Activity 3
Wetlands and Water Quality

Objectives

Students will be introduced to water quality issues as they relate to three local wetland ecosystems, learn how to perform standard water quality tests on water samples from these habitats, and learn how to evaluate the results of their tests.

Students will understand the definition of a wetland ecosystem, know how to measure water quality variables by testing water samples from three local wetland habitats, and be able to collect, compare, classify, and evaluate data.

Terminology

Adaptation, aestivation, amphibian, aquatic biologist, black water stream, camouflage, Carolina bay, classification, colorimetric, community, comparison, consumer, data, decomposer, dependent variable, ecosystem, environment, food chain, food web, habitat, hibernation, hydroperiod, hypothesis, independent variable, industrial coal pond, inference, landforms, life cycle, metamorphosis, migration, niche, nutrients, observation, population, prediction, producer, quantitative, qualitative, resources, wetland, zooplankton.

Grade Level: 3rd-6th

Ideal Class Size: 24 students divided into six groups of four

Subject Areas

Life Science, Earth Science, Inquiry Skills, Math-Algebra-S1-S4

Time

1 hour introduction and presentation.
1 hour activity/experiment.

Materials

Power Point or slide projector w/slides
Flip chart or writing board
Eraseable colored markers
Masking tape
Indelible ink markers
Demonstration Equipment:

- Monitor and lens to view water samples (with zooplankton, salamander larvae/ tadpoles/mosquito larvae, etc. as available)
- Water samples from each of the following local wetlands: Carolina bay, blackwater stream, industrial coal pond
- Colorimetric water chemistry test kits, including the following tests: pH, iron, phosphate, nitrate, dissolved oxygen, and total hardness
- Water bottles filled with deionized water
- Cooler with ice for DO water samples
- Examples of different kinds of water test kits
- Turbidity/total suspended solids demo
- Two clear plastic columns or jars, 1 filled with water and soil, 1 with deionized water

Water Chemistry Activity

- Paper towels
- Water samples: 6 of each habitat in 100 ml covered containers (Carolina bay, blackwater stream, industrial coal pond)
- TesTabs for pH, iron, phosphates, nitrates
- Water bottles filled with deionized water (1/pair)
- Pre-marked test tubes w/caps (2/pair)
- Test tube racks (1/pair)
- Safety goggles (1/student)

Posters

- Methods of Science
- SAFE Rules
- Wetlands & Water Chemistry
- Laminated Data Sheet having spaces to record data collected

Copies

- Students procedures and data sheet (1/student)
- Water test color keys--laminated desk versions for the specific tests being conducted
- Wetlands follow-up science activity (1/student)
- Wetlands are Wonderful word search (1/student)

Advanced Preparation

SREL's activity uses the LaMotte AM12 TesTab Water Investigation Kit (code 5849), available from Carolina Biological Supply. Any colorimetric water test kit could be used, as long as it is appropriate for the age of the students involved.

Immediately prior to the activity collect water samples from a Carolina bay, a blackwater stream, and an industrial coal pond. Perform dissolved oxygen tests immediately and record results to share with class later. Begin tests for total hardness prior to class as it may take many TesTabs to achieve accurate results. Put water samples for student tests in labeled 100ml capped Nalgene bottles, 6/wetland.

If the test tubes to be used for the water quality tests do not have 5ml and 10ml gradations, mark the tubes at these volumes with an indelible marker.

Copy the "Task List Objectives" onto a classroom writing board or flip chart. This will help you complete all the steps in the scheduled amount of time.

Safety Notes

Safety goggles should be worn during water testing activities. Clean goggles after each class.

Background Information

Wetlands are defined by the U.S. Fish and Wildlife Service as, "…areas where water is the primary factor controlling the environment and the associated plant and animal life. They are transitional habitats that occur between upland and aquatic environments where the water table is at or near the surface of the land, or where the land is covered by shallow water that may be up to six feet deep.”

Wetlands are categorized by their general structure or vegetation, flood patterns, water chemistry, and soil types. Some examples of wetlands found in the Southeast are marshes, pocosins, cypress swamps, mangrove forests, Carolina bays, boarder areas around ponds and lakes, and flood plains along steams and rivers. This activity will focus on three wetland habitats: a Carolina bay, a blackwater stream, and an industrial pond that receives rain water runoff from coal wastes at a local power plant.

Any area of land that holds water some of the time, and is dry some of the time can be considered a wetland. This cycle of drying out and filling up with water is referred to as a hydroperiod and is important for the survival of many of the plant and animal species that live in these habitats. There are wetlands, like the Carolina bays, that are not connected with flowing water and therefore only have water in them during rainy periods. The zooplankton (microscopic animals) that inhabit these bays have adapted to these hydroperiods and are able to enter a state of hibernation called aestivation that allows them to dehydrate during droughts and re-hydrate when the bays fill up again. Likewise, amphibians that spend the first part of their life cycle in the water breathing through gills and the rest of their lives on land breathing through lungs have also adapted to a wet/dry cycle.

Hydroperiods aren’t the only reason plant and animal life in wetlands have become so diversified; each wetland habitat has water and soil characteristics that require specialized adaptations by the plants and animals that live there. Water quality can vary from wetland to wetland and makes a difference in the types of species found there. Aquatic ecologists test for a large range of physical and chemical water characteristics such as total suspended solids, total hardness, pH, dissolved oxygen, iron, phosphates and nitrates. They have found that the warm, shallow, slow moving waters of Carolina bays are slightly acidic, have low levels of dissolved oxygen, and relatively high levels of iron, phosphates, and nitrates. In comparison a blackwater stream that is cool, deep, and fast moving has a neutral pH, has high levels of dissolved oxygen, and lower levels of iron, phosphates, and nitrates than the Carolina bay.

Water chemistry analysis can also be used to test for contaminants in wetland waters. Contaminants can be anything found in an area where it doesn’t belong, or in quantities that are too high to be tolerated by the organisms living there. Most organisms need minerals to thrive, but too many can be detrimental. Simple colorimetric tests can be used to quickly determine the presence of a contaminant. A water sample is collected and an indicator chemical is added. The indicator binds with the contaminant in question and causes the color of the water to change according to the amount of the contaminant in the water. The “colored” water sample is then compared to a standardized color chart that lists varying levels of contaminant.

Long before standardized chemical analysis were used to check water quality people inferred the health of an ecosystem by the presence or absence of animal and plant species. Aquatic ecologists have since determined that some living organisms can be better indicators of subtle changes in water quality than chemical analyses, and have created a species tolerance scale that uses the presence or absence of certain species as indicators of organic pollutants; this is the “canary in the coal mine” analogy. Once very sensitive species begin to show signs of trouble, standardized chemical analysis can be run to pinpoint the contaminant.

In addition to being among some of the most biodiverse ecosystems in the world, the unique soil structures of wetlands, built up over hundreds and thousands of years, serve as natural water filters and purifiers. During rain water runoff, creeks and streams are slowed by low lying wetlands where water seeps through layer upon layer of fine, aged organic matter. Impurities are trapped and then broken down by the abundant microbial organisms that live there. The water eventually makes its way toward rivers, lakes, and reservoirs, or into groundwater cleaned and ready for drinking.

Wetlands beautify our planet by the presence of their diverse and abundant flora and fauna, keep us informed of the health of our local environment, and provide us with our most valuable resource – fresh drinking water.

Activity 3: Wetlands and Water Quality
Workshop Outline

LECTURE AND DEMONSTRATIONS (1 hour)

1. Introduction (10 minutes)
- A. Today's topic – Wetlands and Water Quality
- B. Today's task list
- C. Review SAFE rules
- D. Review the Methods of Science as it relates to the previous activity

II. PowerPoint Presentation (15 minutes)

III. Demonstrations (35 minutes)
- A. Pond life observations (10 minutes)
- B. Life cycles (5 minutes)
- C. Five senses testing – qualitative data (5 minutes)
- D. Water quality testing – quantitative data (15 minutes)

WETLANDS AND WATER QUALITY TESTING (1 hour)

I. Introduction and Classroom Preparation (10 minutes)
Pass out equipment and assign tests to student pairs

II. Conduct Water Testing (30 minutes)

III. Science Seminar (10 minutes)
- A. Sharing results
- B. Graphing and interpreting the data

IV. Closer (10 minutes)
- A. Wrap-up questions
- B. Follow-up

LECTURE AND DEMONSTRATIONS (1 hour)

1. Introduction (10 minutes)

A. Today's Topic

Wetlands & Water Quality highlights Dr. Barbara Taylor, an aquatic ecologist, who studies plants and animals in wetlands. We'll learn about the characteristics of some Southeastern wetlands as well as some of the plants and animals that have adapted to living in them, and then learn how to measure the water quality in those wetlands.

B. Today's Task List

Follow a task list to stay on track.

C. Review SAFE Rules

Today the students will be wearing safety goggles to protect their eyes from any splashing water samples or chemicals.

D. Review the Methods of Science

Who remembers what we did last time we were here? *[Relate each step of the Methods of Science to some part of the previous activity.]* Remember that observation and classification were the steps that were most emphasized during that activity.

II. Power Point Presentation (15 minutes)

III. Demonstrations (35 minutes)

A. Pond Life Observations (10 minutes)

[The PowerPoint presentation introduces the students to Dr. Barbara Taylor's research with zooplankton. Take a few minutes to show the students samples of live zooplankton under the camera mounted TV monitor.]

[Have the students review with you the things all living organisms need to survive: a home, food and water. Remind them that some animal and plant species need such clean environments to live in that they can be used as bio-indicators. If the zooplankton die, maybe there is something wrong in their environment. Maybe their water quality is poor.]

[Have the students closely observe the zooplankton and then share their observations with you. Ask them how the zooplankton's behavior or physical appearance might help the creature survive in its natural habitat. Explain that these behaviors and traits are adaptations for survival.]

B. Life Cycles (5 minutes)

[Now show some tadpoles, salamander larvae, mosquito larvae, etc… on the camera-mounted TV monitor but don't tell the students what they are looking at. Explain to the students that many wetland species require water <u>and</u> land to live out their life cycles. Review the definition of "life cycle" (eggs; larvae with gills; adults with lungs) and ask them to guess what they think they are looking. Ask them what they think the larvae will develop into after metamorphosis. Define amphibian and get the students to name as many kinds as possible.]

C. **Five Senses Testing – Qualitative Data (5 minutes)**
Can you tell the general quality of water without conducting scientific tests or using scientific equipment? Yes. You can use your five senses to get a general idea of the quality of the water. Let's talk about each of our five senses and how we would use them to collect some qualitative data about these samples.

[Hold up the two clear plastic tubes of water you prepared before class: one with de-ionized water in it; the other with soil added to it.]

SIGHT: You can easily see the color of the water. The water might be clear, muddy, very green, etc. Suspended solids, algae, and some contaminants in the water affect color. You've all probably seen some water that is clear, and some that is cloudy. Or water that appears very dark like in blackwater streams around here. These streams get their color from the high concentrations of tannins that come from the leaves that fall into them. You can see also see trash, visible contaminants such as oils or dyes, if they were present.

SMELL: Odor is very easy to detect. A bad odor would affect whether you would want to play in the water, drink the water, or live by the water. Sometimes an odor doesn't necessarily mean it is toxic to organisms. Have you ever been to the ocean and smelled marsh mud? Yuck! Just look around though; there are lots of plants and animals living in a marsh. And sometimes having no odor doesn't mean it's clean either.

TASTE: NO! Don't ever taste water to see if it is "clean." Sometimes there are contaminants and microorganisms that are odorless and colorless, but are harmful. (WHO statistic: Five million people die every year in under-developed countries because their drinking water was contaminated by harmful microorganisms.) You can't tell that they are there by using your 5 senses. That's the time to use analytical tests or quantitative tests. We'll talk about that in a minute.

HEARING: You can hear water that is flowing in a creek or river. What is mixing with the water as it falls over rocks? Oxygen. Sometimes you can hear water crackling when it has caught fire caused by oil spills, and sometimes you can hear really dirty water it bubble and pop when submerged gaseous substances rise to the surface.

TOUCH: You can feel different qualities of water on your skin. Is the water slimy? Can you feel soil particles or oil in the water? Does it feel "soft" making it hard to get the shampoo out of your hair? Does it feel "hard" making it difficult to get soap to lather up in the shower?

D. **Water Quality Testing – Quantitative Data (15 minutes)**
Using these same two water samples, how can we analyze them to collect some <u>quantitative data</u>? Remember, we get quantitative data by measuring something. If I ask you and your lab partner, "How clear is this sample?" you might say, "Not very clear," and your lab partner might say, "Cloudy." You both told me about the quality of the water, but you had very different observations.

Aquatic biologists can run a turbidity test using a fancy analytical instrument by shining a light of a specific intensity through a water sample and then measuring the amount of light that passes through. Turbidity is a quantitative test because the measurements are fairly precise and will be the same no matter who is running the test.

In just a few minutes we are going to have you perform some colorimetric tests on several water samples to determine their acidity and find out how much iron, nitrate and phosphate they contain. But before we let you run your tests we are going to demonstrate two colorimetric tests that you won't be doing but that are very important in water quality: dissolved oxygen (DO) and total hardness.

DISSOLVED OXYGEN: Dissolved oxygen is a measure of the amount of oxygen, in the form of a gas, that is dissolved in water. Why do we care about the levels of dissolved oxygen in the water? Because oxygen is used by aquatic plants and animals to breathe! Sometimes scientists use a DO meter with a probe and just stick it directly in the pond or stream and record the location, time of day, and temperature. *[Show the DO meter]* Other times scientists collect a water sample and run a colorimetric test on it. They add a chemical indicator to the water sample and the indicator binds with all the oxygen gas in the water. The more oxygen gas there is in the water, the darker the water gets. The DO test has to be done very quickly so we did the analysis in the field and brought back the results. Discuss the effects of temperature on DO levels *[the higher the temperature the lower the DO levels; the lower the temperature the higher the DO levels]*. We compared the colored water sample to a standardized color chart to get our data the answer.

TOTAL HARDNESS: Another colorimetric test that the scientists run is called Total Hardness. Total harness shows the amount of dissolved minerals in a water sample. The "harder" the water, the higher the levels of calcium and magnesium in the water. These minerals mostly come from sedimentary rocks that slowly dissolve as rain water runs over land and seeps into the ground. Plants and animals need a certain amount of calcium and magnesium to survive. Too little or too much of either can cause problems in development. Have you ever noticed how sometimes it's hard to work up a soapy lather in the shower when you're washing your hair? That's because the water has lots of minerals in it. On the other hand, if you find that you have to rinse your hair five times to get all the soap out, you might have "soft" water or low levels of minerals in your water. Water that is too hard or too soft can indicate problems that requires further analysis. *[Demonstrate the Total Hardness test on the water samples from the three test habitats. Write the answers on the board as the students will enter the answers onto their data sheets during the lab.)]*

WETLANDS AND WATER QUALITY TESTING EXPERIMENTS (1 hour)

I. Introduction and Classroom Preparation (10 minutes)

Are you ready to be junior scientists? Let's get started!

[Pass out the Student Data Sheets, 1/student. Students will be working in pairs to run the tests: student pairs #1 & #2 get pH and iron tests; and student pairs #3 and #4 get phosphate and nitrate tests. Issue each student a pair of goggles and make sure they fit before beginning the activity.]

[Take a moment to explain each of the tests below and what role the parameters play in water quality. Demonstrate the pH test on the three water samples: measuring the water into the test tubes, adding the TesTabs, being careful to open them correctly, shaking the test tube with

cap securely on, reading time on the clock, comparing the sample to the color chart, recording the data with proper units.]

pH: pH is a measure of the concentration of free hydrogen ions (H^+) in a substance. The more free hydrogen ions available, the lower the pH or the more acidic the substance. The fewer available hydrogen ions, the higher the pH or the more basic the substance. pH is measured on a scale of 0-14 where a lemon would have a pH of 2, rain water a pH of ~5.5, distilled water a pH of 7.0, human blood a pH of 7.5, laundry detergent a pH of 10.00, and bleach a pH of 12.5. There are no units associated with pH, as the numbers of hydrogen ions being measured are so small they are counted in moles per liter where a mole equals 6.022×10^{23} atoms, therefore when the students record pH they should be reminded NOT to record any units after their answers. pH is important because the optimal range for most life is between a pH of 6.5 and 8.2. There are many examples of simple life forms, such as certain bacteria, that survive in much more basic or acidic environments.

IRON: Iron (Fe^{2+}) exists naturally in the environment and originates from rock that is dissolved by rain water. Plants and animals need iron to survive. Too little or too much available iron can cause problems in development. Some troublesome aquatic bacteria thrive on excess iron whereas other species disappear in the presence of too much iron. Excess iron usually makes its way into a watershed when pH levels become to acidic, or through industrial dumping. Iron levels are measured in PPT or PPM using analytical instrumentation or colorimetric tests.

PHOSPHATE: Phosphates (PO_4^{-3}) occur naturally in the environment and can be found in rocks, soils, and organic material. All living organisms require phosphorous, another form of phosphate, to grow and most plants cannot survive without it. Animals need phosphates to aid in digestion. As a result there are two main ways excess phosphates end up in the water shed. (1) Farmers put extra phosphorus, in the form of fertilizers, on corps to make them grow better. The fertilizer that isn't absorbed by the plant is washed into streams and rivers as runoff. This excess is then absorbed by aquatic plants, such as algae, that take over a water system and cause other plant and animals species to disappear. (2) Large animal farming, like cattle farms and chicken farms, produce tons of manure that ends up in local watersheds when not disposed of properly and results in the same type of water pollution as overuse of fertilizers. Phosphate levels are measured in PPT or PPM using analytical instrumentation or colorimetric tests.

NITRATE: Nitrates (NO^3) are formed as a part of a complex nitrogen cycle where nitrogen gas (N^2) is broken down into a molecular form that can be used by living organisms to grow and reproduce. Nitrates occur naturally in the environment and are a basic nutrient source for many living organisms. Phytoplankton, or small aquatic plants, thrive on nitrates and create the base of a food web. When animals digest their food nitrates turn into nitrites (NO^2). When too much nitrate is consumed excess nitrites aren't flushed from the body and they combine with hemoglobin in blood and prevent the hemoglobin from carrying oxygen to the body's cells. This can result in "blue baby" syndrome in humans and in animals where the tips of their ears and noses appear blue due to a lack of oxygen, and can result in "brown blood disease" in fish where the fish's blood turns brown. Fish can be observed gulping air from the surface of the water even though there may be high levels of dissolved oxygen present. Because nitrates are a necessary plant nutrient they are used as fertilizers by crop farmers and can cause problems in high amounts when they get into watersheds. Nitrate levels are measured in PPT or PPM using analytical instrumentation or colorimetric tests.

II. Conducting the Activity (30 minutes)

[After all of the materials have been passed out, walk the students through their testing activity and have them record their results on their student data sheets. When all four students at one table are finished with their tests have them share results with each other to complete the data sheets for tests they did not conduct.]

III. Science Seminar (10 minutes)

A. Sharing the Results

[The instructor will call on each student pair to report their findings. The instructor will write down all the results on a large laminated data sheet at the front of the classroom. It works well to have all students who tested for pH and iron for the same habitat to stand up at their desks, with their test tubes and data sheets, and take turns reading their results out loud and then showing the class the color of their water sample. Continue doing this until all of the results are recorded for all three habitats.]

B. Graphing and Interpreting the Data

[Have the students use the class data to complete the questions on the bottom of their data sheets. Engage students in a short discussion on their findings as they compare and contrast the differences in water quality among the three habitats. Students will have an opportunity to create a bar graph using data from last year's water chemistry tests in the follow-up science activity.]

IV. Close Out (10 minutes)

A. Wrap-Up Questions

[Take a minute to answer questions the students may have come up with during the activity, and to assess their comprehension of the material covered.]