

## ABSTRACT

In this activity, students test the quality of a local body of water. Students collect water samples to study pH, dissolved oxygen, temperature, particle suspension, plants, macroinvertebrates, and vertebrates. The class compiles the data and evaluates the overall biological water quality of the study area. Students also examine the land around the sampling area to study the effects of human impact. This activity uses the Calculator Based Laboratory (CBL) system with a variety of probes and graphic analysis software. *Testing the Waters* should be conducted at least twice during the school year and can be used for a long-term project.

## TIES TO CURRICULUM

*Testing the Waters* promotes cooperative group learning and offers students hands-on field experience. In accordance with the *National Science Education Standards*, this activity emphasizes critical thinking skills and interpretation of scientific data. The CBL system and laptop show students how technology is used for data collection and interpretation in the field. *Testing the Waters* integrates concepts used across the curricula, such as applying the scientific experimental method, using a field guide, and identifying and classifying organisms.

## TIME REQUIREMENT

*Testing the Waters* takes approximately 5½ hours. Conduct the activity twice during the year to monitor water quality, or use the activity as a long-term project.

Task	Time	Location
Introduction	1½ hours	Classroom
Geographic area analysis	30 minutes	Field
Chemical data collection	45 minutes	Field
Invertebrate collection and identification	1 hour	Field
Data analysis and class discussion	30 minutes	Field
Data synthesis	45 minutes	Classroom
Class evaluation and data interpretation	45 minutes	Classroom

## LEARNING OBJECTIVES

Students will learn to

- ◆ use a field guide to identify macroinvertebrate, vertebrate, and plant species;
- ◆ gather, organize, and synthesize the data from the pH, temperature, dissolved oxygen, and particle suspension;
- ◆ collect and analyze field data;
- ◆ operate calculator-based laboratory systems;
- ◆ create data tables and graphs of data; and
- ◆ apply data to determine the overall biological quality of the area.

## NUMBER OF LAPTOPS AND GROUP SIZE

Use one laptop for each group of four students.

**MATERIALS**

- ◆ Laptop computers
- ◆ Word processing and spreadsheet software
- ◆ Texas Instrument's (TI) CBL system
- ◆ Graphing calculator
- ◆ Vernier's Graphic Analysis software
- ◆ DIN adapter
- ◆ Probes for the CBL system: temperature, colorimeter, dissolved oxygen, pH
- ◆ Two large jars with lids
- ◆ Duct tape
- ◆ String
- ◆ Aquatic net
- ◆ Waders (two sets per group)
- ◆ Magnifying glasses (two per group)
- ◆ Squirt bottle
- ◆ Eye dropper
- ◆ White collecting tray
- ◆ Forceps (Two sets per group)
- ◆ Field guide to pond life
- ◆ Invertebrate and aquatic plants identification sheets

**LESSON DESCRIPTION****Teacher Preparation**

Locate a suitable site, such as a nearby lake, pond, or stream. Familiarize yourself with the CBL and probes. On the laptop computer, create a macroinvertebrate data sheet to assess water quality (see Appendix 1). Copy the data sheet onto all computers, and protect formulas. Contact the local department of conservation to obtain a macroinvertebrate collection permit.

**Introduction**

Introduce the concepts of biological quality, and how to determine the overall water quality of a site. Demonstrate the use of the CBL, probes, Graphic Analysis software, and spreadsheets. Review the collection and identification of macroinvertebrates, vertebrates, and plants.

Divide the class into groups of four students. Each group should create a unique water-sampling device from the large jar, string, and duct tape.

**Activity*****Geographic area analysis***

At the water sampling site, assign each group to a sampling area. Groups have 30 minutes to evaluate the sampling area. They should observe the impact of humans on the area and search for signs of vertebrate and plant life. After writing descriptions of the sampling area using the laptops' word processor, groups will take water samples.

***Chemical data collection***

In each group, assign two students to be *testers* and two to be *samplers*. Samplers will put on waders and collect water samples. Testers will set up the CBL with probes to record temperature, pH, colorimeter, and dissolved oxygen on the water sample. Samplers use the group's collection device to retrieve a water sample, then bring the sample back to shore. Testers

conduct pH, temperature, dissolved oxygen, and colorimeter tests on the water sample, and enter the data into the computer.

### ***Invertebrate collection and identification***

Students switch roles for the macroinvertebrate sampling. The new samplers wade into the water with aquatic nets, and lay the nets on the bottom of the lake. One sampler walks forward to the net, kicking up the bottom substrate to dislodge macroinvertebrates and send them into the net. Samplers should return to the shore and rinse their findings into the collecting tray. Using forceps, testers transfer macroinvertebrates from the aquatic net to the white collecting tray. Testers should use the squirt bottle to make sure all macroinvertebrates are washed off the aquatic net, and to keep the macroinvertebrates in water on the collecting tray. Testers then use magnifying glasses to identify the macroinvertebrates. Groups may have to repeat the macroinvertebrate collection process to get a good representation of their sampling area. Testers can consult field guides and handouts for help with identification. The whole group tallies the results of the macroinvertebrate sampling on the computer.

### **Data Analysis**

When groups have collected and recorded all data, they should begin to create graphs from each of their data tables. For a final activity in the field, the whole class should discuss the day's results and arrive at a group conclusion about the sampling area. The students should consider factors that might have affected their samples.

Devote one class session to data collection and analysis. Hold a class discussion to compare the results of each group's findings. The class should compile data to calculate an average reading for pH, dissolved oxygen, particle suspension, and temperature of the entire sampling area. Students should also come up with a list of all macroinvertebrates, vertebrates, and plant life present. As a class, evaluate the overall quality of the sampling area.

### **SUGGESTIONS**

- ◆ If possible, bring other teachers to act as observers. An ideal adult-to-student ratio is one teacher for every two groups of four students.
- ◆ Students and teachers should wear water shoes or old sneakers.

**REFERENCES**

This activity was originally conducted as a water quality monitoring project with Friends of the Fox River, P.O. Box 1478, Elgin, IL 60121.

**Books**

Crowder, Jane N., and Joe Cain. *Water Matters, Volume 2*. Arlington, VA: National Science Teachers Association, 1997.

Kaufman, Sue C. *Water Matters, Volume 1*. Arlington, VA: National Science Teachers Association. 1994.

Masterman, David, and Scott Holman. *Biology with Computers*. Portland, OR: Vernier Software, 1997.

National Research Council. *National Science Education Standards*. Washington DC: National Academy Press, 1996.

Reid, George K. *Pond Life*. USA: Golden Books, 1967.

**Web sites**

Benthic Macroinvertebrates. Kentucky State University's key:  
<http://water.nr.state.ky.us/ww/bugs/intro.htm>

Give Water a Hand. University of Wisconsin's watershed education program:  
<http://www.uwex.edu/erc/>

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Each group writes a laboratory report in standard format, including title, introduction, procedure, methods, results, and conclusions based on the group's findings and the class consensus. In the reports, groups should evaluate their sampling areas and include the following points: surface water appearance, substrate composition, substrate appearance, algae growth, odor, shore vegetation, land usage, discharge pipes present, sewage problems, water quality management, potential threats to the area, and barriers to fish movement.

Use this scale to scoring the assessment rubric:

**ASSESSMENT**

Observe groups in the field and assess students' participation. Use this rubric to grade the laboratory report:

	<b>Accuracy of data/graphs</b>	<b>Objective Satisfied</b>
Introduction		
Description of area		
Materials		
Methods		
Group data for pH, temperature, dissolved oxygen, colorimeter		
Class data for pH, temperature, dissolved oxygen, colorimeter		
Group data for invertebrate sampling		
Class data for invertebrate sampling		
Graphs		
Biological quality		
Calculations		
Group conclusions		
Class conclusions		

- 4 = all aspects of objective completed: superior accuracy
- 3 = most aspects of objective completed: high accuracy
- 2 = some aspects of objective completed: moderate accuracy
- 1 = small amount of objective completed: low accuracy
- 0 = did not attempt to complete objective

In addition to the report, assess each student or group on the following criteria:

- ◆ Did each group collect sufficient data to make an accurate prediction of biological water quality?
- ◆ Could the students determine how all the biological factors effect the environment?
- ◆ Did the group identify reasons why its data may not be accurate?

**REFERENCES, cont'd.**

Major Stream Invertebrates. A key to common stream invertebrates:  
<http://imc.lisd.k12.mi.us/msc1/invert/key.html>

USGS's Water Science for Schools:  
<http://www.wga.usgs.gov/edu/indexjs.html>

Water Quality Parameters. Biological and chemical parameters:  
<http://mc.lisd.k12.mi.us/tests.html>

LaMotte Company. Water quality monitoring kits:  
<http://www.lamotte.com/>

PASCO Scientific:  
<http://www.pasco.com/>

Vernier Software:  
<http://www.vernier.com/>

## APPENDIX

### Appendix I: Macroinvertebrate Tally Sheet

This tally sheet assesses water quality based on the species and number of macroinvertebrates present. Create a similar table on the laptop's spreadsheet program. If you use formulas in the spreadsheet, lock the formulas before saving on each group's computer.

Estimate the number of individuals of each species present in the water.

<b>Taxonomic Group 1 – pollution intolerant</b>		<b>Group Score</b>
Stonefly nymph	_____	
Alderfly larvae	_____	
Dobsonfly larvae	_____	
Snipe fly larvae	_____	
Total # of Taxa, Group 1	_____	x 1 _____
<b>Taxonomic Group 2 – moderately intolerant of pollution</b>		
Caddisfly larvae	_____	
Mayfly nymph	_____	
Water penny beetle larvae	_____	
Damselfly nymph	_____	
Dragonfly nymph	_____	
Adult riffle beetle	_____	
Riffle beetle larvae	_____	
Crayfish	_____	
Crane fly larvae	_____	
Clam/mussel	_____	
Total # of Taxa, Group 2	_____	x 2 _____
<b>Taxonomic Group 3 – fairly tolerant of pollution</b>		
Black fly larvae	_____	
Sowbug	_____	
Scud	_____	
Right-handed snails	_____	
Midge larvae	_____	
Total # of Taxa, Group 3	_____	x 3 _____
<b>Taxonomic Group 4 – pollution tolerant</b>		
Aquatic worms	_____	
Leech	_____	
Pouch/left-handed snails	_____	
Blood worm midge larvae	_____	
Total # of Taxa, Group 4	_____	x 4 _____
Total # Taxa, all Groups	_____	Sum of _____ Group Scores
<b>Total # of Taxa/Sum of Group Scores</b>	_____	<b>= Final Score</b>

Identify water quality based on your final score:

1.0 - 2.0 = excellent water quality

2.1 - 2.5 = good water quality

2.6 - 3.5 = fair water quality

3.5+ = poor water quality

## Appendix 2: Pollution Tolerance Categories

This is a general grouping of organisms by pollution tolerance category. Tolerance varies by region, so contact your local conservation agency for specific groupings.

### Group 1

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Pollution intolerant organisms are generally intolerant to nutrient pollution such as sewage or fertilizer, and are especially intolerant of low dissolved oxygen levels. A characteristic of clean water macroinvertebrates is their general diversity and relative abundance. Many different types of organisms are present, and none dominate the community, except for brief seasonal periods. Many members of this group feed upon the stems of decaying leaves. Predators are apparent and depend upon the stream or lake's natural food sources.

### Group 2

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Moderately pollution intolerant organisms are more tolerant of nutrient enrichment from agricultural sewage, municipal sewage, or other sources. The number of pollution intolerant forms begins to decline and may disappear with lowered dissolved oxygen levels. Some natural pollution can occur and increase the number of fairly pollution intolerant forms from seasonal stagnation and heat in the late summer. If only a small amount of human pollution is present, then a number of Group 1 organisms will still be present. Sedimentation can lower the water quality of a stream by suffocating organisms and lowering the tolerance value.

### Group 3

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Fairly pollution tolerant organisms are represented by macroinvertebrates that can accept low dissolved oxygen conditions and fairly high levels of nutrient enrichment increases from agricultural fertilizer, municipal sewage, or other sources. These tolerant organisms tend to be either scavengers or omnivores and are bottom dwellers, and they replace the less tolerant organisms. Streams and rivers with increased pollution will have lost all Group 1 organisms.

### Group 4

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Pollution tolerant organisms are very tolerant to low levels of dissolved oxygen and severe nutrient pollution. The rich nutrient sources in most polluted streams can support huge numbers of the tolerant species. Organisms found here are usually associated with bottom sediments. Some have adapted to obtaining air from the surface because there is so little dissolved oxygen in the water.