheet (See Handouts)

Prep Time: 10 minutes **Activity Time: 60 minutes**

Nevada State Standards Addressed:

N.8.A.6 Students know scientific inquiry includes evaluating results of scientific investigations, experiments, observations, theoretical and mathematical models, and explanations proposed by other scientists.
L.5.C.3 Students know changes to an environment can be beneficial or detrimental to different organisms.
L.5.C.5 Students know plants and animals have adaptations allowing them to survive in specific ecosystems.
N.8.B.2 Students know scientific knowledge is revised through a process of incorporating new evidence gained through investigation and collaborative discussion.

NAAEE Standards:

1.1 Factual accuracy
2.0 Depth
3.2 Applying skills to issues
3.2 Action skills
4.0 Action Orientation
5.0 Instructional Soundness
6.0 Usability

Key Vocabulary:

Water quality — describes the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
pH (percent hydrogen) — the measure of acidity or alkalinity of a solution.
Dissolved Oxygen (DO) —the concentration of oxygen dissolved in a given medium (such as water), expressed as mg/L (parts per million) or percent of saturation.
Nonpoint Source Pollution – Any source of water pollution that does not meet the legal definition of "point source"; pollution which cannot be traced back to a single source. Results from land runoff, precipitation, drainage, seepage or hydrologic modification.
Point Source Pollution - Any discernible, confined and discrete conveyance (such as a pipe or well) from which pollutants are being, or may be, discharged.
Ion – a particle that is electrically charged (positive or negative)

Engager: Loop Lake (taken from "Healthy Water, Healthy People")

This engager can be used to introduce the purpose of water testing, and to make connections between testing for dissolved Oxygen and pH and the health of students' local watershed. It also serves to ignite interest, and give a real world example of why water testing is important and the impacts monitoring water quality can have on a community.
Step 1: Distribute Loop Lake maps, one per student.
Step 2: Read the account, below, of Loop Lake Village aloud to students. It is helpful if students locate and mark the various points on their maps as the account progresses.

Loop Lake Village, the community surrounding Loop Lake, is small but prosperous. Residents of Loop Lake Village include; Jack Pine, the local nursery grower who has just expanded his operation, Mr. and Mrs. Holstein who own and operate a diary farm with cows and sheep. Around the lake are several neighborhoods. There is a well-maintained trailer park that has been a stable part of the community for years. There is an older housing development with very well-maintained lawns stretching down the lakeshore. Farmland was recently sold and a new subdivision is under construction in its place. There is a bustling town center with a strip mall and large parking lot. The town's park has a public swimming pool and a popular pet play area. On the other side of the hill, across the watershed Divide Road, there is a new factory that provides several jobs for the local community members. This summer, for the first time ever, a large algal bloom (when algae grows rapidly in a body of water) developed in the lake, and several fish have died and washed up to shore. Some of the town people are saying that it must be caused from the factory. It could not be just coincidence that the factory was built in the same year that they are finding all this extra pollution causing an algal bloom. They feel the factory should be shut down before they lose their lake. It is up to us to help the town.

Step 3: Explain that the contour lines on the map indicate elevation, and ensure students understand that water flows from a higher elevation to a lower elevation.
Step 4: Have students discuss the Loop Lake Village situation. Students can then make a hypothesis of where they think the pollution is coming from. Is your hypothesis an example of point or non-point source pollution?

Transition: What could we do to test their hypotheses? Test the water! The activities below will help students learn about some of the different tests that are done to determine whether or not their water is healthy.

Activity One: Dissolved Oxygen

Introduction/Pre-Activity Discussion: Do organisms (both animals and plants) living in the water need oxygen to breathe? Where do you think they get it from? Yes. And these organisms obtain their oxygen NOT from the molecule bonded to the Hydrogen to form H_2O, but instead from the gaseous oxygen dissolved in the water as O_2. Certain aquatic animals (animals that live in the water) need more oxygen, others need less; and the levels of DO are rarely stable as they depend heavily on the body of water's motion (streams and rivers), or lack there of (ponds and lakes), temperature and atmospheric pressure. Dissolved Oxygen is essential for water to support life. For example, we want the Truckee River to have a dissolved oxygen level of about 13 ppm in order to support the trout populations that live in it.
Factors that might affect dissolved oxygen levels:
Increase: fast-moving water, or more aerated water (like the pump in an aquarium), plants photosynthesizing, and water to surface contact, cooler temperatures.
Decrease: dying fish or plants because bacteria consumes oxygen, less plants results in less oxygen produced via photosynthesis, warmer temperatures, and debris in the water that can increase temperature and/or suffocate plants.

Using Kits to Test DO Levels:
Step 1: Find a source of water to test, hopefully a local water source. Ideally a stream or water body that is subject to point source and/or nonpoint source pollution so that student groups can test levels of DO at various locations along the water body, compare results, and utilize those results to form conclusions about the health of the body of water. If not feasible to visit a local water source, water can be collected and imported into the classroom for testing. In fact the instructor can have students obtain water samples from various bodies of water available to them and then levels can be compared.
Step 3: Instructor can then break students up into groups (4 or 5 maximum) to perform the test for DO. Depending on time constraints, each group can test every water sample, and/or each group can perform multiple tests upon a single sample and average results to combine with those of their classmates for a cohesive class evaluation of the water samples. The instructor should decide how to structure the experimentation based on samples available, number of students/groups, and time allotted for this activity. A simple student page is attached to this lesson so that students/groups can record their results, and the instructor can make adjustments to it based upon the water source and procedure utilized.

Step 4: Hand out DO testing kits (and also pH kits if testing both at the same time) along with instructions for each test to each student group or at every station. Encourage students to read the instructions before proceeding, and work together to perform each test.

Step 5: The testing process! (these instructions can also be found accompanying the testing kits. If NOT using kits borrowed from SNJ please use the instructions included in the kit being used) 1.) Take the glass stopper out of the bottle and fill the bottle with sample water to the top; avoid bubbles in the sample bottle as best as possible. **2.)** Add contents of reagent packets #1 and #2 (found in the ziplock baggies) to the sample and stopper with the glass stopper; again avoiding bubbles in the sample bottle. **3.)** Shake vigorously, solution should turn an orange-brown color indicating the presence of oxygen. **4.)** Wait 5-7 minutes for solution to settle; so that top half of bottle is clear liquid. **5.)** Remove stopper, add reagent #3 from white container; close bottle and shake vigorously; solution will stay orange-brown in color but become transparent. **6.)** Fill plastic test tube, with solution, as full as possible; then pour into remaining empty/square container. **7.)** Add liquid (sodium thiosulfate solution) from the brown bottle a single drop at a time; after each drop gently swirl solution; continue adding a single drop at a time until the sample becomes colorless; record the number of drops needed to turn the sample solution clear.

Step 4: The total number of drops of sodium thiosulfate solution used to turn the sample to colorless equals the total mg/L of Dissolved Oxygen in the water sample, and also approximately equals the parts per million of Dissolved Oxygen in the sample (One part per million (ppm) is equivalent to 1 milligram of something per liter of water (mg/L)). Provide a space on the student sheet, for students to record their data.

Step 5 (Debrief): Have students either clean up their areas and return to their desks or proceed on to testing their samples' pH if time allows. Utilize a public display area (whiteboard) in the classroom to record the data collected by each group and/or for each water sample.

Discussion Questions:

- Did everyone get the same results?
- Why might there be variation in people's results?
- Are there any numbers that seem to stand out from the others?
- Does the water seem to be healthy?

Activity Two: pH!

Introduction/Pre-Activity Discussion/Demonstration (see Appendix II for a more advanced introductory Activity): pH is a measure of the hydrogen ion (H^+) concentration in a solution. When substances are mixed, water molecules do not always stay complete (as H_2O); sometimes molecules will break apart into Hydrogen (H^+) and Hydroxide (OH^-) ions. Make full page signs for this activity labeled OH^- (Hydroxide) and H^+ (Hydrogen); ensure enough for a dozen or so students and equal numbers of each type. Ask for two volunteers to come up to the front of the room and be molecules in a solution. Hand one student a hydrogen card and the other a hydroxide card. Together what do these students make? H_20! Water!

Step 2: Have several more students come up to the front of the room and evenly distribute H^+ and OH^- cards. As there are equal numbers of both hydrogen and hydroxide molecules "in the solution", therefore a test of the pH would be neutral or 7.

Step 3: Ask one or two students holding OH^- cards to step away from the group. Is the solution balanced? What ion do we have the most of now? Hydrogen! When there is excess hydrogen in a solution, the solution becomes slightly acidic, and the pH decreases.

Step 4: Ask one or two students holding H^+ cards to step away from the group. Is the solution balanced? What ion do we have the most of now? Hydroxide! When there are excess hydroxide ions in a solution, the solution becomes slightly acidic, and the pH decreases.
Step 5: Thank your volunteers and have them return to their seats. Explain that the middle of the pH scale is neutral (around a 7). The scale ranges from 0-14. As the numbers decrease from 7, a substance becomes more acidic (greater concentration of Hydrogen ions), whereas an increase from 7 indicates a more basic (greater concentration of Hydroxide ions), or alkaline, solution.
Step 6: What is a healthy pH for natural bodies of water? Most tap water is around a 7 or 7.5. This is the range that most animals require to survive and flourish.
HINT: Although it is important for students to have a basic understanding of pH since they will be testing pH levels of the water, the instructor can choose to go more or less in depth depending on the particular group of students.

Using Kits to Test pH:
Step 1: Utilize the same testing procedure as in the Dissolved Oxygen testing, have each group now test pH as they did DO.
Step 4: Hand out pH testing kits, if necessary, along with instructions for each test to each student group or at every station. Encourage students to read the instructions before proceeding, and work together to perform each test.
Step 5: The testing process! (these instructions can also be found accompanying the testing kits. If NOT using kits borrowed from SNJ please use the instructions included in the kit being used) 1.) Fill both test tubes with the sample water up to the black line. **2.)** Set test tubes side by side in the slots in the black container with the color wheel inside. **3.)** Add 6 drops of pH indicator solution to the test tube on the right side (the side that is NOT covered by the color wheel, the covered one is the "control") **4.)** Swirl the tube gently to mix. **5.)** Place the tube back into the right side of the container. **6.)** Hold container up to light source, rotate color disk until the best possible match between the two openings is achieved (it is okay if between colors, just choose the color that is closest). **7.)** The color can then be found on the pH scale to determine a pH value for that water sample.
Step 6 (Debrief): Have students either clean up their areas and return to their desks. Utilize a public display area (whiteboard) in the classroom to record the data collected by each group and/or for each water sample.
Discussion Questions:

- Did everyone get the same results?
- Why might there be variation in people's results?
- Are there any numbers that seem to stand out from the others?
- Does the water seem to be healthy?

Review Questions:

1. What is pH?
2. What is the ideal pH level for healthy water?
3. What is dissolved oxygen and its unit of measurement?
4. What is an ideal dissolved oxygen level for healthy water?
5. What are some factors that affect dissolved oxygen?

Assessment/Evaluation:

-Students can respond accurately to above review questions.

Constructed Response:

You have learned about water quality, how to test for water quality, and some of the different factors that can affect the quality of our water.

1. In 3-4 sentences, discuss dissolved oxygen and pH and explain why they are important.

Cross-Curricular Extension:

- **Math**—use gathered pH, and DO, and have students calculate the average, mode, and median of each measurement.
- **Social Studies**—have students research a recent incident of water pollution and how it impacted surrounding communities.

Differentiation:

1. Learning Intelligences Addressed:
   - **Kinesthetic:** students will conduct water quality tests which require hands-on pouring, measuring, shaking, etc.
   - **Logical-Mathematical:** students will use logical-mathematical reasoning in the Loop Lake activity to identify potential sources of pollution.
   - **Linguistic:** linguistic learners will excel at reading and following written instructions for the pH and dissolved oxygen tests.
   - **Spatial:** spatial learners will benefit from the pH demonstration with hydrogen and hydroxide cards.
   - **Interpersonal:** students will work in groups to conduct water quality tests.
2. Gifted and Talented:
   - Have students research local areas where water quality is poor. Create a presentation about how these areas could be cleaned based on knowledge acquired in class and through outside research.
   - If applicable, plot water sample locations used for this experiment on map and graph different levels of DO and pH at each location. Research potential causes of different levels in readings, and come to a conclusion about the health of the water source utilized for this activity.
3. English as Second Language:
   - Place students who struggle with reading in groups with stronger readers. When circulating throughout class, take special care to make sure ESL students are taking part in experiments.
   - Develop pictorial instructions for undertaking DO and pH testing on water samples.

Appendix I: Background

pH (Percent Hydrogen):

Mathematically speaking, pH is the negative logarithm of the hydrogen ion concentration. Hydrogen ion concentration in a solution, or substance, is a very small number and very difficult to understand, therefore, scientists created an easier tool for understanding. Today, we measure pH on a number scale of 1-14. The number seven being neutral and any measurement above a 7 on the scale is considered a base and any number below a seven on the scale is considered an acid. The pH scale is a logarithmic scale, therefore every one unit of change on the pH scale there is a ten-fold change of acid or base content of the water or solution.

Generally, natural waters have a pH of 5-9 (also the measure for human consumption) and most aquatic organisms survive in water with this range. If pH ranges higher or lower, aquatic life is less likely to survive. Water sources with a lower than five pH generally allow the solubility of phosphates and nitrates (assist in them dissolving in a body of water) which increases the likelihood of an algal bloom. This can indirectly lower the amount of oxygen in the water due to a higher level of bacteria living off of dying blooms.

Dissolved Oxygen:

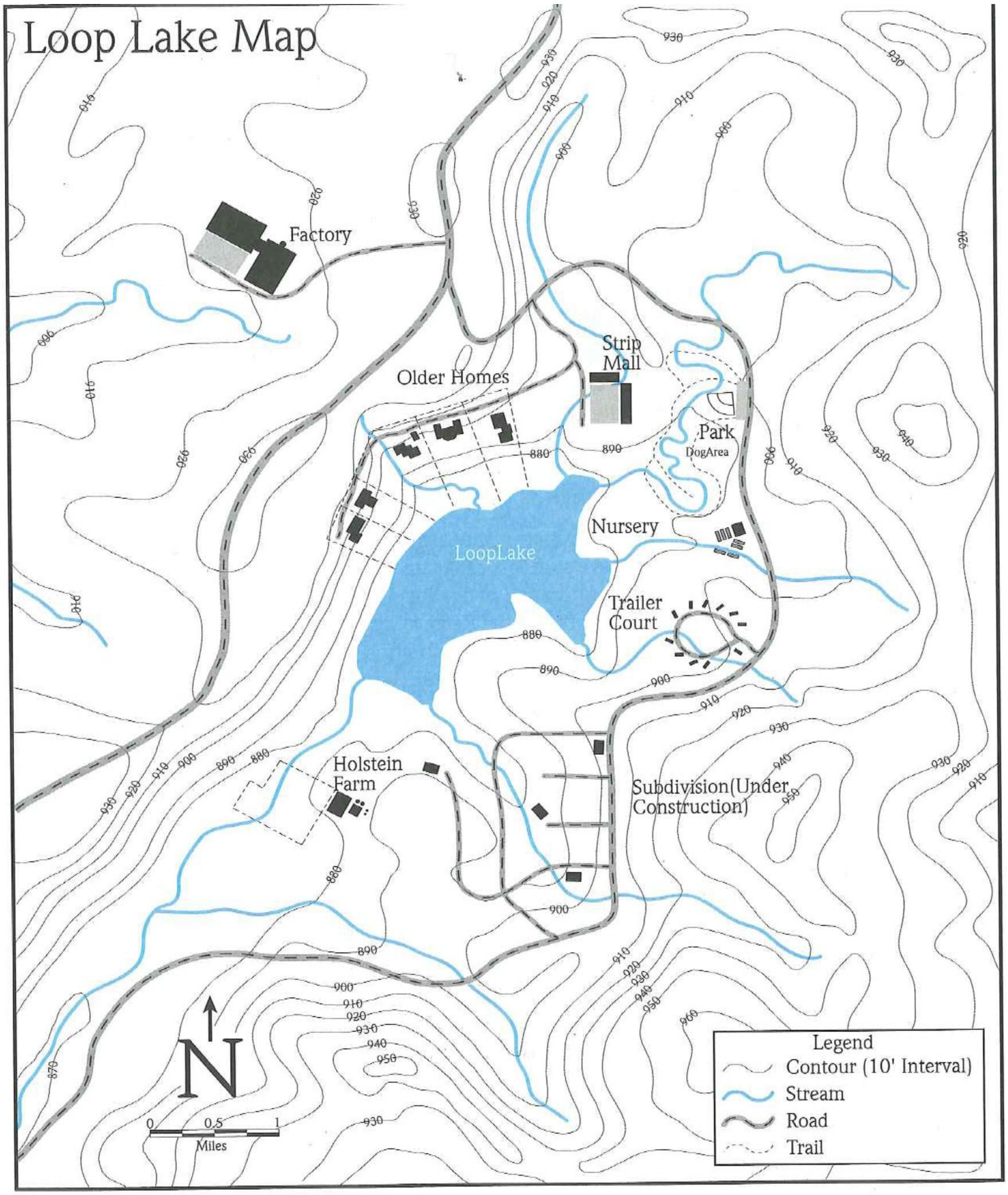
Most aquatic plants and animals like humans need oxygen to live. However, aquatic organisms need oxygen that is not atmospheric like humans; they need oxygen that is dissolved in the water called *Dissolved Oxygen.* Certain animals need more, others need less, which is what determines their ability to live in certain water sources.

Oxygen can be dissolved in water in a variety of ways. When water tumbles of rocks or bubbles down a steep fall atmospheric oxygen is forced into the water source. Plants found underwater that photosynthesis can also produce oxygen into a water source. Slower meandering streams or stagnant water typically has a lower dissolved oxygen level than down fast-flowing rivers or streams thus lending to different species of fish or plants and typically a healthier source.

APPENDIX II: Advanced pH Demonstration (Adapted from and courtesy of PROJECT WET; Activity: *Where are the Frogs?*)

1. Divide the class into three groups with approximately equal numbers of students in each group. One group are oxygen atoms, and the other two are hydrogen atoms. Hydrogen atoms should carry signs with "**e^-**" written on them. This represents the hydrogen's electron.
2. Have students form groups of three, with one oxygen and two hydrogen atoms in each group, to represent water molecules. Hydrogen atoms can stand on either side of each oxygen atom to demonstrate the actual structure of a water molecule. When all groups are formed the students now represent a solution with all water molecules intact.
3. HOWEVER, water molecules do not always stay complete in a solution, a natural water source, or in a substance. Water molecules will break apart or dissociate. Have a few of the student "water molecules" break up into hydroxide (OH^-) and hydrogen (H^+) ions. Therefore there should be groups joined as one hydrogen and one oxygen, and individual students representing lone hydrogen ions.
4. Have lone hydrogen ions give their "**e^-**" card to a hydroxide ion group. Thus the hydroxide groups will now be negatively charged, as they have an extra electron; and the lone hydrogen ions will be positively charged as they have 'lost' their electron and retain only their positively charged proton.
5. As there should now be equal numbers of OH^- and H^+ (in addition to the remaining H_2O molecules) the solution represented by the students has a neutral pH.
6. Inform students that a substance has been added to the solution that attracts OH^-; remove a few hydrogen ions from the solution, and explain that there are now more H^+ than OH^- in the solution. Therefore the solution has now become acidic, the pH has decreased.
7. Allow the hydrogen ions to re-enter the solution. Inform students that a substance has been added to the solution that attracts H^+; this time remove a few hydroxide ions from the solution, and explain that there are now more OH^- than H^+ in the solution. Therefore the solution has now become alkaline or basic, the pH has increased.
8. Check for understanding with the students. Proceed to the water testing.

APPENDIX III: Loop Lake Map



Appendix IV: Hydrogen and Hydroxide Cards

To create hydrogen and hydroxide visual aids, create half or full sheets of paper with "H^+" written on some and "OH^-" written on others. Be sure to make the typeface large enough for students who are sitting in the back of the room to see. Create 5-10 of each card.

Appendix V: Resources

- "USGS Water-Quality Information" http://water.usgs.gov/owq/
- "Project WET—Worldwide Water Education" http://www.projectwet.org/