MONITORING WATER QUALITY IN YOUR STREAM

STREAM ACTIVITY

SUMMARY

In this activity, students will begin monitoring the water quality in their study stream by recording physical attributes (temperature and turbidity), chemical attributes (such as pH and dissolved oxygen), and the presence/absence of certain aquatic macroinvertebrates. Macroinvertebrates are small, but not microscopic, organisms such as snails, clams, mussels, crayfish, and insect larvae.

OBJECTIVES

Students will:

- measure and record the temperature of the water in several locations in the stream.
- measure and record the turbidity of the water in several locations in the stream.
- measure and record several chemical attributes of the stream.
- look for and record the presence of macroinvertebrates in the stream.

TIME REQUIRED

- 70 minutes in Classroom
- 100 minutes in Field
- After completing the activity once, monitor once a week (about 45 minutes each time) for five weeks to look for changes.

MATERIALS

- Pencils
- Field notebooks
- Map for marking testing locations (this could be a topo map or the sketch map that each student made in Getting to Know Your Stream in Module 1)
- Copies of the first appendix on pages I-IV in the *Healthy Water Healthy People Testing Kit* to use as a student handout. (optional) It has all of the major water quality tests with an explanation of what they are testing, the pollutants sources, and a couple other columns that sum up nicely what the students might need to know.

For measuring physical characteristics:

- Thermometers or temperature probes
- Secchi disks or tubes (instructions for making these are in the Background section)

For testing for bacteria and identifying macroinvertebrates:

- Copies of macroinvertebrate identification charts (laminated)
- Nets or kick seines
- Large plastic containers (for rinsing rocks)
- Small plastic containers, such as yogurt cups or plastic ice cube trays (for identifying macroinvertebrates)
- Magnifying glasses (optional)
- Bacteria test kits

For measuring chemical characteristics:

- Test kits or probes for one or more of the following:
- Dissolved oxygen
- pH
- Alkalinity
- Conductivity
- Hardness
- Nitrate
- Phosphate

MAKING CONNECTIONS

If we want to know if a person is healthy or sick, we take certain measurements. Temperature, blood pressure, and pulse are quick, simple measurements that can help doctors diagnose problems. More complicated measurements include CAT scans, mammograms, and blood work (chemical and biological analysis of the blood). There are also more quantitative measurements – asking the patient how he or she feels, or simply observing that the patient seems sluggish. Most of these measurements are helpful on a one-time basis, but are even more helpful when repeated and recorded over time. A certain blood pressure reading might be considered high for someone who typically has low blood pressure. The same reading might be considered low for someone who typically has high-normal blood pressure.

BACKGROUND

Is a stream healthy? Sometimes you can tell just by looking – Cleveland's Cuyahoga River was so polluted that it caught fire in 1969. More often the question requires some scientific investigation. There are a number of different measurable characteristics that can help. These characteristics fall under the categories of physical, biological, and chemical.

Physical characteristics include temperature and turbidity (how much suspended sediment is in the water).

Chemical characteristics include dissolved oxygen, pH, alkalinity, conductivity, hardness, and the amount of nitrates and phosphates present.

Biological characteristics include microscopic bacteria as well as macroinvertebrates.

In this activity, students will measure water quality using a selection of these characteristics. We recommend you collect data on temperature, turbidity and macroinvertebrates. Amongst the other characteristics, choose those that are most relevant to your stream. For example, if your stream runs through farmlands, you'll probably want to test for bacteria, nitrates and phosphates. Also, let your equipment availability and budget be your guide.

It's important for students to understand that regular, long-term monitoring is essential to really know whether a stream is healthy or not. Regular monitoring allows discovery of significant changes. A sudden increase in turbidity could signal a construction project upstream that is not using proper sediment traps. A sudden disappearance of pollution-sensitive insect larvae would indicate an increase in pollution, and would indicate the need for some sleuthing to find the source. After completing this activity once, have your class repeat the monitoring once a week for five weeks to look for any changes.

Below are brief descriptions of a range of attributes you might choose to measure and monitor. See the *Healthy Water, Healthy People Field Monitoring Guide* for more information to help you decide which attributes are most important for your stream.

TEMPERATURE

Many water animals require a specific range of temperatures to survive and reproduce. A change in temperature caused by clear-cutting shade trees around a stream could kill off some of the animals in the stream. Changes in temperature can also affect the amount of dissolved oxygen and the rate at which many chemical reactions take place. Make sure to measure temperature in several places (in the shade, in the sun, in shallow water, in deep water), and to note on the map exactly where you measured so you can measure in those same places next time.

TURBIDITY

Turbidity refers to the amount of suspended sediment in water. Turbid waters are cloudy with silt or sand. Plowed fields and construction areas are sources of extra sediment in a stream. Turbidity can adversely affect water plants (by blocking sunlight) and animals (by silting up valuable habitat spaces and clogging gills). Turbidity also increases the temperature of water in the sun by providing more surfaces and mass for solar gain (an increase in temperature, in turn, can cause a decrease in dissolved oxygen). Turbidity is measured with a Secchi disk or Secchi tube. To make a Secchi disk, punch or drill a hole in the center of a metal lid (at least 6-8 inches in diameter). Paint a large black cross, whose lines intersect at the hole, forming equal quadrants. Paint two quadrants black and two quadrants white. Put an eyebolt through the hole and secure it with a nut on the other side (the unpainted side). Tie a piece of thick string or thin rope to the eyebolt. The string should be long enough to lower the disk to the bed of the stream. With a permanent black marker, mark off the string in feet and inches (beginning at the disk and working up). To measure turbidity, note the depth at which the black-and-white pattern becomes invisible when you slowly lower the disk into the water. If your stream is too shallow for this, you can use a Secchi tube. To make one, get a clear plastic tube (used to store fluorescent tubes) at a hardware store. From the plumbing section, get a white PVC cap that fits the tube. Use a black permanent market to divide the cap into equal quadrants, and fill in two of the quadrants with black. Mark off inches on the plastic tube, starting at the bottom where the cap is. Fill the tube with water until you can no longer see the pattern when you look down the tube. Record the number of inches of water in the tube.

BACTERIA

There are many different types of bacteria, some "good," some "bad." Water treatment plants regularly test for a group of bacteria called coliform bacteria. Not all coliform bacteria are dangerous, but their presence often signals the presence of dangerous bacteria. A subgroup of coliform bacteria are fecal coliforms, which come from the intestines of mammals. If the catchment basin for your stream includes farms with livestock, you'll want to test for fecal coliforms. Also, sewage lines often run parallel to or across urban streams. If present, you may want to text for fecal coliforms.

MACROINVERTEBRATES

Macroinvertebrates are invertebrates that are small but visible to the naked eye, such as snails and insect larvae. One way to rate the water quality of a stream is to identify what kinds of macroinvertebrates are present. Macroinvertebrates such as leeches and mosquito larvae are very tolerant of pollution, while mayfly and stonefly nymphs require unpolluted water. The chart included in this activity illustrates how to rate your stream using macroinvertebrates.

DISSOLVED OXYGEN

Water-living plants and animals depend on gaseous oxygen that is dissolved in the water. Cold water can hold more dissolved oxygen (DO) than warm water. Turbulent water brings in more oxygen than still water. Photosynthesizing plants also bring DO into water. You can measure DO using several different kinds of test kits, or a CBL probe. Follow testing instructions carefully when using the test kits to ensure meaningful results.

pH

pH indicates, on a scale of 1-14, how acidic or basic water is. Neutral water has a pH of 7; acidic water has a pH of less than 7; and basic water has a pH of more than 7. Acid precipitation can lower the pH of natural waters to the point where they can no longer support aquatic life. pH can be measured with test strips or probes.

ALKALINITY

Alkalinity is the ability of water to resist a decrease in pH when acid is added. Alkaline waters typically occur in areas where the bedrock is limestone. Over time, rain water dissolves carbonates out of limestone and other rocks, and deposits it in streams and lakes. Carbonates neutralize acid. When acid is added to alkaline waters (acid precipitation, for example), the water resists a change in pH until the carbonates are all used up. Then, the water is no longer alkaline and if more acid is added, the pH of the water will fall suddenly and rapidly.

NITRATES

All living things require nitrogen. Plants consume nitrogen in the form of nitrate, which is a key ingredient in fertilizer. But when fertilizer washes into streams, it can cause an increase in algae growth, which can then block light from reaching other aquatic plants. When these plants die and decompose, oxygen is depleted. This in turn negatively impacts aquatic animals that depend on oxygen. Nitrate in drinking water is bad for humans, too. It can cause a condition called methemoglobinemia (also called “blue-baby” syndrome) in babies, pregnant women, and elderly people. Nitrate is often a problem in streams in agricultural areas.

CONDUCTIVITY

Conductivity is a measure of how well water conducts electricity, which depends on how many dissolved ions are present. Some of these ions (such as nitrates and phosphates) are problematic in high concentrations. Other ions aren’t. Conductivity doesn’t tell you which ions are concentrated, but can give you a good indication of whether you need to investigate further. Conductivity is related to Total Dissolved Solids (TDS) by the equation TDS = conductivity x 0.67. Conductivity is usually measured with a meter or a probe.

PHOSPHATES

Phosphorous, like nitrogen, is essential to life. However, when too many phosphates end up in water they can cause harmful algal blooms, just as nitrates do. Phosphates are no longer used in laundry detergents in the United States and Canada for this reason. Phosphates still enter our streams through fertilizers and animal wastes.

HARDNESS

Hard water does not make as many soap suds as soft water. Hardness is primarily a function of magnesium and calcium ions in the water. The more magnesium and calcium, the harder the water. Because these ions can be dissolved out of limestone, hard water is common in areas where the bedrock is limestone, and soft water is more likely in areas of hard bedrock, such as granite.

PROCEDURE

A short video with tips on how to implement this activity is available at www.itsourwater.info.

WARM**UP**

Before the students begin taking data, review all the techniques students will be using. Allow plenty of time for this. Make sure everyone understands the proper procedures for using the thermometers, turbidity meters, and chemical tests. Review identification of some of the most common macroinvertebrates. If you are covering this information in the classroom (as opposed to stream-side), try to have some stream water on hand with macroinvertebrates in it. Also review the section, “Safety Rules for Field Work at the Stream,” in the Overview and any other safety precautions that you may have come up with when you scouted out the study stream.

Discuss efficient and clear ways of taking and recording data. A number without a unit is useless. All measurements should be labeled with the name of the test, the date, the time, and the exact location where the measurement was taken. Locations of various tests should also be marked on a map. Students will be repeating these tests over several weeks, so it pays to set up an organized way of recording data from the beginning.

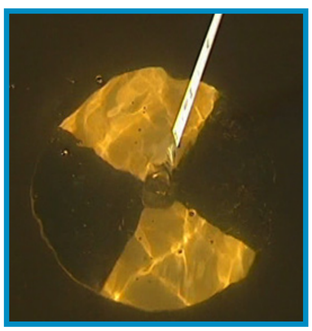
Spend some time (before taking data) discussing whether students think the water quality of their stream is healthy or not. What evidence are they basing their decisions on?

THE ACTIVITY

PART I: MEASURING TEMPERATURE

Follow the directions on the thermometer or probe you are using. Measure in the shade (if available). Record not only the temperature, but the date, the time of day, the weather, and the exact location you measured: where and how deep.

PART II: MEASURING TURBIDITY



If the stream is deep enough, turbidity can be measured using a Secchi disk. It is a metal circle with a black-and-white pattern on it. You lower the disk into the water until you can no longer see the pattern. That distance is a measure of the turbidity.

For shallow waters, use a Secchi tube, which is a clear plastic tube with a black-and-white pattern on the bottom. Collect stream water in the tube, being careful not disturb the stream bottom, and record the height of water at which you can no longer see the pattern on the bottom of the tube.

Record exactly where you measured turbidity, as well as the date, the time, and the weather (including whether there has been any rain recently).

PART III: MACROINVERTEBRATE SAMPLING AND BACTERIA TESTING

Finding and identifying macroinvertebrates is fairly straightforward once you have a little experience. At the water's edge, fill a large container and several ice cube trays with stream water.

Have students try several methods for finding macroinvertebrates.

- Pick up rocks and examine their undersides. Rinse them off into the container. Do you see little critters wriggling around?
- If you have a large net, have one or two people hold it perpendicular to the flow of the stream (in a shallow area) while someone else wades in the water, scuffling among the rocks, about a yard upstream. You will probably find some macroinvertebrates in the net.
- Small aquarium nets can be used for exploring in holes, under roots and trees, and in leaf litter.

Take any living creatures that you find and place them in the ice cube trays for easier identification. Use a macroinvertebrate chart for help in identification. Based on the kinds of macroinvertebrates you find, use the enclosed chart to rank the health of your stream.

For bacteria testing, follow the directions for the test kit. For each measurement, record where the measurement was taken (use your map), the date, the time, and the weather.

PART IV: CHEMICAL MEASUREMENTS

For all chemical measurements, follow the directions for the equipment or test kit.

For each measurement, record where the measurement was taken (use your map), the date, the time, and the weather.

WRAP UP **AND** ACTION

In a class discussion, ask the students whether they think the water quality in their stream is good or not. What is their evidence? Have their answers changed since you asked this question in Warm Up? Ask students if they were surprised by anything they observed or measured. Was there anything about the stream that had changed since the last time the class did field work?

What additional information could they gain by repeating the tests they did today regularly over a long time?

Students will need to turn in all monitoring data with their final report, so remind them to make sure it is recorded neatly and accurately.

ASSESSMENT

Have students:
- Explain in writing or out loud how to perform any of the monitoring techniques they learned in this activity.
- Compare and evaluate the measurements they recorded for their stream to data you provide from another stream (either a real stream or a hypothetical one).

EXTENSIONS

Sign up to participate in GLOBE, a worldwide data-sharing program. GLOBE requires very specific testing protocols, so check out the website for more details (www.globe.gov).

Water quality monitoring is most valuable when done steadily over a long period of time. Save the data your students collect each year and have students compare their data to the data of previous years.

Have students monitor other streams or natural bodies of water and compare the results to their study stream. Or have students compare their results to those of other nearby streams as reported by government agencies.

RESOURCES

GLOBE (www.globe.gov)

Healthy Water, Healthy People Testing Kit Manual. 2002. Bozeman, Montana: The Watercourse at Montana State University.

Izaak Walton League of America. 2006. *A Guide to Aquatic Insects and Crustaceans*. Stackpole Books.

Voshell, J. R., Jr. 2002. *A Guide to Common Freshwater Invertebrates of North America*. The University of Nebraska Press.

Murdock, T., M. Cheo, and K. O'Laughlin. 2001. *The Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods*. Everett, Washington: Adopt-A- Stream Foundation.

US EPA – Office of Water. *Volunteer Stream Monitoring: A Methods Manual*. www.epa.gov/volunteer/stream/

Winborne, Ferne B. 2003. *A Guide to Streamwalking*. Raleigh, NC: Division of Water Resources, North Carolina Department of Environment and Natural Resources. http://www.ncwater.org/Reports_and_Publications/Stream_Watch/

2012 North Carolina Essential Standards

for 8TH GRADE SCIENCE GOALS & OBJECTIVES

The stream activities in each module are intricately tied. Although this activity may not be correlated to your standards, it is needed for the complete picture of the stream and to achieve the objectives listed below.

8.E.1: Understand the hydrosphere and the impact of humans on the local systems and the effects of the hydrosphere on humans.

8.E.1.3: Predict the safety and potability of water supplies in North Carolina based on physical and biological factors, including:

MONITORING WATER QUALITY IN YOUR STREAM

Student Page #1

BIOTIC INDEX

FOR DETERMINING THE DEGREE OF POLLUTION IN STREAMS

POLLUTION TOLERANT

Pouch Snail and Pond Snails: Class Gastropoda. No eperculum. Breath air. When opening is lacing you, shell opens on left.

Leech: Order Hirudinea. 1/4"-2", brown, slimy body, ends with suction pads.

Midge Fly Larva: Suborder Nematocera. Up to 1/4", dark head, worm-like segmented body. 2 tiny legs on each side.

Aquatic Worm: Class Oligochaeta. 1/4"-2", can be very tiny, thin work-like body.

Rat-tailed Maggot

Clam: Class Bivalvia

Mosquitoes

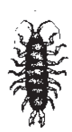
1 POINT FOR EACH DIFFERENT SPECIES FOUND

SEMI-POLLUTION TOLERANT

Crane Fly: Suborder Nematocera. 1/3"-2", milky, green or light brown, plump caterpillar-like segmented body. 4 finger-like lobes at back end.

Dragon Fly: Suborder Anisoptera. 1/2"-2", large eyes, 6 hooked legs. Wide oval to round abdomen.

Damselfly: Suborder Zygoptera. 1/2"-1", large eyes, 6 then hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body. (See arrow.)



Sowbug: Order Isoboda. 1/4"-3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

Crayfish: Order Decapoda. Up to 6". 2 large claws. 8 legs, resembles small lobster.

Flatworms

2 POINTS FOR EACH DIFFERENT SPECIES FOUND

POLLUTION INTOLERANT

Riffle Beetle: Order Coleoptera. 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

Stonefly: Order Plecoptera. 1/2"-1 1/2", 6 legs with hooked lips, antennae, 2 hair-like tails. Smooth (no gills) on lower hall of body.

Water Penny: Order Coleoptera. 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs and fluffy gills on the other side. Immature beetle.

Gilled Snail: Class Gastropoda. Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

Mayfly: Order Ephemeroptera. 1/4"-1", brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

Fishfly Larva: Family Corydalidae. Up to 1 1/2" long. Looks like small hellgrammite, but often a lighter, reddish-tan color, or with yellowish streaks. No gill tuffs underneath.

Caddisfly: Order Trichoptera. Up to 1". 6 hooked legs on upper third of body, 2 hooks at back end. Maybe in a stick, rock or leaf case with its head stick out. May have fluffy gill tufts on underside.

3 POINTS FOR EACH DIFFERENT SPECIES FOUND

TOTAL POINTS

VERY CLEAN .... (23-30)
CLEAN .... (17-22)
NOT SO CLEAN .... (11-16)
POLLUTED .... (5-10)

Student Page #2 Instructions

THE ACTIVITY

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