Benthic Bugs and Bioassessment

This lesson plan is adapted from the Healthy Waters, Healthy People: Water Quality Educators Guide.

Summary:

Students investigate the relative water quality of a stream by conducting a simulated bioassessment by sampling aquatic macroinvertebrates (represented by ordinary materials).

Grade Level: 4th grade

Subject Areas: Biology, Environmental Science, Mathematics, Language Arts

Duration: Two 50-minute periods

Setting: Classroom

Vocabulary: bioassessment, macroinvertebrate, biodiversity, benthic

Objectives:

Students will:

- investigate the role that aquatic macroinvertebrates play in determining water quality.
- Simulate the process of rapid bioassessment of aquatic macroinvertebrates.
- Collect, sort, classify, identify, analyze, and evaluate a sample of materials representing aquatic macroinvertebrates.
- Determine a stream's water quality using a pollution tolerance index based on a sample of aquatic macroinvertebrates.
- Compare the differences between the relative water quality of different samples.

Materials

- Copies of Macroinvertebrate Identification Chart (1 per group)
- Copies of Macroinvertebrate Data Sheet I and II (1 each per group)
- Materials for Bioassessment (provided in kit)
    - 3 large plastic tubs
    - 3 small plastic tubs
    - 3 aquarium nets
    - 3 ice cube trays
    - 3 calculators
    - 100 small paper clips
    - 50 large paper clips
    - 50 beads of the following colors (green, blue, yellow, red, black, white)
    - 50 fake or real pennies
    - 50 thin rubber bands
    - 50 thick rubber bands
    - Optional: Water and food coloring (not provided in kit)

Background

The best way to determine the health of a body of water is to see what lives in it! This is called biological assessment, or bioassessment. When using biological surveys and other direct measurements of living systems within a watershed, you can compare the biological health of a waterbody to an established benchmark of biological health. Aquatic macroinvertebrates (animals without backbones that live in aquatic environments and are large enough to be seen without the aid of a microscope or other magnification) are commonly monitored and are the basis of this activity.

Macroinvertebrates are valuable indicators of the health of aquatic environments in part because they are benthic, meaning they are typically found on the bottom of a stream or lake and do not move over large distances. Therefore, they cannot easily or quickly migrate away from pollution or environmental stress. Because different species of macroinvertebrates react

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differently to environmental stressors like pollution, sediment loading, and habitat changes, quantifying the diversity and density of different macroinvertebrates at a given site can create a picture of the environmental conditions of that body of water.

If exposed to an environmental stressor (e.g. pollution, warming due to low flows, low dissolved oxygen due to algal blooms, etc.), those macroinvertebrates that are intolerant to that stress may perish. Tolerant macroinvertebrates often inhabit the spaces left by the intolerant organisms, creating an entirely different population of organisms. For example, an unimpacted body of water will typically contain a majority of macroinvertebrates that are intolerant of environmental stressors, such as mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). A body of water that had undergone environmental stress may contain a majority of macroinvertebrates that are tolerant of these conditions such as leeches (Hirudinea), tubifex worms (tubifex sp.), and pouch snails (Gastropoda).

Bioassessments of macroinvertebrates are particularly helpful to biologists and others trying to determine the health of a river or stream. Bioassessment of macroinvertebrates is a procedure that uses inexpensive equipment, is scientifically valid if done correctly, and can be conducted by students. Bioassessments can provide benchmarks to which other waters may be compared and can also be used to define rehabilitation goals and to monitor trends. Trend monitoring is a common application of bioassessment by student groups and others involved in water quality monitoring.

Collecting, identifying, and quantifying macroinvertebrates are the initial steps in bioassessment. The next step involves using formulas to calculate the relative water quality based on the diversity and quantity of the sampled organisms. These formulas, called metrics, relate the numerical diversity and density of organisms to a water quality rating. The most common metrics are the EPT/Midge Ratio and the Pollution Tolerance Index. For our activity, we will be using the Pollution Tolerance Index (PTI).

The Pollution Tolerance Index assigns a numerical value to each macroinvertebrate order, with the high numbers assigned to pollution intolerant organisms, and decreasing numbers assigned to increasingly pollution tolerant organisms. The scores are totaled and compared with a water quality assessment scale to yield a relative water quality rating for the sample.

To gather the best quality and most usable data, the Environmental Protection Agency (EPA) recommends that biological sampling of macroinvertebrates be conducted during the same time each year. Additionally, sampling is conducted when sites are easily accessible and the number of organisms is high. This usually occurs in the spring after the ice has broken and late-stage larvae are present, or in the late fall when organisms are more mature. The Friends of the Shiawassee River conducts their bi-annual STREAM TEAM monitoring of the Shiawassee River during the first weeks in May and October.

While bioassessments are extremely important in and of themselves, they are most useful when combined with chemical and habitat assessments. Gathering additional data is helpful to identify a potential environmental stressor, as well as give guidance to implement appropriate mitigation of that stressor.

Procedure

1. Show students the Macroinvertebrate video provided in flash or Google drive. Give additional background information as needed.
2. Ask students to define the term “aquatic macroinvertebrate” (invertebrate that live in streams, rivers, lakes, or ponds that are large enough to be seen without the aid of a microscope or other magnification).
3. Have students give examples of macroinvertebrates (e.g. leeches, mayflies, snails, dragonflies, etc.), and their role in the food web of a stream.
4. Show students examples of macroinvertebrates and their tolerance groups, both found in flash or Google drive provided.
5. Briefly explain to the students that aquatic macroinvertebrates are used as indicators of the relative health of a stream, and that the common form of sampling them is called bioassessment, which they will conduct in this activity.

The Activity

1. Inform students that they will be simulating a bioassessment of a stream using ordinary objects to represent macroinvertebrates.
2. Set up three sets of collecting stations (see image), each containing the following: stream sampling site, collection bucket, sorting trays, the Macroinvertebrate Identification Chart, and Macroinvertebrate Data Sheets I and II.
3. Optional: For the stream sampling sites: fill three large plastic bins with four inches of water and label them Stream 1, 2, and 3. (Also optional: add coloring to the water until objects on the bottom are not clearly seen).
4. Place objects representing macroinvertebrates in the three tubs according to the following chart:

Macroinvertebrate	Represented By	Number of Items per Sample			Total
		Stream Sample 1	Stream Sample 2	Stream Sample 3	
Mayflies	Yellow beads	35	15	0	50 beads
Stoneflies	Small paper clips	65	35	0	100 clips
Dobsonflies	Large paper clips	30	20	0	50 clips
Caddisflies	Red beads	30	20	0	50 beads
Craneflies	White beads	25	13	12	50 beads
Dragonflies	Green beads	20	20	10	50 beads
Scuds	Black beads	5	15	30	50 beads
Midges	Blue beads	0	20	30	50 beads
Leeches	Thick rubber bands	0	15	35	50 bands
Pouch Snails	Fake pennies	0	15	35	50 pennies
Tubifex Worms	Thin rubber bands	0	15	35	50 bands
	Total items in each stream	210	203	187	

5. Divide students into three groups. Assign students within each group to one of the following four tasks: stream sampling, sorting at the collection bucket, counting/recording on Macroinvertebrate Data Sheet I, and calculating/evaluating on Macroinvertebrate Data Sheet II.
6. Instruct students to simulate a rapid bioassessment at their stream sampling site as follows:
    a. Using an aquarium net, the students at the site have twenty seconds to collect as many macroinvertebrates (paper clips, beads, etc.) from the stream as possible. They should place the macroinvertebrates in the collection bucket.
    b. Students at the collection bucket then sorts the collected macroinvertebrates into like categories based on the Macroinvertebrate Identification Sheet and place them in the ice cube tray or cups. For example, they should place all of the mayflies into one cube, caddisflies into another, etc.

c. The students using the Macroinvertebrate Data Sheet I will record the number of each organism.

d. The students using the Macroinvertebrate Data Sheet II takes the data from Macroinvertebrate Data Sheet I to complete the Pollution Tolerance Index to determine their Water Quality Assessment score for their stream sample.

7. Have students compare their results with the other groups. What were the similarities and differences between the three sites? Which stream had the highest level of water quality? The lowest?

Wrap Up (optional)

Have students write a paragraph that describes their stream based on the macroinvertebrate sample they collected. If they sampled an impaired stream they should describe the habitat, address possible pollution sources, and give other pertinent details. Allow them to be creative.

Ask students what they think of this type of scientific sampling process. Do students feel that they could use the same process to perform a bioassessment in an actual stream? Did their samples accurately reflect the population of invertebrates in their stream? How do they know? Ask students to brainstorm how the process could be modified to increase its accuracy (e.g., conduct the sampling three times for each stream and compare or average the results)?

Have them identify positive and negative aspects of this type of sampling. For example, do they believe that they netted larger insects more easily than smaller insects? Can such a biased sampling occur in an actual rapid bioassessment of invertebrates?

Assessment

Have students:

- investigate the role that aquatic macroinvertebrates play in determining water quality. (Warm Up)
- Simulate the process of rapid bioassessment of aquatic macroinvertebrates. (Steps 5 and 6)
- Collect, sort, classify, identify, analyze, and evaluate a sample of materials representing aquatic macroinvertebrates. (Step 6)
- Determine a stream's water quality using a pollution tolerance index based on a sample of aquatic macroinvertebrates. (Step 6)
- Compare the differences between the relative water quality of different samples. (Step 7)

Extensions

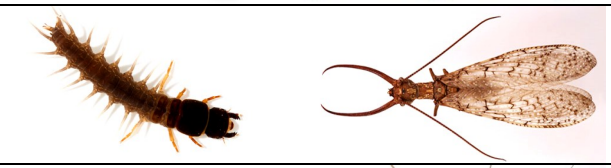
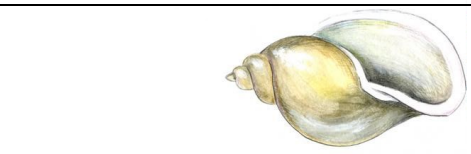
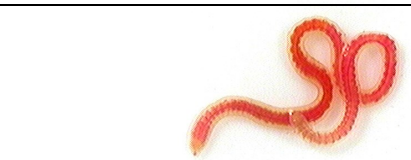
Connect with the Friends of the Shiawassee River or DeVries Nature Conservancy to conduct an actual bioassessment of a local stream, river, or lake.

Research the pollution tolerance, habitat, and regional distribution of the individual species. The North American Benthological Society maintains a website with links to various state and regional aquatic macroinvertebrates at www.benthos.org.

This lesson plan was adapted from the Healthy Waters, Healthy People: Water Quality for Educators Guide and developed by the Friends of the Shiawassee River and DeVries Nature Conservancy. This project is partially funded by grand funds made possible by the Michigan Department of Education.

MiSTEM Network
Mid-Michigan Region

Macroinvertebrate Identification Chart

Macroinvertebrate	Looks like (juvenile and adult)	Represented by
Mayflies (Order Ephemeroptera)		Yellow Beads
Stoneflies (Order Plecoptera)		Small Paper Clips
Caddisflies (Order Trichoptera)		Red Beads
Dobsonflies (Order Megaloptera)		Large Paper Clips
Midges (Order Chironomidae)		Blue Beads
Craneflies (Order Diptera)		White Beads
Dragonflies (Order Odonata)		Green Beads
Scuds (Order Amphipoda)		Black Beads
Pouch Snails (Class Gastropoda)		Pennies
Tubifex Worms (Class Oligochaeta)		Thin Rubber Bands
Leeches (Class Hirudinea)		Thick Rubber Bands