Establishing a Student-Science Stream Monitoring Program

Using stream macroinvertebrates and their pollution sensitivities to assess and monitor stream or river health.

OVERVIEW

Students will be actively involved in sampling aquatic macroinvertebrates from a local stream or river, and then identifying the organisms using pictorial keys. Based on the relative pollution sensitivities of each macroinvertebrate group, overall stream health will be determined using a spreadsheet template or a simpler qualitative data sheet. Mercury levels in sampled dragonflies is an additional activity that can connect student data to a growing national data set.

TIME REQUIRED

One 2-4 hour period

MATERIALS

- Stream Invertebrate Sampling Options
  - Surber sampler -OR-
  - Kick nets
- Thermometer
- Tape measure (or measuring sticks)
- Tennis ball
- Stop watch or other timer
- Plastic bins or trays
- Plastic ice cube sorting trays
- Forceps
- Sharpie or pencils
- Printed/laminated copies of one of the following:
  - West Virginia Department of Environmental Protection's "WV Save Our Streams Field Guide to Aquatic Invertebrates" *[High level of detail]*
  - Izaak Walton League of American's "Save Our Streams Aquatic Macroinvertebrate Identification & Pollution Sensitivities" *[Simpler identification method]*
- Materials for Optional Dragonfly Mercury Sampling:
  [sampling kits can be requested through Dartmouth University]
  - Clean plastic spoons
  - Powder-free nitrile gloves
  - 20 Small- & 20 Medium-sized Ziplock bags
  - Cooler with ice/cold packs
  - Plastic ruler
  - Sample ID labels
  - Field Cards to ID Dragonfly Nymphs to Family
  - Dragonfly & Site Evaluation Field Sheets (link)

PREPARATION

- Identify a nearby stream or river suitable for students to wade into and collect samples from

AUTHOR

Richard Hathaway

GRADE LEVEL

High School (9th-12th)

ANCHORING PHENOMENON

You like to fish for brook trout and have noticed your local "hot spot" has fewer flying insects above its rolling waters. You've also noticed a decline in the trout you are catching. What could be the cause of the insect decline, and does it indicate anything about the stream's health?

DRIVING QUESTIONS

How can stream macroinvertebrate populations be used to monitor the overall health of a stream or river?

IMPORTANT VOCABULARY

- Benthic macroinvertebrates
- Surber sampler
- Pollution sensitivity
- Mercury bioaccumulation

STANDARDS

- HS-LS2-1 - Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
- HS-LS2-2 - Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- HS-LS2-6 - Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing

LEARNING GOALS & OBJECTIVES

- Students will be able to:
  - define “benthic macroinvertebrate” and explain their role in a stream ecosystem.
  - identify key macroinvertebrate orders and recognize their general characteristics.
  - explain how the levels of different macroinvertebrates can be used to assess and monitor stream health.
  - define “mercury bioaccumulation” and describe how mercury levels in dragonfly larvae can be a valuable addition to evaluating stream health.

INTRODUCTION

Freshwater streams and rivers are important elements of any community. These aquatic ecosystems are habitats for a wide assortment of different vertebrate and invertebrate species, and these organisms provide important connections to aquatic and terrestrial food webs in the local environment. Streams and rivers also serve important roles in the lives of community members, including aesthetic values, recreational opportunities, fishing locations, and water sources. The importance of these aquatic locales warrants their continued health monitoring and conservation. With the vast number of streams and rivers across the local landscape, their regular monitoring and health assessment is a monumental task for researchers and environmental protection officials. Recent citizen science movements have helped fill in some of this lack of manpower in the monitoring and protection of ecosystems. An untapped source of citizen science exists in the classroom. Student-science driven projects can not only help monitor and establish conservation efforts, but also serve as opportunities for service projects, club activities, and problem-based learning beyond the classroom. A challenge that can exist for some citizen- and student-science projects is a lack of equipment, skills, and funds. Monitoring aquatic ecosystems often involves specialized chemistry probes, equipment, and professional training that your everyday citizen does not have access to. Simplified procedures using readily available supplies can allow anybody and everybody to contribute their time, talents, and efforts to tracking the health of their local environment.

Freshwater streams and rivers contain an assortment of benthic macroinvertebrates that can be used as indicators of the overall stream’s health. These invertebrates are restricted conditions may result in a new ecosystem.

SUPPLEMENTAL RESOURCES

1. West Virginia Department of Environmental Protection’s “WV Save Our Streams Field Guide to Aquatic Invertebrates”.
2. Izaak Walton League of American’s “Save Our Streams Aquatic Macroinvertebrate Identification & Pollution Sensitivities”.
3. USGS’s “Sampling Guide for the Collection of Dragonfly Larvae Samples... for Mercury Analysis”.
4. Dartmouth’s “Dragonfly Lab Video”.
5. “Dragonfly Mercury Project: A Citizen and Community Science Effort” Video.
6. “Field Cards for Identifying Dragonfly Nymphs to Family”.
7. “Dragonfly & Site Evaluation Field Sheets”.
8. Sea Grant Lake Champlain’s “Stream Monitoring and Stewardship Program Handbook”.

to those waters and their survival depends on the physical, biological, and chemical properties in that aquatic system. Research has shown that the various groups of aquatic macroinvertebrates have different tolerances for pollution and other negative water qualities. Mayflies (order *Ephemeroptera*), stoneflies (order *Plecoptera*, and caddisflies (order *Trichoptera*) are three groups that are highly sensitive to local pollutants and water quality changes. Their presence in stream waters generally indicates a healthy, relatively stable system. Other groups such as leeches (class *Hirudinea*), aquatic worms (class *Oligochaeta*), and true fly larvae (order *Diptera*) are quite tolerant of pollutants and impacted water. The types of macroinvertebrate groups present along with their diversity and densities are indicative of the stream's overall health. Stream invertebrates are quite easy to sample using surber samplers or kick nets, and identifying them down to order or family can be done using pictorial keys. This means that stream monitoring by citizen-science groups is an opportunity to empower volunteers to help monitor and contribute to the protection of our local streams and rivers... and there is no better place to start than in the classroom with student-science!

LESSON PROCEDURE

General Preparation and Organization

Any smaller stream or river can be utilized for this monitoring program, preferably one that is within walking distance of the school to avoid issues with travel. Students will be wading into the stream for the sampling, so maximum stream depth is limited to the footwear students have access to. Students can utilize rubber boots, waders, or plastic bags taped over pants along with old shoes. It is best to preassign students into groups of between 2-4 students, with each group responsible for all parameters/samples described below.

General Stream Parameters

Upon arrival at the stream, all groups should record basic information such as stream name, date, group name, student names, and weather. A basic thermometer can be used by each group to record air temperature and water temperature. GPS coordinates could also be a useful piece of

information to identify the exact sampling location. Each student group should then be assigned a sampling location spread out along the stream length. At each site, students should use a tape measure or meter stick to measure the stream's width and depth at the sampling site. To estimate the stream velocity, students should measure a 300cm length of stream near their sampling site. One group member will set a tennis ball in the stream at the upstream point of this length and another student will time how long it takes the tennis ball to travel the 300cm distance. Groups should repeat this 3 times to come up with an average stream velocity in cm/sec.

Benthic Invertebrate Sampling Option 1: Surber Sampler & Quantitative Spreadsheet Analysis

This is option #1 for sampling the stream invertebrates and requires access to a surber sampler. Ensure the sampling bottle is attached to the surber sampler. Students will bring the surber sampler into their sampling site and approach it from downstream so as not to disturb the site or anything upstream. The frame of the surber sampler will be placed onto the stream bed so that the net opening faces upstream and the water movement opens the net downstream. Students will pick up every rock within the frame and use their hands to brush off all surfaces of the rock so that the water current carries any organisms into the net. Each completed rock is to be placed out of the frame and the students will continue until all rocks within the frame have been brushed off. Then students will use their hands to disrupt the bottom of the stream underneath where the rocks were to cause any remaining organism to be disturbed and carried downstream into the netting. When complete, the surber sampler is picked up and the netting dunked multiple times back into the water to ensure all invertebrates are washed into the sampling bottle. Make sure no water enters through the opening of the netting to prevent any new organisms from entering and being carried into the sample. The surber sampler can then be brought onto the stream bank. Students will remove the sampling bottle and wash all organisms into plastic bins or trays for identification and counts. Students will then use tweezers to remove all stream invertebrates and place them into separate areas in a plastic ice cube tray. This helps ensure they do not attack each other. If there are a lot of invertebrates, similar groups can be placed into the same area of the ice cube tray. When complete, students will use either the West Virginia Department of Environmental Protection's "WV Save Our Streams Field Guide to Aquatic Invertebrates" or the simpler Izaak Walton League of American's "Save Our Streams Aquatic Macroinvertebrate Identification & Pollution Sensitivities" to identify and count the number of each stream invertebrate group sampled. Students will eventually be recording their counts into this "Stream Invertebrate Monitoring Data Sheet" spreadsheet, so having a paper copy on-hand to record the data while in the field will help ensure the correct groups are distinguished and counted. If opting to also assess mercury levels in sampled dragonfly larvae, see the section below before doing anything else with the invertebrates. Upon completion, stream invertebrates can be returned to the stream and all data recorded into the "Stream Invertebrate Monitoring Data Sheet", which will generate two graphs automatically to look at the densities of each invertebrate group as well as the proportion of pollution sensitive, moderately sensitive, and pollution tolerant invertebrates present. This last graph can be used to assess the overall health of the stream.

Benthic Invertebrate Sampling Option 2: Kick Net Sampling & Simpler Qualitative Data Sheet

If a surber sampler is not available, a student group can be given a kick net to sample the stream invertebrates. Students will approach their sampling site from downstream and place their kick net in the stream so that the frame rests on the bottom and the water current opens the netting. Students can then use their feet and/or hands to disturb the rocks, sediments, and debris just upstream from the kick net. This sampling method is less quantitative in nature and so students can disturb a significant area upstream of the kick net to ensure enough invertebrates are gathered. When done, students will bring the net onto the stream bank and use cups or bottles of stream water to rinse the captured organisms into plastic bins or trays for identification and counts. For this sampling option, students will be using the simpler "Biological Assessment" page from the Sea Grant Lake Champlain's "Stream Monitoring and Stewardship Program Handbook". For this, students only need to record whether each invertebrate group is present or not by checking the corresponding boxes. Students can still use the ice cube tray method described above and either the West Virginia Department of Environmental Protection's "WV Save Our Streams Field Guide to Aquatic Invertebrates" or the simpler Izaak Walton League of American's "Save Our Streams Aquatic Macroinvertebrate Identification & Pollution Sensitivities" to identify each stream invertebrate group sampled, but with no need to perform exact counts. Again if opting to also assess mercury levels in sampled dragonfly larvae, see the section below before doing anything else with the invertebrates. At the end, stream invertebrates can be returned to the stream and all data recorded onto a "Biological Assessment" page. Students can follow the directions on that page to calculate the stream's "Pollution Tolerance Index Rating", which can be used to assess the overall health of the stream.

Isolating Dragonfly Larvae for Mercury Level Assessment

(a step-by-step list of instructions for this section can be found on pages 4-7 of this document)

If opting to assess the dragonfly larvae mercury levels, be sure this part is completed while the stream invertebrates are still in the sorting trays or ice cube trays. Upon identifying a dragonfly larvae in the sorting tray that is 10mm or greater in length, a clean plastic spoon should be used to transfer the single dragonfly into a small Ziplock bag and then sealed to avoid outside material (soil, debris, etc.) from getting in. Only the clean spoon should touch the dragonfly larvae and the person opening the Ziplock bag should have on clean, powder-free nitrile gloves to avoid adding mercury to the samples. The gloved hand should not touch any other surfaces to prevent mercury contamination of the sample. The dragonfly larvae should be measured for total length and identified down to Family level using these "Field Cards for Identifying Dragonfly Nymphs to Family". The small Ziplock bag with the larvae should then be put into a medium-sized Ziplock bag along with a fully completed "Sample ID label" and the entire thing immediately placed on ice. This procedure should be repeated at that sampling site until at least 20 dragonfly larvae have been collected, bagged, identified, labeled, and placed on ice. Additional net samples might be required to obtain this minimum number. When enough have been sampled, a "Site Evaluation Field Sheet" should be completed and the samples kept in a freezer until they can be passed along for mercury analysis.

The Results in a Yearly Sampling Program

By sampling stream invertebrates in a stream over many years at the same sampling sites, data can be collected to look for trends in the invertebrate groups present. Both sampling options given above provide a final assessment of the stream's health based on the pollution sensitivity levels of the organisms present. Any changes from year-to-year could indicate significant changes in the stream's overall health due to new external factors affecting the stream. Additionally, data for mercury levels in the dragonfly larvae will be added to the USGS database which can be accessed, visualized, and tracked over time at the "Dragonfly Mercury Project Data Visualization Tool".

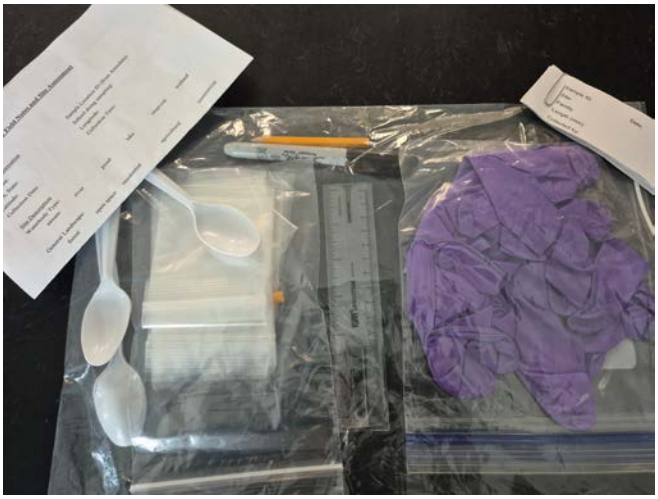
CONCLUSION

This lesson is a great way to turn students into citizen scientists that will contribute data to a yearly program to monitor the health of a local aquatic ecosystem. In a single 2-4 hour field excursion, students will gather data for physical, chemical, and biological parameters that can be used to give a broad overview of the stream's health. Through yearly repetition of the procedure, students will be able to assess whether changes in the stream health could be linked to any apparent stressors or changes in the local environment.

SUPPORTING IMAGES/VIDEOS

		
Supplies needed for Surber sampling	Surber sampler placed in a high-flow riffle area	Surber sampler placement in stream flow

		
Sorting tray with sample and ice cube tray for separation	Sample in sorting tray for isolating invertebrates	Picture of invertebrates sorted into ice cube tray slots



Mercury sampling supplies kit