

Is There AMD In This Stream?

Adapted from: "Is There Mine Drainage Impacting This Stream?" in *AMD Biology Module*. St. Vincent College Environmental Education Center, 2002.

Grade Level: Basic

Duration: 45 minutes

Setting: Classroom

Summary: In a simulation, students collect macroinvertebrates to determine the health of a stream.

Objectives: Students will be able to explain the rationale behind biomonitoring and identify the effects of abandoned mine drainage.

Vocabulary: abandoned mine drainage, acid mine drainage, bituminous coal, anthracite coal, yellow boy, macroinvertebrates, biological monitoring, chemical monitoring, physical assessment, sensitive, somewhat sensitive, tolerant, Pollution Tolerance Index (PTI), active treatment, passive treatment, alkaline, open limestone channel, anoxic limestone drain

Related Module Resources:

Additional Module Resources Fact Sheets:

- "What is Acid Mine Drainage?"
- "The Science of Acid Mine Drainage and Passive Treatment"
- "Coal Mine Drainage and Aquatic Life"
- "Saving our Mountain Streams"
- "About Biological Indicators"
- "Why Use Biological Indicators?"

Materials (Included in Module):

- Data sheet, answer sheet, and data sheet transparency
- 15 wet erase markers [Main Box]

Is There AMD in this Stream Box:

- Blue stream sheet (Stream #1)
- Orangish stream sheet (Stream #2)
- 24 cardboard rocks
- 34 green arrowhead leaves
- 20 bunches of brownish leaves
- 15 lunch bags
- 300 white macroinvertebrate cards
- 250 yellow macroinvertebrate cards
- Laminated Macroinvertebrate Identification flashcards
- Module Activity Envelope:
 - 5 Photos of streams affected by AMD
 - Disk with 5 photos of streams affected by AMD

Additional Materials (NOT Included in Module):

- Chalkboard or whiteboard
- Overhead projector
- Computer / projection unit / screen

ACADEMIC STANDARDS: (ENVIRONMENT AND ECOLOGY)

7th Grade

4.1.7.B Understand the role of the watershed

- Explain factors that affect water quality and flow through a watershed.

4.3.7.B Describe how human actions affect the health of the environment.

- Identify residential and industrial sources of pollution and their effects on environmental health.
- Explain how nonpoint source pollution can affect the water supply and air quality.

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, and sedimentation).

BACKGROUND:

The Pittsburgh Coal Seam of western Pennsylvania was one of the biggest concentrations of coal in the world. Nearly one fourth of all coal ever mined in the United States came from this coal seam. **Bituminous coal** ("soft coal") was mined from this seam to supply the world with coal, the major source of energy early in the last century. (**Anthracite coal** or "hard coal" was also mined in Pennsylvania but in the eastern half of the state.) Today, more than half of Pennsylvania's electricity is generated in coal-burning power plants.

Although coal mining can be economically beneficial by creating jobs and generating energy, coal mining can also be harmful environmentally. Coal mining can cause extensive soil erosion, which leaves the land stripped of precious topsoil and waterways choked with sediment. **Abandoned mine drainage (AMD)** is also a serious problem related to coal mining. AMD is the biggest source of water pollution in Pennsylvania, affecting more than 2,400 miles of stream and costing millions of dollars to clean up. When mines are abandoned, water may end up flowing through and out of them. On the way, the water mixes with the pyrite (also called "fool's gold") found in the remaining rocks. When the solution of water and pyrite reacts with oxygen, iron hydroxide and sulfuric acid are created. The iron hydroxide is an orange solid (called **yellow boy**) that coats the rocks of streams and turns the water a yellow, orange, or red color. (This may not

happen in all streams; sometimes the water appears clean and clear because the water is so acidic that it has dissolved all of the pollutants.) The sulfuric acid may lower the pH of the stream, but that is not always the case. This is the reason the “A” in AMD stands for “Abandoned” and not “Acid.” In some cases the surrounding rocks are able to prevent the acid from lowering the pH of the nearby water.

AMD affects the life in the ecosystem in several ways. The orange solid that coats the rocks and stream bottom prevents **macroinvertebrates** (animals without backbones that are big enough to be seen with the naked eye) from living in their favorite habitats under rocks and in the leaf litter. The orange solid also stops sunlight from penetrating the water so aquatic plants are unable to survive. Without plants and macroinvertebrates, two important links in the food chain are missing. Other problems result from the chemical reactions using up the dissolved oxygen needed by the stream organisms and the high levels of toxic metals that exit the mine with the drainage. Even in very low amounts these metals, such as iron, aluminum, and manganese, are deadly to fish and other organisms.

To determine the extent to which AMD has affected the health of a stream, there are three main techniques: **biological monitoring**, **chemical monitoring**, and **physical assessment**. These three techniques can also be used to evaluate stream health in general. A physical assessment involves an examination of land uses around a stream and a search for potential sources of pollution. Chemical monitoring uses chemical tests to determine the quantitative values for parameters such as temperature, pH, oxygen, nitrates, and phosphates. Biological monitoring uses the plants and animals living in the stream to determine a stream’s health. Since each organism has its own set of requirements for its habitat, the qualities of a stream can be deduced. The **Pollution Tolerance Index (PTI)** is a biological monitoring technique that classifies organisms as either **sensitive**, **somewhat sensitive**, or **tolerant**. The sensitive creatures require very specific conditions and cannot tolerate even small amounts of pollution. Their presence in a stream usually indicates high water quality. The tolerant organisms can be found within a greater range of conditions, including water that contains pollutants. Finding tolerant organisms in a stream without finding any sensitive creatures usually means there is a pollution problem. The somewhat sensitive organisms fall somewhere between sensitive and tolerant. They will be able to withstand certain poor water quality conditions but not many.

To stop AMD once it is detected, two basic types of technologies may be employed: **active treatment** or **passive treatment**. Active treatments involve the addition of chemicals such as limestone or ammonia, which are basic in pH. The goal is to raise the pH of the water but this method is expensive due to the costs of the chemicals, the amount of equipment needed, and the ongoing maintenance required to continually add the alkaline (basic) substances.

Passive treatment methods rely on naturally occurring chemical and biological reactions so that once the system is in place, no humans or machines are needed to facilitate the treatment. In one method, wetlands are constructed with a series of “cells,” or ponds with

cattails. As the polluted water flows through each cell, the bacteria that grow within the plants' root system extract the metals found in AMD. Also as the metals move through the shallow wetlands, they are exposed to oxygen, which causes the dissolved metals to turn to solids, which then settle to the bottom. The water no longer contains the dangerous metals by the time the water emerges from the last cell.

Another passive method is an **open limestone channel** or a ditch lined with large limestone rocks. As the AMD moves over the rocks, the alkalinity of the water is increased and the water is exposed to oxygen, allowing the dissolved metals to turn to soil, as in the wetland method above. **Anoxic limestone** drains work similarly to open limestone channels, except that they are buried beneath several feet of clay, eliminating exposure to oxygen. Before the drainage is emptied into a stream, it goes through a settling pond where the metals are finally exposed to oxygen and settle out.

If there is not enough room to build wetlands for treatment, a **vertical flow system** may be installed. A pond with a drain at the bottom forces the AMD to flow downward through layers of compost and limestone. As it moves, alkalinity increases along with the pH. **Diversion wells** are another option for passive treatment. AMD is pushed through a tank full of crushed limestone to increase the alkalinity and pH. Deciding which of these systems to use will depend on the nature of the AMD. Each choice is suited to a particular land use as well as the pH, alkalinity, and type of metals found in the AMD to be treated.

In 1968, Pennsylvania instituted limitations on mine discharges. In 1977, the federal Surface Mining Control and Reclamation Act began to regulate the drainage from coal mines. By these laws, mining companies were forced to reclaim the land or return it to its original state, and continue to treat the drainage long after they had extracted all of the coal. The common choice for treatment was active methods and due to the high costs involved, many companies were forced into bankruptcy. But many of Pennsylvania's problems come from the approximately 7,800 mines that have been long abandoned by companies that no longer exist, so the responsibility for clean-up has fallen to state agencies and local organizations.

OVERVIEW:

Students will collect and count organisms from two simulated streams – one healthy and one affected by abandoned mine drainage. Using biomonitoring techniques, students will determine the health of each stream and explore the cause of the orange color in one of the streams.

PROCEDURE:

Teacher Preparation:

1. Locate the Data Sheet, Answer Key, and overhead transparency data sheet at the end of this activity. Make copies of the data sheet for your students. Procure and set up an overhead projector.

2. Locate the rock, plant, and leaf game pieces, the two "streams", and the macroinvertebrate cards in the module. Also find the lunch bags, the photos of streams affected by AMD or the disk of the photos of streams affected by AMD, and the laminated macroinvertebrate identification flashcards. (If you plan to use the disk, procure and set-up a computer, projection unit, and screen.)
3. Set up the two streams before class begins. (If space permits, set up the streams in two different locations before class begins.)
4. Randomly spread the rocks, plants, and leaves in the streams. Place the blue macroinvertebrate cards under the rocks, plants, and leaves in the blue stream and then do the same with the orange macroinvertebrate cards in the orange stream.
5. Decide how to group your students. There are enough materials for 15 groups.

Student Activity:

1. Briefly introduce acid/abandoned mine drainage to students using the physical photos of streams affected by AMD.
2. Ask students to make a list in their notebooks of conditions needed for a healthy stream.
3. Make a class list on the board.
4. Ask students what would happen to a stream if one or more of these conditions were eliminated.
5. Ask students how a stream's health can be determined. If not supplied by the students, explain how the organisms living in a stream can indicate its health.
6. Show students several of the laminated macroinvertebrate identification flashcards. Ask students where they would find such creatures in the stream.
7. With their partner(s), students should go to Stream #1 (the blue stream) and find 15 macroinvertebrate cards: at least two should come from under rocks, two from around a plant, and two from leaf litter. Students should place the macros in their bag.
8. Have students record the number of each species in the Stream #1 column on the Data Sheet.
9. Repeat steps 6 and 7 with Stream #2 (the orangish stream).
10. Count up the number of tolerant, somewhat sensitive, and sensitive macros for each stream.

11. Make a chart on the board to record the class results or use the overhead transparencies included in the module to pool class data.
12. Have students answer the questions on the Data Sheet.

DISCUSSION:

Discuss student answers on the Data Sheets using the Answer Key provided in the module.

EVALUATION:

- Correctly completed data sheet.

EXTENSIONS AND MODIFICATIONS:

- Head to a local stream or two and try biomonitoring for real.
- Allow students to practice identifying macroinvertebrates with a key by using macro cards without the names on it.
- Have each student research a different macroinvertebrate. They should try to find out what causes it to be classified as sensitive, somewhat sensitive, or tolerant.
- Explore the passive and active methods of remediating AMD streams.
- Visit a stream affected by AMD and one of the remediation sites.
- Research the process of reclamation used today that attempt to restore mined lands to the original condition.

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



DATA SHEET : IS THERE AMD IN THIS STREAM?

Name _____ Date _____

<u>ORGANISM</u>	<u>TOLERANCE</u>	<u>STREAM #1</u> (blue stream)	<u>STREAM #2</u> (orangish stream)
Caddisfly larva	Sensitive		
Mayfly nymph	Sensitive		
Stonefly nymph	Sensitive		
Gilled snail	Sensitive		
Dragonfly nymph	Somewhat Sensitive		
Damselfly nymph	Somewhat Sensitive		
Cranefly larvae	Somewhat Sensitive		
Dobsonfly larvae (Hellgrammite)	Somewhat Sensitive		
Midge larva	Tolerant		
Rat-tailed maggot	Tolerant		
Leech	Tolerant		
Backswimmer	Tolerant		

Macroinvertebrates	Stream #1 (blue)	Macroinvertebrates	Stream #2 (orangish)
Sensitive		Sensitive	
Somewhat Sensitive		Somewhat Sensitive	
Tolerant		Tolerant	

Questions:

1. Was there a difference in the types of macroinvertebrates found in Stream #1 and Stream #2?
 - 2a. In which stream did you find more sensitive species of macroinvertebrates?
 - 2b. What does finding a high number of sensitive species tell you about a stream?
 - 3a. In which stream did you find more tolerant species of macroinvertebrates?
 - 3b. What does finding a high number of tolerant species tell you about a stream?
4. Based on the macroinvertebrates found, which stream is healthier? Why?
5. In the stream with more tolerant species and no sensitive species, what might be the source of pollution? Explain your reasoning.
6. If you found 14 tolerant macroinvertebrates and 1 sensitive macroinvertebrate in one stream, would you conclude that the stream is healthy or polluted? Explain your choice.



ANSWER KEY : IS THERE AMD IN THIS STREAM?

1. Was there a difference in the types of macroinvertebrates found in Stream #1 and Stream #2?

Yes.

2a. In which stream did you find more sensitive species of macroinvertebrates?

Stream #1

2b. What does finding a high number of sensitive species tell you about a stream?

The stream's water is of a high quality since it can support species that require specific conditions like high levels of dissolved oxygen.

3a. In which stream did you find more tolerant species of macroinvertebrates?

Stream #2

3b. What does finding a high number of tolerant species tell you about a stream?

The stream's water quality is poor. The species living there are not picky about their conditions and can tolerate low levels of oxygen and certain pollutants.

4. Based on the macroinvertebrates found, which stream is healthier? Why?

Stream #1 is healthier since more sensitive and somewhat sensitive species were found there. These creatures require high quality water. Stream #2 contained no sensitive species and mostly tolerant species indicating an unhealthy stream.

5. In the stream with more tolerant species and no sensitive species, what might be the source of pollution? Explain your reasoning.

When you get to this question, gather as many responses as possible. If students do not come up with abandoned mine drainage, explain what it is. Share the pictures of streams affected by AMD. Abandoned mine drainage results from water moving through old mines and reacting with the pyrite found in the rock. When this solution mixes with oxygen, iron hydroxide, an orange solid is formed that discolors the water and coats the rocks of streams. Depending on the types of rocks in the area, the water may or may not become more acidic (decrease in pH) because of the mine drainage.

6. If you found 14 tolerant macroinvertebrates and 1 sensitive macroinvertebrate in one stream, would you conclude that the stream is healthy or polluted? Explain your choice.

Due to the presence of that one sensitive organism, the stream would probably be healthy. Sensitive organisms are unable to live in polluted water so the water must be clean enough to support sensitive creatures. Basing a decision on 15 macroinvertebrates, however, would not be best scientific practice. A larger sample should be examined to draw a definitive conclusion.



OVERHEAD : IS THERE AMD IN THIS STREAM?

<u>ORGANISM</u>	<u>TOLERANCE</u>	<u>STREAM #1</u> (blue stream)	<u>STREAM #2</u> (orangish stream)
Caddisfly larva	Sensitive		
Mayfly nymph	Sensitive		
Stonefly nymph	Sensitive		
Gilled snail	Sensitive		
Dragonfly nymph	Somewhat Sensitive		
Damselfly nymph	Somewhat Sensitive		
Crane fly larvae	Somewhat Sensitive		
Dobsonfly larvae (Hellgrammite)	Somewhat Sensitive		
Midge larva	Tolerant		
Rat-tailed maggot	Tolerant		
Leech	Tolerant		
Backswimmer	Tolerant		

Macroinvertebrates	Stream #1 (blue)	Macroinvertebrates	Stream #2 (orangish)
Sensitive		Sensitive	
Somewhat Sensitive		Somewhat Sensitive	
Tolerant		Tolerant	

