How Sensitive Are They?

Adapted from: An original Creek Connections activity.
Creek Connections, Box 10, Allegheny College, Meadville, Pennsylvania 16335.

Grade Level: intermediate

Duration: 45 minutes

Setting: Laboratory classroom

Summary: Students will interpret several reference collections of aquatic macroinvertebrates to determine pollution sensitivity by using pollution tolerance index classification.

Objectives: Students will develop an understanding of why it is important to have a Pollution Tolerance Index, which uses aquatic macroinvertebrates to determine the health of a waterway.

Vocabulary: Macroinvertebrates, benthic, indicator organism, biodiversity, pollution tolerance index, tolerance level, sensitive, facultative, tolerant

Related Module Resources:

Materials (Included in Module):

- Reference collections
- Field guides / identification sheets / books [box and binder]
- Pollution Tolerance Index data sheets [binder]

Additional Materials (NOT Included in Module):

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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.C Explain biological diversity.
- Explain how diversity affects ecological integrity of the natural resources.

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

4.7.7.B Explain how species of living organisms adapt to their environment
- Explain how living things respond to changes in their environment
- Explain how one species may survive an environmental change while another might not.

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

4.1.12.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)

4.6.12.A Analyze the interdependence of an ecosystem
- Analyze the positive and negative impacts of outside influences on an ecosystem

4.6.12.C Analyze how human action and natural changes affect the balance within an ecosystem.
- Analyze effects of human action on an ecosystem.

4.7.12.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
- Explain the relationship between species' loss and biodiversity.

BACKGROUND:

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 that 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.

Indicator organisms are creatures that are sensitive to changes in water quality and will react to changes in their environment in predictable ways. Aquatic macroinvertebrates are one group of such organisms. Because different aquatic 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.

The **Pollution Tolerance Index** (PTI) is a means of measuring stream quality based on indicator organisms and their tolerance levels. **Tolerance levels** refer to the amount of pollution the organisms can handle before dying or moving to another habitat. By sampling a measured area of a waterway, usually a total of 3 square meters, and determining which aquatic macroinvertebrates are present and which are not, the pollution levels of a stream can be determined.

The indicator organisms are grouped into three categories based on their tolerance of pollution conditions. These categories are:

Sensitive (Group I)- The presence of sensitive organisms generally indicates GOOD WATER QUALITY because these aquatic macroinvertebrates cannot survive under polluted conditions.

Facultative (Group II)- These organisms can exist under a wider range of water quality conditions than sensitive organisms can. Therefore, they are found in MODERATE WATER QUALITY *and* good-quality water.

Tolerant (Group III)- The heartiest organisms, they are tolerant of pollution. In large numbers, they point to POOR WATER QUALITY conditions, but can also be present in good and fair water qualities.

Each of these indicator groups is assigned an index value, with the least tolerant group having the highest index value. The index score for a stream is based on the number of indicator organisms present per group.

In good-quality streams, each aquatic 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 the majority of the sample is from the sensitive range. However, a net full of worms and midges with no sensitive organisms will earn a poor stream survey rating.

A Pollution Tolerance Index is a common way for stream ecologists to assess the health of a waterway through biological methods. Chemical, bacterial, and land use monitoring exist as well 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 of the year. Aquatic macroinvertebrates are subjected to day-to-day and longer term changes in pollution, oxygen levels, and acidity levels. Most scientists believe that the PTI better reflects the overall condition of a stream.

OVERVIEW: Students will move from one lab station of select aquatic macroinvertebrates (in reference collection) to another, answering questions concerning characteristics of each organism on a worksheet. Upon completion, the students will be able to categorize which group each collection of organisms falls under. This will encourage the students to determine water quality using a biological assessment and pollution tolerance index classification.

PROCEDURE: Teacher Preparation

1. On different lab tables, place six stations of preserved aquatic macroinvertebrates from the reference collection using the chart below. You could use the labeled specimens or the unlabeled specimens (make them practice identification).

STATION 1	STATION 2	STATION 3
Riffle beetle adult	Crane fly larva	Leech
Mayfly nymph	Fishfly larva	Blackfly larva
Case-building caddisfly larva	Damselfly nymph	Aquatic worm
STATION 4	**STATION 5**	**STATION 6**
Dragonfly larva	Stonefly nymph	Dobsonfly larva
Alderfly larva	Midge fly larva	Water penny beetle larva
Net-spinning caddisfly	Mayfly nymph	Aquatic sowbug
	Crayfish	Scud

Station 1- GOOD QUALITY
Station 2- MODERATE QUALITY
Station 3- POOR QUALITY
Station 4- MODERATE QUALITY
Station 5- GOOD QUALITY
Station 6- GOOD QUALITY

2. Instead of using preserved aquatic macroinvertebrates, you could place live aquatic creatures into six different containers, trying to create stations with different results much like those above. Using live creatures will make students have to use their identification skills.

PROCEDURE: Student Procedures

1. Split students into six groups and provide them a "Macroinvertebrates Grouped by Level of Pollution Tolerance" sheet and the enclosed worksheet.

2. Have rotate through the stations and examine the specimens using magnifying glasses and/or microscopes and answer the questions on the worksheet. You should tell student to remain at the station until told to rotate. You will need to decide an appropriate amount of time to spend at each station.

3. *Or*, you could have each group remain at that station and share their results with the rest of the class.

DISCUSSION:
Scientists use various types of biological assessments to determine the health of a waterway – using aquatic insects, fish, algae, and plants. There are many versions of pollution tolerance indexes used by various organizations and government agencies, but this version for aquatic insects is actually encouraged to be used by all volunteer water monitoring groups in Pennsylvania.

Discuss the water quality ratings or pollution tolerance groups for each of the stations? Why was station 5 and 6 still considered to be good even though they had some group 3 bad creatures in them? *In good-quality streams, each aquatic macroinvertebrate group should be represented, though there will probably be more sensitive organisms than tolerant or facultative organism.*

Why do scientists like to use aquatic macroinvertebrates to determine stream health? *See background section.*

How do you think stream scientists decided on how to group aquatic insects into pollution tolerance categories? *Through lots of stream work, collecting lots of data comparing chemical and physical parameters and aquatic life found in the stream. Seeing if there were correlations between poor water quality and the types of bugs still able to survive in them. Experiments in labs could also help reveal this – these are called bioassays, where live creatures are subjected to varying degrees of polluted water to determine their tolerance level or survival level. Observation of these insects behaviors, morphology, and habitat needs were also done.*

Bring to the attention of the students that some organisms (such as the water strider, dragonfly larva, backswimmer) not counted in the Pollution Tolerance Index. *Not all aquatic insects are counted in the PTI because not all insects are affected directly by water pollution. Only the insects that live underwater and rely on it for food and breathing are counted. Bugs that live on the water surface are not counted because they obtain their oxygen from the air. No matter how polluted the stream was or depleted of oxygen, they could still breathe and live on the water. Some insects that live underwater, such as dragonflies, are not counted because they can rise to the surface and obtain air from the atmosphere, then dive back underwater. Some dragonflies even can live out of the creek or in a dry creek bed under rocks as long as there is slight moisture. If you notice on the PTI form, many beetles that live under water are also NOT counted because they too take oxygen from the surface then go return underwater- a polluted stream (void of oxygen) does not have much effect on them either.*

What problems might be causing stream pollution that negatively affects aquatic life? *Acid rain can decrease the pH of the water to a range at which some organisms cannot function. Erosion loads sediment into a stream, creating murky water and destroying aquatic macroinvertebrate habitat. Likewise, urban areas produce runoff that can contain toxic chemicals and sediment. Agricultural areas may add fertilizer runoff into the stream, causing increased algal and bacterial growth. There are many other examples, as well.*

EVALUATION:

- Be able to identify and name organisms that are tolerant, facultative, and sensitive.
- Explain why aquatic macroinvertebrate sampling is important for determining stream health.
- Correctly completed worksheet.

EXTENSIONS AND MODIFICATIONS:

- Use the Pollution Tolerance Index to determine the stream health value of an actual stream with the class (See "Aquatic Macroinvertebrate Sampling" activity).
- Have groups create new stations to use on other groups in the class.

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

Activity Version: May 2003

Work Sheet: How Sensitive Are You?

Names: _____ Date : _____

_____

_____

_____

Lab Station #1:

Identify the aquatic macroinvertebrates.

_____

_____

If you found many of each of these insects from this station in a stream, what type of health would you predict the stream to have?

_____

Lab Station #2:

Identify the aquatic macroinvertebrates.

_____

_____

If you found many of each of these insects from this station in a stream, what type of health would you predict the stream to have?

_____

Lab Station #3:

Identify the aquatic macroinvertebrates.

_____

_____

If you found many of each of these insects from this station in a stream, what type of health would you predict the stream to have?

_____

Lab Station #4:

Identify the aquatic macroinvertebrates. _____

_____

If you found many of each of these insects from this station in a stream, what type of health would you predict the stream to have?

_____

Lab Station #5:

Identify the aquatic macroinvertebrates. _____

_____

If you found many of each of these insects from this station in a stream, what type of health would you predict the stream to have?

_____

Lab Station #6:

Identify the aquatic macroinvertebrates. _____

_____

If you found many of each of these insects from this station in a stream, what type of health would you predict the stream to have?

_____

Other questions:

1. Which category would a water strider fit into? Why? _____

   _____

2. In which type of water quality would you find only leeches? Why? _____

   _____

3. Name two kinds of pollution that could affect a stream's biodiversity. _____

   _____

   _____

INFORMATION: AQUATIC MACROINVERTEBRATES GROUPS BY LEVEL OF POLLUTION TOLERANCE