Aquatic Macroinvertebrate Sampling

Adapted from: "Stream Doctors" in Hands on Save Our Streams. Firehock, Karen. The Izaak Walton League of America, 1994. AND original Creek Connections instructions for biological sampling.

Grade Level: all

Duration: 1½ - 2 hours

Setting: field site, flowing water

Summary: Students sample aquatic macroinvertebrates to determine water quality using kick nets.

Objectives: Students will discover organisms that live in streams, their habitats, learn some identification skills, and learn how aquatic macroinvertebrates can determine stream health.

Related Module Resources:
- Various Macroinvertebrate Activities, Fact Sheets [binder]
- Pollution Tolerance Index [binder]
- Books/Field Sheets
- Videos: on aquatic life and sampling technique
- Reference Collections
- Microscope Slides (bugs)
- D-frame nets

Vocabulary: macroinvertebrate, riffle, run, pool, substrate, sensitive, facultative, tolerant, substrate, biodiversity, Pollution Tolerance Index, point, nonpoint source, discharges

Materials (Included in Module):
- kick nets
- white plastic sheets
- forceps, spoons, & eyedroppers
- magnifying glasses / boxes
- white sorting trays
- bug cups
- macroinvertebrate guides, field sheets [box and folder]
- Brock microscopes
- Data sheets

Additional Materials (NOT Included in Module):
- boots, waders, creek sneakers
- clipboards

ACADEMIC STANDARDS (ENVIRONMENT AND ECOLOGY)

7th Grade

4.3.7.A Identify environmental health issues.
- Identify various examples of long-term pollution and explain their effects on environmental health

4.3.7.B Describe how human actions affect the health of the environment.
- Identify land use practices and their relation to environmental health

4.7.7.A Describe diversity of plants and animals in ecosystems.
- Select an ecosystem and describe different plants and animals that live there

10th Grade

4.1.10.C Describe the physical characteristics of a stream and determine the types of organisms found in aquatic environments.
- Describe and explain the physical factors that affect a stream and the organisms living there
- Identify terrestrial and aquatic organisms that live in a watershed
- Identify the types of organisms that would live in a stream based on the stream's physical characteristics

4.3.10.C Explain biological diversity as an indicator of a healthy environment.
- Explain species diversity

12th Grade

4.1.10.C Analyze the parameters of a watershed.
- Interpret physical, chemical and biological data as a means of assessing the environmental quality of a watershed
- Apply appropriate techniques in the analysis of a watershed (e.g., water quality, biological diversity, erosion, sedimentation)

4.3.10.C Analyze the need for a healthy environment.
- Explain how human systems affect the environment

4.7.10.A Analyze biological diversity as it relates to the stability of an ecosystem.
- Examine and explain what happens to an ecosystem as biological diversity changes

ACADEMIC STANDARDS (SCIENCE AND TECHNOLOGY)

7TH Grade

3.3.7.A. Describe the similarities and differences that characterize diverse living things.
- Explain how to use a dichotomous key to identify plants and animals.

BACKGROUND:

There is a lot more living in a stream, river, or pond then most people realize. Everyone thinks about fish, frogs, crayfish, or lily pads, but there are between 5,000 and 6,500 species of aquatic insects that often go unnoticed. It is estimated that 7% of the 91,000+ North American insects are aquatic or semi-aquatic. In every part and type of waterway, these organisms can be found. Aquatic insects are a varied group but they all have one thing in common – at one stage during their life cycle, they rely on water.

Macroinvertebrates are organisms without internal skeletons that can be seen with the unaided eye (often considered larger than 0.5mm). Reference to the term "aquatic macroinvertebrates" can include arthropods (insects in all life cycle stages, nymph, larva, pupa, or adult or crustaceans or arachnids), mollusks, and worms. Examples of aquatic macroinvertebrates include mayfly nymphs, stonefly nymphs, dragonfly larvae, midge larvae, crayfish, leeches, aquatic worms, and water beetles. Some of these creatures are called **benthic** (bottom-dwelling) macroinvertebrates, which means they live in, move along, or attach themselves to the waterway bottom or **substrate**. Not all aquatic macroinvertebrates remain on the bottom though – some swim through the water or live on the surface.

Macroinvertebrate sampling is one technique used to determine the health of a stream. Chemical and bacterial testing, physical and habitat assessments also exist to provide more information on the health of a stream. Although chemical tests are frequently used, they have limits that can be overcome with biological sampling. For instance, chemical monitoring may miss a pollutant in the stream because the kit used may not include tests for that particular substance. Also, chemical testing is only a snapshot determination of stream health and pollution for that moment. Results may suggest a stream is clean even if it is polluted the other 364 days in the year. Meanwhile, macroinvertebrates are subjected to day to day and longer term changes in pollution, oxygen levels, and acidity levels. So what macroinvertebrates you find in the stream reflects how healthy that still is overall or most of the time.

Aquatic macroinvertebrate sampling is usually done in riffle areas. Streams alternate between riffle and run areas. **Riffles** are areas where 2- to 10- inch stones are found, water is shallower, and moves faster as it bubbles over the rocks. The **run** area is the long stretch between riffles where water is usually deeper. Even deeper sections or **pools** may be present within the run area.

Aquatic insects are found in greatest abundance in riffle areas because riffles provide **substrate** (bottom habitat) for the organisms to hold onto, a place to attach their homes, shelter from predators such as bass and trout, and an oxygen-rich area. There are insects that can be found in all other areas of a stream also though.

As water bubbles over rocks, it interacts with air, capturing oxygen. The oxygen-rich environment of the riffle provides favorable living conditions for macroinvertebrates. The larger the rocks, the greater the number of macroinvertebrates that can be found. For example, more surface area means more spots for macroinvertebrates to dwell, and more bubbling and better oxygenation of the water will occur.

Macroinvertebrates, such as burrowing dragonflies and damselflies, also can be found in deeper muddy areas in the run section of streams and on streamside vegetation. However, these areas generally do not have as rich a diversity of organisms as the riffle area.

There are three major pollution tolerance categories of macroinvertebrates - **sensitive**, **facultative** and **tolerant**. The presence of sensitive organisms generally indicates good water quality because these macroinvertebrates cannot survive under polluted conditions. Facultative creatures are normally a sign of moderate water quality. These macroinvertebrates can exist under a wider range of water quality conditions than sensitive organisms can. Macroinvertebrates that can live in polluted waters are called tolerant. In large numbers, they point to poor water quality conditions.

In good-quality streams, *each* macroinvertebrate group should be represented, though there will probably be more sensitive organisms than tolerant or facultative organisms. Finding a worm or midge larva (both tolerant organisms) does not mean the stream is polluted, as long as there is a variety of other types of insects (sensitive and facultative) in the sample. The worms and midge larvae are just helping to make a biodiverse stream. However, a net full of worms and midges with no sensitive organisms will give a stream survey a poor rating because biodiversity is lacking. A **Pollution Tolerance Index** is a method that is used to rate stream quality based on macroinvertebrates. Samples are taken and examined for the presence and abundance of the different types of organisms. These values are put into an equation, which gives an overall number value to the stream. Certain numbers indicate poor quality, while others indicate moderate or good quality water.

Because different macroinvertebrates have different levels of tolerance to pollution, the amount of stress a stream is under can be measured by the organisms that live in that stream. Environmental degradation decreases the number of different types of organisms in a community by eliminating sensitive creatures while increasing the number of tolerant ones. This decreases the **biodiversity** (number of different forms of life) of the stream.

Environmental stress can come in a variety of forms. Often, pollution is classified into two categories: **point source** and **nonpoint source** pollution. Point source pollution is a single, identifiable source that **discharges** (empties) pollutants into the environment. Examples would include a leaking waste storage container and a drainage pipe from a sewage treatment plant, industry, or off a city street. Nonpoint source pollution's source is more difficult to pinpoint because this pollution type can enter a stream with runoff from a widespread land area. Examples include farm fields, large construction sites, mining operations, lawns, and parking lots.

There are many different types of water pollution in Pennsylvania. Acid mine drainage is the state's biggest threat causing pH levels to drop too low to support aquatic life and releasing toxic metals. Poor agricultural practices is the second biggest source of pollution in the state and can cause nutrient enrichment, soil erosion and sedimentation, pesticides and herbicides, and water withdrawel. Acid rain is a nonpoint source of pollution that can also decrease the pH of the water to a range that some organisms cannot tolerate. Sewage inputs from malfunctioning or outdated municipal treatment plants or from private home systems is another threat. Urban and suburban areas can produce pollution from paved surface runoff, road salt, industrial discharges,

overfertilized or chemically treated lawns, sewage disposal, and the lack of streamside vegetation.

OVERVIEW: Using kick nets, students sample aquatic macroinvertebrates to discover the diversity of aquatic insects that exist in a waterway, learn how to identify aquatic insects, and to determine the water quality of a stream based on organisms captured.

PROCEDURE:

Teacher Preparation:

Before visiting the site with your students, check it out to be sure that it is safe and wadeable. The site should have a rocky or gravelly bottom and have flowing water. The area selected should be a riffle that can be safely and easily accessed. If on private property, permission must be obtained prior to the field trip. All those going on the field trip should be dressed appropriately – with old clothes that can get wet. Make sure everyone is wearing either boots, waders, or old shoes – no one should go barefoot into a waterway.**

Student Activity:

1. Before going out to the field, discuss the background information and the procedure with the students. Also be sure to go over rules for safety and respect (of both other students and the natural environment).

2. Also before reaching the field site, divide the class into groups of three or more students.

3. Once at the site, discuss information specific to the site and review other background information as necessary. Hypothesize with the students about what organisms will be found in the stream, based on its unique features and pollution level. You can use the Aquatic Insect Research Planning Sheet at the end of the activity if you want students to make predictions on what kind of bugs they may find, where they might find them or the best biodiversity, or to compare two different microhabitats.

4. A demonstration should be given to ensure that students know what they are expected to do while kick netting. After the demonstration, students can decide what role they would like to perform for their team.
   NOTE TO TEACHER: If using the Pollution Tolerance Index, only 3 square meters of sampled macroinvertebrates should be counted. These samples can be from three separate 1 square meter sections.

5. Allow students to select an appropriate area to sample for each team based on the information in the background section.

6. Have the students fill in the section of the Data Sheet that pertains to the stream's physical characteristics and weather conditions. They should do this BEFORE taking the sample.

7. Have the students fill the sorting trays with water and place them on a flat area near the stream. Instruct them to lay the white sheet out and put the other equipment (sorting trays, sorting equipment) near it so organisms can be immediately collected once the kick net is removed from the water.

8. Each team should select a different area in the riffle to sample. Teams should not disturb others' sample areas prior to sampling. Additionally, when approaching their sampling area, teams should not walk through it. Tell the students to come from downstream so organisms are not disturbed prior to sampling.

9. Have two members of the team hold the net taut at the downstream edge of the sample area. They should angle it slightly away from the sample area and hold it firmly against the bottom.

10. Tell them that a few large rocks *taken directly upstream of the net* should be anchored at the base of the kick net to weigh it down. This will prevent organisms from escaping under the net.

11. Have the teams determine a one square (1x1) meter sampling area directly upstream from the net (This is about the size of the net portion of the kick nets included in the modules). One or two students should clean off rocks from the square meter area, allowing anything removed from the rocks to flow into the net. They can do this by wiping the rocks gently with their hands. They should place the clean rocks out of the square meter.

12. Once the area is cleared of large rocks, one or two members of the team (these can be the same people that cleaned off the rocks) should "dance" in the square meter area. This is done to kick up organisms that have burrowed in the bottom sediments, so they should shuffle their feet with this in mind. Tell them to continue this for three minutes.

13. The students should remove the large rocks from the bottom of the kick net *after* they have been cleaned off.

14. To pick up the net, the "dancer(s)" should lift the bottom of the net up quickly to a horizontal position. Water should not be allowed to flow over the net and care should be taken not to lose any organisms while lifting the net.

15. The net should be carried to shore without losing any insects and placed over the sheet. Students can then pick organisms off the net with forceps and/or spoons and place them into the sorting trays.

16. Students should identify as many organisms as possible. They can be placed in the bug cups (filled with water, of course) to separate different organisms. There are also large white trays that can be used. Brock Field Scopes, other types of field

microscopes, magnifying glasses, or magnifying boxes could be used so students can get a better look at some of the creatures.

17. When all organisms have been identified, the students should tally them on their Data Sheet.

18. Have the teams clean off the net in the water so any organisms still clinging to it can return to the water. They should empty the sorting trays and bug cups into the stream, as well. Tell the students that organisms should be returned to their original home areas to the extent possible.

19. The students can complete a Pollution Tolerance Index at this time. Information and PTI forms are found in the PTI section of the module resource folder.

DISCUSSION:

Discuss with the students about the water quality rating of the stream. Was it the rating that they expected? Why or why not?

What is biodiversity? *Differences in life.* Did the stream have good or poor biodiversity of aquatic insects?

What was the Pollution Tolerance Index Score and what level of health does it indicate?

What does it mean for an insect to be pollution sensitive and pollution tolerant? *See background section.*

If you found a pollution-tolerant organism (like a blackfly), what would it mean if it was the only type of organism you found? If it was found along with pollution sensitive and facultative creatures? *See background section.*

Were students surprised at anything they found? Did the expect to find more or less aquatic life?

What problems might be causing stream pollution at your site or in general? *See background section or other resources on water pollution.* Do you think that the water quality of the stream today is the same as it was before people lived in the area? What effects might people have on streams and how would this affect the organisms living in the stream? *See background section or other resources on water pollution.*

Hypothesize about what the stream will be like in 10 years. *Although this is an opinion question, students should consider water quality, increasing populations of people and animals, tree removal, etc.* Brainstorm ways people can fix pollution problems now so that the stream will be clean for future generations.

Why do you think it is a good idea to use aquatic insects to determine stream health? What are some other ways to determine stream health? Why do aquatic insects reveal a more complete story about the stream's overall health? *See background information.*

How can the source of a water quality problem be pinpointed by monitoring? *(Monitoring upstream and downstream of possible pollution sources will help to determine what the cause of the problem is. Then you would have to do other types of testing – chemical, bacterial, physical assessments, habitat and land use assessment).*

EVALUATION:

- Discussion questions above.
- Be able to identify and name organisms that are tolerant, facultative, and sensitive.
- Explain why macroinvertebrate sampling is an important way to determine stream health.
- Explain the method used to sample macroinvertebrates in rocky bottomed streams and why that method is used (i.e. why is sampling done in a riffle, etc.)
- Correctly filled out data sheet and Pollution Tolerance Index.

EXTENSIONS AND MODIFICATIONS:

- Do the "Pollution Tolerance Index" activity as an introduction to this activity.
- Perform chemical tests on the water you are sampling. This should be done at the same time or within a few hours of the macroinvertebrate sampling if possible.
- Collect or identify other types of aquatic life (fish, algae, plants) and try to identify them. Return specimens to the stream.
- Compare your findings over time or space (but do not sample in the same location until two months have passed). That is, sample again at a different time of year or in a different stream or section of the stream. Be sure to keep your methods the same every time you sample, so that your data can be compared.

NOTES (TEACHERS, PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

Activity Version: May 2003

DATA SHEET: AQUATIC MACROINVERTEBRATE SAMPLING

Student Name _____ Date _____

Stream/Creek/River Name: _____

Site Location:_____

_____

Observations: *Creek Appearance (odors, color, frozen, etc.) _____

_____

*Weather in Past 24 hours _____

*Water Depth / Speed _____

_____

	NUMBER OF INSECTS			
Insect Name	From D Net #1	From D Net #2	From D Net #3	TOTAL #

Planning Sheet: **Aquatic Insect Research Planning**

Group Names: _____

Area of Study:

Hypothesis:

Plan of Study: