

COLLECT AND ASSESS MACROINVERTEBRATES

OBJECTIVES

- Identify stream macroinvertebrates by their major classification groups
- Identify structural and behavioral adaptations of aquatic invertebrates that allow them to obtain their necessary environmental requirements
- Understand the concept of environmental indicators
- Assess the water quality of the stream by monitoring its invertebrate community

TOPICS

- Macroinvertebrates
- Stream ecology
- Water quality
- Environmental indicators

TEKS ALIGNMENT

Grade 5 Science:

1A, 1B, 2B, 2C, 2D, 2E,
2F, 2G, 3A, 4A, 4B, 9A,
9B, 9C, 9D, 10A, 10C

Grade 7 Science:

1A, 1B, 2A, 2C, 2D, 2E,
3A, 4A, 4B, 5C, 8C,
10A, 10B, 11A, 12A

Grade 8 Science:

1A, 1B, 2A, 2C, 2D, 2E,
3A, 4A, 4B, 11B, 11C

BACKGROUND MATERIAL

One of the best ways to determine if a stream is healthy is by looking at a group of organisms collectively known as “benthic macroinvertebrates.” “Benthic” refers to the fact that these organisms live on the bottom streams, while “macroinvertebrate” means that the animals within this group are without backbones (invertebrates) and are large enough (macro-) to be seen without a microscope.

Benthic macroinvertebrates have adaptations that suit their environment. Many have flattened or streamlined bodies that allow them to live in flowing water; others attach themselves to rocks with hooks or claws on the end of their legs or abdomen, by spinning silk threads or by constructing cases of sand grains which are attached to rocks. Some organisms have gills to obtain oxygen from the water whereas others have breathing tubes to obtain oxygen from the atmosphere. Some organisms have mouthparts that are adapted for scraping algae from rocks or chewing leaves; some have fan-like or comb-like structures on their heads or legs to collect or filter small bits of organic matter from the sediments or water. Some benthic macroinvertebrates are predators, and consume other individuals in this group.

Benthic macroinvertebrates are an important part of stream ecosystems. Not only are they connected to the foods that they eat as described above, but they in turn are an important source of food for many fish, birds, raccoons and other animals. Furthermore, many insects that you see flying around in the air are macroinvertebrates that actually spend part of their lives in water as benthic macroinvertebrates. This is because the adult insects lay their eggs in the water. The eggs hatch out and the immature insect (nymph or larva) lives in the water until it becomes an adult. The adults emerge from the water then fly away and lay eggs in the same stream or in a different stream.

The benthic macroinvertebrates that live in rivers and streams are affected by the flow of water, the type of habitat, food sources, interactions with other organisms (such as exotic species) and water quality (water pollution). Since significant changes in the habitats of macroinvertebrates are frequently caused by human activities, observing and analyzing the types of organisms that live in streams and rivers is a good way to find out if human activities are altering these ecosystems.

Aquatic organisms react variably to changes in physical and chemical characteristics. Some groups of aquatic organisms are intolerant of changes. Their presence in high numbers indicates a healthy stream that has not undergone significant change due to human activity. Some groups of organisms are more tolerant of environmental change and can be found in water that is slightly or moderately polluted. Other organisms are tolerant of disturbance and can be found in polluted water. The presence of organisms that are tolerant of pollution, along with a lack of intolerant organisms, indicates an unhealthy stream. A biological survey of macroinvertebrates indicates whether or not a stream has a healthy community, but it cannot, by itself, tell us what the problems are. However, once an assessment indicates that the stream may be unhealthy, other tests to find the source of the problem may be conducted.

KEY TERMS

Benthic macroinvertebrates are animals without backbones that live on the stream bottom and are

large enough to be seen with the naked eye

Nymph is the immature stage of an insect that

Larva is the immature stage of an insect that undergoes incomplete metamorphosis

PROCEDURES

- A. Prior to beginning any sampling activity, ask the students to think about what types of animals they might expect to find in a river or stream. Most students likely will not include the macroinvertebrates (except maybe crayfish) on their lists. Ask them to list what aquatic organisms need from their environment and what structures they would use to obtain their needs. Ask them how the organisms would react if their environment could no longer provide their needs.
- B. Before going out to the stream, make sure that the students understand all safety precautions:
1. Do not go out or wander off alone; always stay with a group.
 2. Do not wade into the water unless you can see the bottom and know that the current and depth are safe (remember that rocks in streams are often covered with algae and are slippery).
 3. Steep banks indicate deeper water and are often slippery
 4. Carry a first aid kit, insect repellent and drinking water.
 5. Watch for poison ivy, briars, fire ants, mosquitoes, wasps, etc.
 6. Wear rubber gloves when you are collecting water samples (because you do not know if the water is polluted or not).
 7. Do not go into the water barefooted or wearing water shoes or old tennis shoes. These will be slippery.
 8. Do not engage in horseplay, rock throwing, etc.
 9. Respect the stream – leave it in the condition that you found it. Do not leave garbage or equipment behind.
- C. Using the kick net and the dip net, have the students sample several parts of the stream reach to capture a variety of macroinvertebrate types. For example, you can have some students sample the edges of the stream where there is vegetation by using dip nets at the water surface. You might have other students take samples of the riffle structures in the middle of the stream using kick nets, where the students disturb the sediment and loosen any macroinvertebrates into the net. Then, the students will use the water bottles to rinse the macroinvertebrates out of the nets and into the white sorting trays, where they can be picked out and placed into collection jars.
- D. Back in the classroom, the students should randomly sample 100 individuals and identify them to their taxonomic order. As the students are looking at the organisms under the microscope or with a hand lens, ask them to write down observations about what characteristics that group of organisms have in common which might enable them to adapt to a stream environment. For more information, on groups of organisms, they can look at the charts on Student Sheets 2-4.

MATERIALS

- Kick nets
- Dip nets
- Spray bottles
- Collection jars
- White sorting trays
- Dissecting microscopes or hand lenses
- Forceps
- Probes

- E. Have each student fill out the table found on Student Sheet 1 with the invertebrate type and the number collected. Then have the student use the charts in Student Sheet 2-4 to calculate the water quality level indicated by their samples and fill in their table.
- F. Have the students calculate an indicator score for the 100 samples. The indicator score is calculated in the following way:
1. Multiply the number of each type of organism collected by a factor of 3 for good water quality indicators, 2 for fair water quality indicators, and 1 for poor water quality indicators
 2. A total score of 225-300 indicates good water quality
 3. A total score of 150-225 indicates fair water quality
 4. A total score of less than 150 indicates poor water quality
- G. Now that the students understand how benthic macroinvertebrates are indicators of water quality, ask the students to examine the table on Student Sheet 5 describing what ranges for each water quality parameters is considered to be good, fair or poor

GUIDING QUESTIONS

- What types of adaptations do benthic macroinvertebrates have in order to obtain oxygen from the water?
- What types of adaptations do benthic macroinvertebrates have in order to allow them to live in flowing water without being washed away?
- How might high or low temperature levels affect stream organisms? What might cause high or low temperature levels
- How might high or low dissolved oxygen affect stream organisms? What might cause oxygen levels to be high or low?
- If the pH gets high (basic) or low (acidic), how might stream organisms be affected? How might humans affect the pH of the water?
- If high levels of nitrates or phosphates are measured, how might stream organisms be affected? How might low levels affect the organisms? How might humans affect the levels of nitrates and phosphates in the water?
- How might high or low turbidity levels affect stream organisms? What might cause high or low turbidity levels?

EVALUATION

Have each student pick one group of organisms that they identified, and have them write a short report about that group. Ask the students to include the following information: how many were collected, the mechanism they use to collect oxygen, how they obtain food, how they maintain their position in the water current, and what kind of indicator they are of water quality.

STUDENT SHEET 2

Pollution Intolerant Organisms

Different aquatic organisms react differently to changes in physical and chemical characteristics. Some groups of aquatic organisms are intolerant of changes (in other words, cannot tolerate). Their presence in high numbers indicates a healthy stream that has not undergone significant changes. How many types of good water quality indicators did you find in the stream?



This Mayfly has its gills behind the last pair of legs on the abdominal segment and on its sides.



The Stonefly has two distinct sets of wing pads which will later form its wings in its adult stage.



This Snailcase Maker Caddisfly constructs a spiral shaped house around itself and pokes its head out when needed.



This Longhorned Case Maker Caddisfly leaves its head and legs poking out of its house that is attached to a small twig.



This Common Netspinner Caddisfly spins a net it makes with silk outside its house, which is glued to solid objects.



These prolegs contain a pair of hooks each to help the Hellgrammite hold onto surfaces in fast-moving waters.

Table 3: Macroinvertebrates Found in the San Antonio River Basin, Their Pollution Tolerance Classification, and as Water Quality Indicators.

Invertebrate type	Pollution tolerance	Water quality Indicator
Mayfly nymphs	Pollution Intolerant	Good
Stonefly nymphs	Pollution Intolerant	Good
Caddisfly larvae	Pollution Intolerant	Good
Hellgrammite larvae	Pollution Intolerant	Good
Gilled snails (right-handed snails)	Pollution Intolerant	Good
Riffle beetles (adults and larvae)	Pollution Intolerant	Good
Water penny larvae	Pollution Intolerant	Good

STUDENT SHEET 3

Intermediate Organisms

Some groups of aquatic organisms are more tolerant of environmental change and can be found in water that is slightly or moderately polluted. How many types of fair water quality indicators did you find in the stream?



The Water Penny Beetle has a flattened and rounded or oval body to assist with minimizing friction as it crawls along smooth surfaces on the stream bottom.



The Long-toed Water Beetle has his head partially retracted into the thorax segment.



The Cranefly has a retracted head (right), which usually is not visible.



The raised rings around the shell of this Asian Clam are growth rings like rings on a tree showing its age.



This Dragonfly's lower jaw covers its mouth when retracted and extends to catch and hold prey when feeding.



The triangular shaped lower jaw of this Damselfly extends to catch and hold prey.

Table 3: Continued

Invertebrate type	Pollution tolerance	Water quality indicator
Creeping water bugs	Moderately tolerant	Fair
Crane fly larvae	Moderately tolerant	Fair
Aquatic caterpillar larvae	Moderately tolerant	Fair
Crayfish	Moderately tolerant	Fair
Planarians	Moderately tolerant	Fair
Asiatic freshwater clams	Moderately tolerant	Fair
Dragonfly nymphs	Moderately tolerant	Fair
Damselfly nymphs	Moderately tolerant	Fair
Amphipods	Moderately tolerant	Fair
Clams	Moderately tolerant	Fair
Water scorpions	Moderately tolerant	Fair

STUDENT SHEET 4

Pollution Tolerant Organisms

Other organisms are tolerant of disturbance and can be found in polluted water. The presence of organisms that are tolerant of pollution, along with a lack of intolerant organisms, indicates an unhealthy stream. How many types of poor water quality indicators did you find in the stream?

If the water quality is not good, the good water quality indicators usually try to drift farther downstream to a spot where the water quality is better. The fair and poor water quality indicators are able to tolerate a wider range of conditions.



The **Creeping Water Bug** is dorso-ventrally flat and has modified front legs to assist with grabbing and holding prey.



Below its head are a pair of prolegs that help this **non-biting Midge** move on the stream bottom.



The **Blackfly** has two clumps of hairs that act as filtering fans that filter flowing water for food.

Table 3: Continued

Invertebrate type	Pollution tolerance	Water quality indicator
Midge fly larvae	Pollution tolerant	Poor
Blackfly larvae	Pollution tolerant	Poor
Diving beetles	Pollution tolerant	Poor
Pouch snails (left-handed snails)	Pollution tolerant	Poor
Flattened-coiled snails	Pollution tolerant	Poor
Leeches	Pollution tolerant	Poor
Aquatic worms	Pollution tolerant	Poor

STUDENT SHEET 5

Temperature measured values

Good water quality: less than 85° F (29° C)
Fair water quality: 85° F (29° C)-90° F (32° C)
Poor water quality: 90° F (32° C) or greater

pH measured values

Good water quality: 6-9 range
Fair water quality: 5-6 range
Poor water quality: less than 5 or greater than 9

Dissolved oxygen measured values

Good water quality: 6 mg/L or above
Fair water quality: 4-6 mg/L
Poor water quality: less than 4 mg/L

BOD measured values

Good water quality: 8 mg/L or below
Fair water quality: 8-100 mg/L
Poor water quality: above 100 mg/L

Nitrate measured values

Excellent water quality: 1.5 mg/L or less
Good water quality: 1.5 – 4.0 mg/L
Fair water quality: 4.0 – 8.0 mg/L
Poor water quality: greater than 8.0 mg/L

Phosphate measured values

Good water quality: less than 0.1 mg/L
Fair water quality: 0.1-1 mg/L
Poor water quality: 1 mg/L or greater

Macroinvertebrates as Guides to Water Quality

Good water quality indicators

mayfly nymphs, stonefly nymphs, riffle beetles (adults and larvae), water penny larvae, caddisfly larvae, hellgrammite larvae, gilled snails (right-handed snails)

Fair water quality indicators

crane fly larvae, creeping water bugs, aquatic caterpillar larvae, crayfish, damselfly nymphs, dragonfly nymphs, planarians, Asiatic freshwater clams, amphipods, clams, water scorpions

Poor water quality indicators

midge fly larvae, blackfly larvae, diving beetles, pouch snails (left-handed snails), flattened-coiled snails, leeches, aquatic worms

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