Lesson 4: Water ph
Water Quality Sampling

Time Frame: Two 45-50 minute class periods

Grade Level: 8th – 12th Grade

Overview: Water pH

Water pH is an indication of the water's acidity measurements on a scale of 1.0 to 14.0, with a pH of 7.0 considered neutral. Solutions with a pH below 7.0 are considered acidic, and those above 7.0 are considered basic. In any given solution, some molecules of water break apart to form H+ (hydrogen ions) and OH- (hydroxyl ions). The pH scale shows which ion has the greater concentration. At a pH 7.0, the concentration of both ions is equal and the water is said to be neutral, neither acidic nor alkaline. Pure water has a pH of 7.0. When the pH is less than 7.0, there are more hydrogen ions than hydroxyl ions and the water is said to be acidic. When the pH is greater than 7.0, there are more hydroxyl ions than hydrogen ions and the water is said to be basic or alkaline.

The pH scale is based on the negative logarithm of the hydrogen ion concentration, so every one-unit change in pH actually represents a tenfold change in acidity. This means that pH 6.0 is ten times more acidic than pH 7.0, and ph 5.0 is 100 times more acidic than pH 7.0.

A range of pH 6.5 to pH 8.2 is optimal for most organisms. Rapidly growing algae and submerged aquatic vegetation remove carbon dioxide from the water during photosynthesis. This can result in significant increases in pH levels, which in turn can affect aquatic life indirectly by changing other aspects of the water chemistry. For instance, toxic metals trapped in sediment are released into the water at lower pH levels, and the level of ammonia that fish can tolerate varies tremendously within a small range of pH values. For the majority of streams, ponds, lakes and bays in Texas, the pH is usually slightly alkaline ranging from 7.0 to 9.0. Many streams and ponds in East Texas are acidic with pH values as low as 5.5.

Water's ability to resist changes in pH is its buffering capacity or alkalinity. Buffering materials are added to the water from the soils, minerals and rocks in the watershed. If a body of water has an abundance of buffering materials, it is more stable and resistant to changes in pH. The buffering capacity of a water body is critical to aquatic life. Generally, an aquatic organism's ability to complete a life cycle greatly diminishes as pH becomes greater than 9.0 or less than 5.0.

Photosynthesis by aquatic plants also influences pH. It removes carbon dioxide from the water, which increases the alkalinity. In especially low-velocity or still waters with lots of plant life (including planktonic algae), an increase in pH can be expected during the growing season or even during warm, sunny afternoons.

The carbon dioxide content of water in rivers and streams is less likely to change pH, but be aware of other events in the watershed that may affect pH. Human activities such as accidental spills, agricultural runoff (pesticides, fertilizers, animal wastes), and sewer overflows may also change pH.

Preparation:

Equipment & Materials for Water Quality Testing

- Octo-Slide Viewer
- Wide Range Indicator
- Test tube

Academic Question:

What is the significance of a water pH value?
How do pH values effect water quality in an aquatic ecosystem?

Objective:

- To be able to explain what a pH value represents.
- To recognize a single step in the pH range scale represents a 10 fold change.
- To conduct a water pH test.
- To see the effects acidity has on organisms in an aquatic environment.
- To relate land changes to aquatic pH changes.

Key Term:

Acidic, alkaline, basic, buffer, logarithmic

Process/Activities

Activity 1: Introduction – Demonstration of Understanding pH

1. Gather the following materials:
    a. 11 matching clear containers - plastic 2 liter bottles
    b. 3 bags of split yellow peas - representing H+ (hydrogen ions)
    c. 3 bags of split green peas - representing OH- (Hydroxyl ions)
    d. scale
2. Have student create one set of pH demonstration containers. Each container will represent the H+ (hydrogen ions) and OH- (Hydroxyl ions) at each number of a pH value.
    a. Begin with a pH of 0. This means H+ and OH- are exactly equal. Put one green pea and one yellow pea in the container.
    b. Acidic values, those below 7, have more H+ than OH-. Ten times more, so for ph 6.0, put in 10 yellow peas and 1 green pea.
    c. Continue making containers representing acidic pH values below 7.0.
        i. For pH 5.0 – there are 100 yellow peas, 1 green pea
        ii. For pH 4.0 – there are 1000 yellow peas, 1 green pea
        iii. For pH 3.0 – there are 10,000 yellow peas, 1 green pea
        iv. For pH 2.0 – there are 100,000 yellow peas, 1 green pea

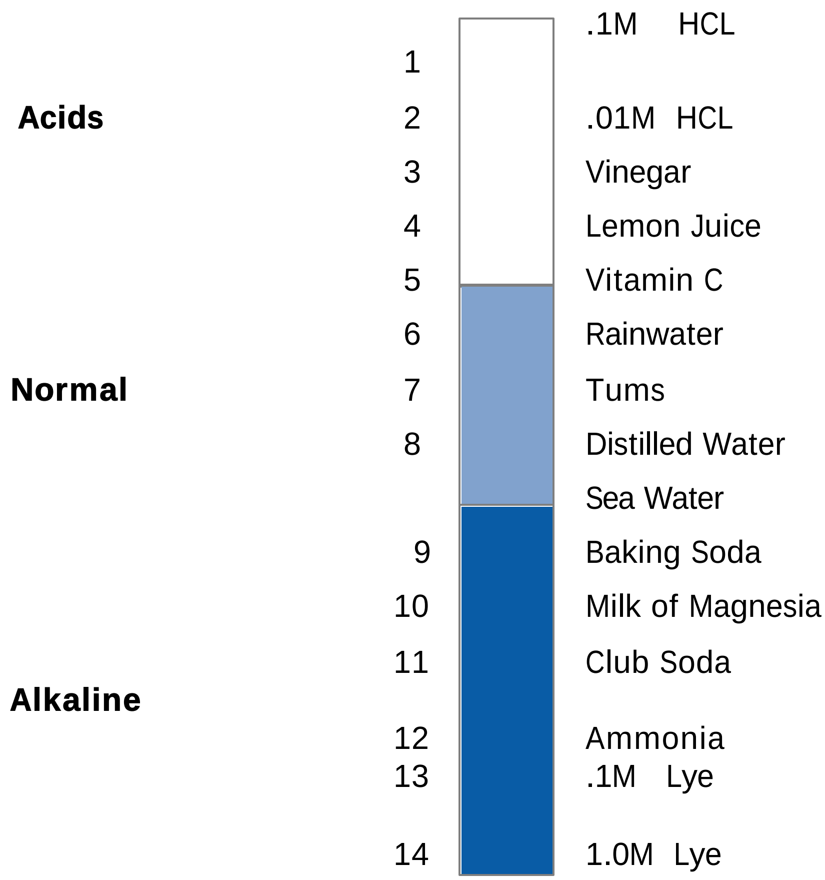
        *Do not count 100,000 peas. Count 100 peas and weigh on a scale. Multiply this weight by 1,000 and weigh out this amount of peas.
    d. Make containers for basic pH values about 7.0. These containers would have pH values below
        i. For pH 8.0 – put 10 green peas, 1 yellow pea
        ii. For pH 9.0 – put 100 green peas, 1 yellow pea
        iii. For pH 10.0 – put 1000 green peas, 1 yellow pea
        iv. For pH 11.0 – put in 10,000 green peas, 1 yellow pea
        v. For pH 12.0 – put in 100,000 green peas, 1 yellow pea*

        *Unless you have a private source for dried peas, the demonstration won't go into the million parts pH.

3. Save these demonstration containers for use in activity 2.

Activity 2: Relating pH to Common Substances

1. Gather the following materials:
    a. substances to test (as listed in step 5)
    b. indicator paper – wide range
    c. butcher paper
    d. pH demonstration container from activity 1.
2. Stretch the sheet of butcher paper across the board and attach. Draw a line and put on the pH scale from 0 to 14.
3. Ask students to enter, below the line, their best guesses for each test substance's pH.
4. Have students test pH of each substance. Write the correct order of the substances above the line.
5. Ask those students with the closest guesses for each substance to come forward and chose one of the yellow and green pea demonstration container that best represents that pH value.



Activity 3: Low pH Impacts

1. Gather the following materials:
   a. 6 tennis ball cans
   b. oil, detergent, vinegar, salt, fertilizer
   c. creek water
   d. algae – filamentous
   e. camera
2. Ask students to set up the experiment in a sunny windowsill with algae in creek water in all 6 tennis ball cans
3. The treatments for the different cans are:
   a. Can 1 – 1 Tbsp motor oil (parking lots, roadway, pollution)
   b. Can 2 – 1 Tbsp vinegar (acid rain)
   c. Can 3 – 1 Tbsp salt (oil production discharge)
   d. Can 4 – 1 Tbsp fertilizer (lawn runoff – sewage discharge)
4. Take photos of the cans over the next 2 weeks. Keep refilling the cans with extra creek water as the levels drop from evaporation.
5. Ask students what type of pollution each of the treatments represents. How toxic was the acidic pollution? Rank the pollutants by impact on the algae.

Activity 4: Conduct the Water pH Testing in the Classroom

1. Gather the following materials:
   a. Laminate testing procedures, one for each set of pH measuring equipment
   b. Have enough wide range indicator and octo-slide viewers for each group to conduct the activity
2. In class, go over the definition and what affects pH changes have on organisms – put up transparency – Effects of Acidity (4.1)
3. Have students break into groups to watch testing procedures.
4. Teach the students the pH testing procedure.
5. Have students work through the procedure while in groups.
6. Have students complete Water pH Worksheet (4.2)

Activity 5: Possible Activity

Where does water acidity come from?
See attached "Where is the acid rain in the U.S.?"

Assessment/Evaluation:

1. To evaluate the student's comprehension of pH range scale and what it represents by asking the students to guess, for each pH range from 2.0 to 12.0, the bottle that best represents the pH value.
2. To assess the student's understanding of the effects of acidity on an aquatic environment by asking the students to discuss different types of toxic pollutants and their affect on algae in creek water.
3. The student's worksheet (4.2) may be used as an assessment of the student's comprehension of pH and the testing procedure.

Resources:
National water conditions pH of Precipitation
http://h20.usgs.gov/nwc/NWC/pH/html/ph.html
Texas Watch Monitoring Manual

Transparency 4.1

Water pH	Effects of Acidity on Fish Species
6.5	Walleye spawning inhibited
5.8	Lake trout spawning inhibited
5.5	Small mouth bass disappear
5.2	Walleye, burbot, lake trout all disappear
5.0	Spawning inhibited in many fish
4.7	Northern pike, white sucker, brown bullhead, sunfish, and rock bass disappear
4.5	Perch spawning inhibited
3.5	Perch disappear

Worksheet 4.2

Name: ____________________
Date: ____________________

Water pH Worksheet

1. List two substances in your house that are acidic:
   a. ____
   b. ____

2. List two substances in your house that are basic:
   a. ____
   b. ____

3. At what pH can fish no longer survive in water?______________________

4. The pH scale is from ________________________to _________________________.

5. What does pH represent? ____

6. Every one-unit change in pH is equal to a ________________- ____________________ change in acidity. Therefore, a pH of 5.0 s.u. is __________________x more acidic than a pH of 7.0 s.u.

7. What is the pH of unpolluted rainwater? _____________________

8. Texas waters generally have a pH within the range of _____________ to _____________.

9. There are bodies of water in East Texas that have pH values as low as 5.5; what could be the cause of this?

   ____

   ____

   ____

   ____

10. List types of nonpoint source pollution that may enter a water body and alter its pH.
    a. ____
    b. ____
    c. ____

11. Describe a way that stream bank erosion and land use may have an affect on the pH level of a river or a lake. ____

    ____

    ____

Where Is The Acid Rain In The United States?

Taken From USGS "Water Resource Professional Outreach Notebook" OFR 94-73

Materials needed:

- Outline map of the United States (showing state boundaries)
- Measured rainfall pH values for various locations (either already plotted on the map or a list of values and their locations)
  http://h2o.usgs.gov/nwc/nwc/pH/html/ph.html - National Water Conditions with pH readings
- Pencils

Procedures:

1. If you start with a blank map of the United States, record the rainfall pH values from the list on the map.
2. Look at the values on the map. What states have experienced the most acid rainfall? What states have experienced the least acidic rainfall?
3. You can draw contour lines for various pH levels on the map to see areas covered by specific pH ranges.

   To Draw Contours: Choose a level, such as pH=4.4 and find a point where that value was recorded. With a pencil, start at that point and draw a line to another place with the same pH value, placing your line between dots for other pH measurements where it would belong. For instance, if you start with a pH 4.4 as you move towards another point of 4.4, draw the line between points pH = 4.3 and pH = 4.5. As you draw each portion of the line you need to look around the point in all directions to identify the correct place to draw the line thought those points. The contour lines for each level that you make (4.4, 4.6, 4.8, etc.) should never cross each other. Each line should be a smooth curve. For this type of data you may not be able to close all of the contour lines into complete loops. There also may be some areas where a contour line is repeated but it does not connect to lines of the same value elsewhere in the map.
4. Is there a particular region or area of the United States that has more acidic rainfall? Why do you think one region might have more acidic rain than another region?

What happened?

Remember, the lower the pH, the more acidic the rain. States east of the Mississippi River tend to have more acidic rain that states west of the Mississippi. In particular, Ohio, Pennsylvania, Maryland, New York, and New Jersey have more acidic rain. Western states, such as California and Nevada have less acid rain. Rain in the east tends to be acidic because there are more concentrated sources of pollution in those areas where population and industry are concentrated. Monthly averages of rain pH may vary because of the amount of rainfall in the measurement period.

Contours of pH of rain will tend to show a "bulls-eye" type of figure for acid rain that is centered around Pennsylvania, Ohio, New Jersey, and New York. Contour lines in the southeast and west tend to be broad and don't have a noticeable trend or shape.

Stretch Your Mind:

- Look at some pH maps for several years. How has the pH changed for the time span? Can you find an area in which rain has become more acidic? Can you find an area in which rain has become less acidic? Has there been any change where you live? Why do you think these changes have happened? Can you see a trend in the rain acidity, is the geographic area affected by acid rain getting larger or smaller? (What if you compare different intervals of time?)

- See if you can get some local information about rain acidity. How does your local rain pH compare with the national rain measurement? Is your local rain different from the yearly or monthly average in your area? (Think about single measurements vs. averages, local effects vs. broader areas.)

- Make a plot (bar or line graph) of site vs. pH for each month of data. Compare all the months. Do you see a season or a month that is more acid than others? Is one less acid? Why might this happen? (Think about rainfall amounts during those periods, or pollution sources that might be more prevalent at one time than at another.)

- Calculate an average pH for each site for the year using the monthly averages. How do the year averages compare with the monthly data? Which do you think is a good representative of the rainfall pH? What value would you use to describe the rainfall acidity for your state? (Think about how that information might be used: Do you need it for a general environmental description? Are you concerned about trends to the future? Are you concerned about single points that might have a one-time effect? Would you use different values if you wanted to support a special point of view?)

- How much difference is there between the lowest and highest pH? Is this significant? (Remember, each unit of pH is ten times as strong as the next unit.)

Water pH Test Procedure

Examples of acidic substances:

Car Battery Acid (pH of 0.3)

Lemon Juice (pH of 2.1)

Orange Juice (pH of 4.3)

Rain Water (pH of 5.8)

Milk (pH of 6.9)

Examples of alkaline substances:

Human Blood (pH of 7.5)

Sea Water (pH of 8.0)

Baking Soda (pH of 8.3)

Ammonia (pH of 11.4)

Lye (pH of 13.6)

This procedure for determining the value of pH is by the use of a liquid "Wide Range" indicator and Octo-Slide Viewer. Wide Range pH indicator is a dye that changes color according to the pH of the solution. The color is then matched to color standards representing known pH values using a Color Comparator viewer system. A Liquid Wide Range Indicator allows measurement of pH in a range of 3.0 pH to 10.5 pH. **Note: If the water is strongly colored or extremely turbid, do not perform this test.**

Step 1: Rinse the sample tube supplied with the pH kit twice with water from the sample bucket or water body

Step 2: Fill the test tube to the 5 ml line with sample water.

- ✓ **Use your safety goggles and gloves during the remainder of this test, but remove goggles for color comparison (step 5).**

Step 3: Add 10 drops of the pH wide range indicator. Cap and gently invert 10 times.

Step 4: Insert the tube in the top of the Color Comparator Viewer.

Step 5: Hold the Color Comparator Viewer up to a light white background to read.

- Make sure you are not looking through tinted glasses or safety goggles.
- The pH value is determined by matching the color comparator to the sample tube color.
- Read the results in pH standard units (s.u.)
- Estimate the pH value to the nearest 0.1 pH unit.
- Record your results.

- ✓ **The key to this test is the color of the sample. If your sample looks green, without a trace of yellow, your pH is somewhere above 8.0. But if your sample looks green with a trace of yellow, you know that the pH is below 8.0.**

Teachers Guide 4.3

Name: ____________________
Date: ____________________

Teacher's Guide
pH Worksheet

1. What are two substances in your house that are acidic?
   a. Lemons, oranges
   b. Vinegar, orange juice, milk

2. What are two substances in your house that are basic?
   a. Baking soda, ammonia, lye
   b. Pumpkin, detergent, soap

3. At what pH can fish no longer survive in water? **3.0 pH**

4. The pH scale is from **1.0** to **14.0.**

5. What does pH represent? (**Means power of the hydrogen ion**.)

6. What is the pH of unpolluted rainwater? **5.8 pH**

7. Every one-unit change in pH is equal to a **tenfold** change in acidity. Therefore, a pH of 5.0 s.u. is **100 x** more acidic than a pH of 7.0 s.u.

8. Texas waters generally have a pH within the range of **7.0** to **9.0**.

9. There are bodies of water in East Texas that have pH values as low as 5.5; what could be the cause of this? **Acidic soils and the excessive deposition of plant material such as pine trees.**

10. List types of nonpoint source pollution that may enter a water body and alter its pH.
    a. pesticides
    b. fertilizers
    c. animal waste
    d. OTHERS: accidental spills and sewage

11. Describe ways that stream bank erosion and land use may have an affect on the pH level of a river or a lake. **Any reasonable answer may be accepted here.**