Lesson Plans

MOSS

McCALL OUTDOOR SCIENCE SCHOOL

University of Idaho
College of Natural Resources

Title: The Importance of pH
Grade Level: 5th - 8th grade

Topic:	**Introduction to the concept of pH and its importance in water bodies**
Background:	pH is the measure of acidity or alkalinity of a solution. Solutions that are alkaline are also referred to as basic. When a solute is dissolved in water it produces charged molecules (ions). These ions interact with water and cause changes on the molecular level. Acidic solutions contain more hydrogen ions (H^+), while basic solutions have more hydroxyl ions (OH^-). pH is unique because it has no measurement units, as it is found using a mathematical equation in which you take the inverse logarithm of the H+ content. pH is measure on a scale of 0-14; neutral water (distilled water) has a pH of 7. Anything below 7 on the scale is acidic; a reading of 0 is the most acidic a substance can be. Anything above 7 is considered basic, with 14 being the most basic or alkaline. The logarithmic nature of the scale means that a change of one unit on the pH scale represents a tenfold change in hydrogen ion concentration. The pH of a body of water is indicative of the water chemistry and has implications on the types of organisms that can live in it.
Next Generation Standards:	5.SPM c, PS1. A and PS1.B, K.OTE, ESS2.E, & ESS3.A
Essential Questions & Goals:	Questions that will guide this lesson are: 1. What is pH and why do scientists measure it? (i.e.: why is it important?) 2. How is pH measured? 3. Why does the pH of water change depending on location?
Objectives:	By the end of this lesson students should know: 1. pH is a measure of acidity 2. Be familiar with the pH scale and the neutral value 3. Different types of water bodies (streams, lakes, swamps) have different pH levels 4. pH affects what organisms can live where 5. Safety protocols surrounding acids and bases (both acids and bases can caustic) By then end of this lesson students should be able to: 1. Test pH using pH strips and a colorimetric chart

Materials:	- 3 glasses - 200mL orange juice - 200mL distilled water - 200mL soapy water - A tablespoon - Baking soda - Litmus paper - pH strips and colorimetric key - Household liquids to test - Sufficient number of glass containers to hold household liquids - Chemical resistant gloves (at least one pair per group of students) - Safety goggles if utilizing strong acids and bases - Samples of water from local water bodies, if available - Internet access, if available - 15 pieces of construction paper that correspond to pH scale - Attachments to this document
Set up:	In advance, you will need to 1. Collect the liquids and baking soda required in the "Engage" experiment 2. Collect household liquids for "Explore" module 3. Cut and prepare materials for "Evaluation" module 4. Print out the attachments
Classroom Time:	~1.5 hours
Introduction (Engage):	The first activity of this lesson is designed to catch the student's attention; with a few simple ingredients we can introduce the complex topic of pH to students. For this experiment you will need 3 glasses, orange juice, distilled water, soapy water, baking soda, a tablespoon, a beaker or liquid measuring cup, a copy of the activity print out for each student, litmus paper, and the pH scale (attached). Hand out the activity sheet to each student in the class. Pour 200ml of distilled water into one glass, 200ml of juice into the second glass, and 200ml of soapy water into the third glass. Ask: "By raising your hand, tell me who here has helped

	their family cook?" Then probe for observations the students have made while cooking. This brief discussion should funnel towards reactions of ingredients when mixed together. Bread rising is a good example to fall back on. After the discussion, students should understand that different combinations of ingredients create different reactions. At this point, briefly introduce the concept of acids and bases by telling the students that many of the reactions they've witnessed in cooking occur because every food is either acidic or basic, and when these substances are mixed together, you see physical reactions. Introduce the experiment, and explain that you will be testing to see if each solution is acidic or basic by adding a tablespoon of baking soda to each glass. (If you feel comfortable, have three different students add the baking soda to the containers at the front of the class). Tell the students that acidic solutions should bubble when the baking soda is added to them because baking soda is basic. Ask each student to make some observations on their handouts about what they witness. As you add baking soda to the distilled water, nothing should happen; the pH scale is based on distilled water and its neutral pH of 7. When baking soda is added to the juice it should bubble because the juice is acidic. And when baking soda is added to the soapy water there should be no reaction because baking soda and soapy water are both alkaline. After the experiment ask the students to share what they witnessed. Ask: Which solutions do you think were acidic/basic? Why? Introduce the pH scale with the attached sheet, by projecting it for everyone to see or by handing out individual copies. The scale has common items on it such as milk and bleach. Based on the reactions they witnessed ask them to predict where juice, distilled water, and soapy water fall on the scale. The last part of this activity allows the students to test the pH themselves by using litmus paper.
Activity (Explore):	This part of the lesson builds on the exposure to the concept of pH that students gained in the "Engage" module. Recalling the demonstration using juice

	and soapy water, ensure that students know that everything has a pH value that can be measured if the substance can be dissolved in liquid. Ask students to think of other household items that might be testable for pH. Test selected household liquids, prepared ahead of time, in small groups. Provide each group of students with pH strips and a colorimetric chart, and liquids to test. (Include tap water. Other substances might include: milk, leftover soup, laundry detergent, Lysol, Windex, lemon juice, 3.5% hydrogen peroxide, coffee.) Before allowing students to begin testing, ensure understanding of basic laboratory safety protocol regarding handling of acids and bases. If substances with pH < 3 or > 12 are utilized, individuals handling the substance must wear chemical resistant gloves and safety goggles. Instruct students that chemicals with a pH at either extreme of the scale are equally caustic. (In other words, bases can be just as dangerous as acids if not handled properly.) Once testing has been completed, recall the pH scale and ask students whether the substances they tested were acidic or basic. Ask whether the substances would be likely to react with baking soda. We have thus far tested household items for pH, but what about liquids found out in nature? Tell students that water bodies have a pH too and that they could test these pH values in the same way. Either: 1) Test the pH of samples previously collected from local water bodies or 2) investigate datasets for nearby water bodies at: waterdata.usgs.gov.
Explanation:	Having explored pH measurements for household and natural substances, it will be important to investigate with students the question: **What *is* pH?** pH can be explained to students as a measure of the acidity of a liquid. It is a measure of the dissociation of hydrogen ions in solution. Hydrogen ions are positively charged. This dissociation is related to how tightly hydrogen cations (positively charged ions) are bonded to their corresponding anions (negatively charged ions). If the anions readily give up the hydrogen ion, there is a high quantity of

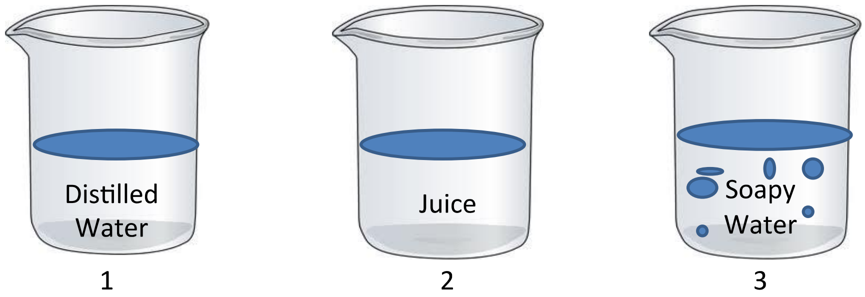
	hydrogen ions freely floating in solution. If the anions hold the hydrogen ion tightly, fewer hydrogen ions are freely floating and thus detectable in the solution. Water molecules can break apart, or dissociate, into hydrogen and hydroxide ions (H^+ and OH^-). In pure water, this dissociation occurs to a certain degree, where some molecules are dissociated and some remain bound together as H_2O. The neutral value of pH = 7 was set as the amount of hydrogen ions dissociated from water at equilibrium. This quantity was then converted to an inverse logarithmic scale of 0-14 for convenience. The pH depends on the inverse of the hydrogen ion concentration, so the higher the concentration, the lower the pH value. When an acid (containing readily dissociating H^+ ions) is added to water, the concentration of H^+ ions increases, so pH decreases. When a base (containing readily dissociating OH^- ions) is added to water, the OH^- ion concentration increases (and H^+ ion concentration decreases), increasing pH. "pH" is an abbreviation for "power of hydrogen." The H must be capitalized because it represents an element on the periodic table. **Why do scientists measure pH? What is its importance?** The pH of water bodies is one factor that is important in determining habitat suitability for different organisms (just like temperature, light levels, nutrient levels). Show examples of bell curves representing organisms' preferred pH ranges. (Diagram included in the attached slides.) Explain that the curve represents the numbers of organisms that survive at a particular pH value; the bell shape is due to the fact that for any given species the majority of organisms can survive at an intermediate value within the species' tolerance range. pH has specific impacts on aquatic organisms: - Aquatic macroinvertebrates with calcium-containing exoskeletons are generally sensitive to pH levels below neutral. - Developing eggs and larvae of insects have a narrower tolerance range than adults. - Activity of enzymes in organisms' bodies have

	specific pH ranges for optimal functioning. - Metals can dissolve more easily in water with pH < 5. These metals are needed in small quantities by organisms but at higher concentrations absorption can interfere with proper body functioning.
Elaboration:	After discussing the ecological importance of pH for organisms, students will be better able to understand that pH can influence what organisms can live in which water environments. Discuss general pH ranges of streams and lakes (~6.5-8.5), swamps (< freshwater) and ocean (~8-8.2) ecosystems. Mention to students that there are many factors besides pH that also influence water quality and the habitat preferences and requirements of different species (in other words, pH is not the only factor to consider when evaluating habitat). (See other lesson plans for more detail regarding such parameters). **Why would water be a certain pH?** ROCKS. The chemical composition of rocks underlying a lake or streambed can influence the pH of the water body. For example, rocks containing calcium carbonate or limestone ($CaCO_3$) or gypsum ($CaSO_4$) may contribute to higher pH values, as the carbonate ion acts as a buffer, accepting H^+ ions and removing them from solution. Bedrock present in the region that drains into a given body of water (the watershed) will influence that water, via runoff or percolation through groundwater. Check out the rocks comprising the surficial geology in your location at this website! http://ngmdb.usgs.gov/maps/MapView/ VEGETATION AND DECOMPOSITION. Plant growth often increases the pH of water bodies as it consumes hydrogen. Lakes with higher quantities of vegetation will often have a higher pH than less productive lakes. Then, as organisms decompose they alter the pH of their surroundings, often lowering it as they produce acids. Decomposition occurring in soils surrounding a water body has a similar effect, as water acidifies as it percolates through the decaying matter and then enters the water body. NATURAL ACIDITY. Rainwater is naturally slightly acidic because as it falls the water interacts with

	carbon dioxide in that atmosphere to form carbonic acid (H_2CO_3). Hydrogen ions can dissociate from this compound and contribute to the acidity of the rainwater. As carbon dioxide concentrations in the atmosphere increase, it may be the case that carbonic acid will be generated in higher concentrations and contribute to increased acidity of rainwater. Review question: Why is pH of water bodies different than that of distilled water?
Evaluation:	At the end of this lesson, create a life size pH scale using 15 pieces of colored construction paper. It should be coordinated to the color scheme used during the lesson. Each paper should have one number written on it and the color should correspond to the scale of pH colors and numbers 0-14. Lay the scale somewhere that each student can access it in turn. Next, have the students partner up. Hand out an animal or a plant picture to each group (attached, but feel free to use local animals and plants as well). Ask the students to consider where their organism lives, and what the pH may be in that habitat. One at a time, have each student place their print out along the scale where they think their animal/plant would survive based on pH. Some simple guidelines for life and pH: Water with a pH of <4 or >10 will kill most organisms Very few species can tolerate water <3 or >11 5-7.5 is healthy pH for most trout species 6-7.5 is the ideal range for terrestrial plants Rainwater normally has a slightly acidic pH ~5.5 Natural pH levels fall between 6-9

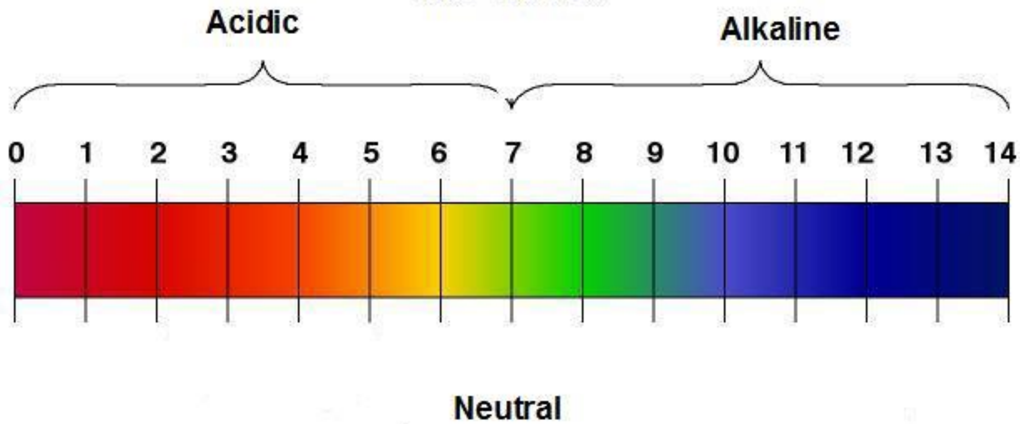
An Experiment with Acids and Bases

In this experiment we will be exploring acidic and basic solutions. At the front of the classroom your teacher has three containers. The first container has distilled water; the second container has juice; and the third container has soapy water. Starting with the distilled water, add 1 tablespoon of baking soda, and wait for the reaction.



How did each solution react to the baking soda? Which one(s) bubbled? Which one(s) stayed the same? Why did they react this way?

The PH Scale


Acidic
Alkaline
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Neutral


0
Battery Acid
1
2
Lemons
3
4
Rain Water
5
6
Distilled Water
7
8
Sea Water
9
10
11
12
Soapy Water
13
14
Drain Cleaner

Rainbow Trout

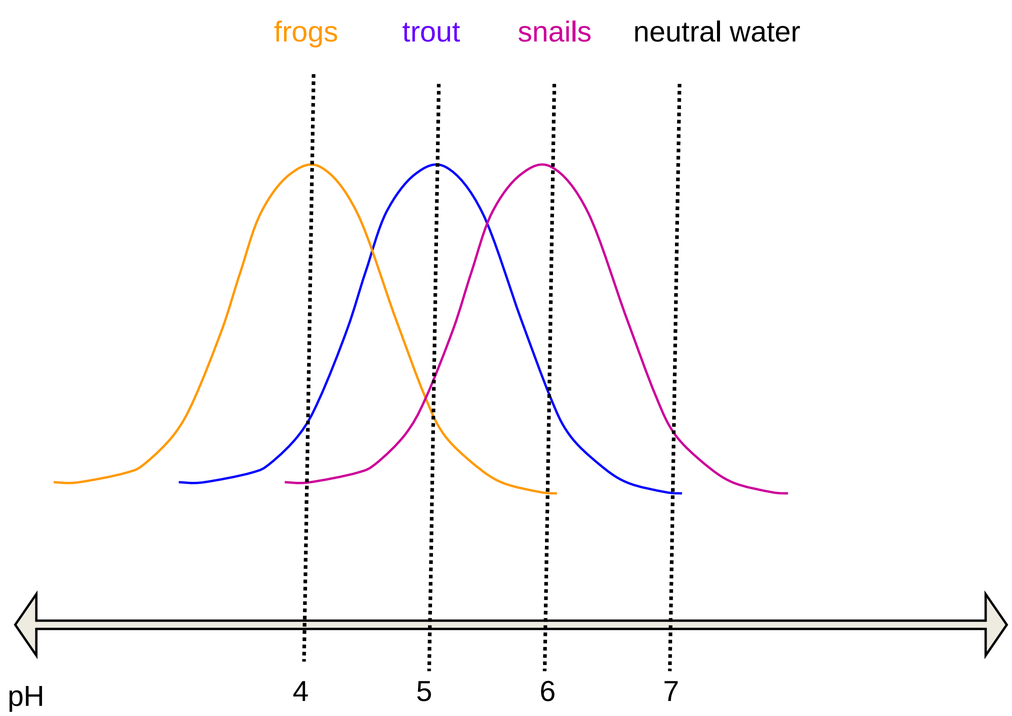
Brown Trout

Salmon

Lily Pads

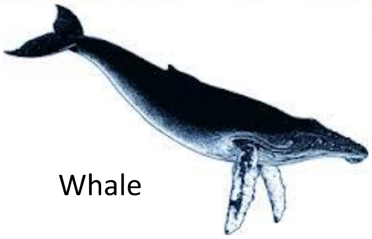
Frog

Tolerance ranges



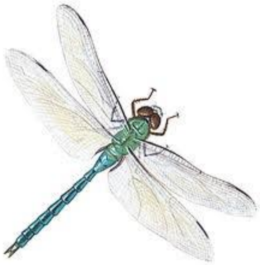

Freshwater Minnow


Seaweed


Whale


Pine Needles


Cattails


Dragonfly


Mayfly


Salt Marsh Grass

Rainbow Trout

Brown Trout

Salmon

Lily Pads

Frog

Additional resources:
For information on pH definition:
http://www.elmhurst.edu/~chm/vchembook/184ph.html
http://fishandboat.com/anglerboater/2001/jf2001/wpollbas.htm
For information on pH effects:
http://www.epa.gov/acidrain/effects/surface_water.html
For information on ocean pH:
http://www.epa.gov/climatechange/science/indicators/oceans/acidity.html
For general pH and water quality information:
http://www.waterencyclopedia.com/En-Ge/Fresh-Water-Natural-Composition-of.html
http://www.ecy.wa.gov/programs/wq/plants/management/joysmanual/ph.html