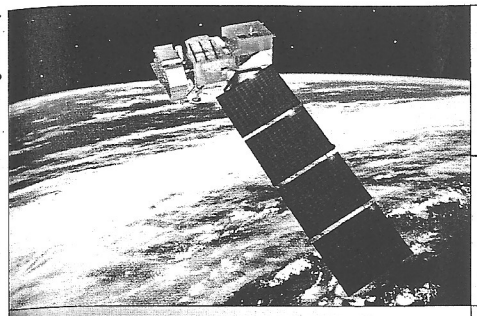


Photo credit: © Landsat Imagery courtesy of NASA Goddard Space Flight Center and U.S. Geological Survey

Macroinvertebrate Mayhem

How does the phrase "appearances can be deceiving" apply to the water quality of a sparkling, crystal-blue stream?

- **Grade Level**
  Upper Elementary, Middle School
- **Subject Areas**
  Ecology, Environmental Science, Mathematics
- **Duration**
  Preparation time: Part I: 20 minutes; Part II: 50 minutes
  Activity time: Part I: 50 minutes; Part II: 50 minutess
- **Setting**
  Large playing field
- **Skills**
  Gathering information (researching); Organizing (categorizing); Interpreting (relating, drawing conclusions)
- **Charting the Course**
  "Hitting the Mark" orients students to the importance of precision and accuracy in collecting water quality data. In "A Snapshot in Time," students discover the differences in value between an individual data set collected at one place and time versus a series of data sets collected at various points over time. Before participating in "Macroinvertebrate Mayhem," students should conduct "Water Quality? Ask the Bugs!" a simulated bioassessment of a stream. Students can learn how nonpoint source pollutants accumulate in a stream in "Sum of the Parts." Treating polluted water is addressed in "Reaching Your Limits."
- **Vocabulary**
  macroinvertebrate, biodiversity, water quality, environmental stressors, mayflies, stoneflies, dragonflies, rat-tailed maggots, scuds, leeches, snails, larvae, nymphs, sewage, fertilizers, algae, bacteria, oxygen, sediment, habitats, alien species, channelization, caddisfly

▼ Summary

Students play a game of tag to simulate the effects of environmental stressors on macroinvertebrate populations.

Objectives

Students will:

- illustrate how tolerance to water quality conditions varies among macroinvertebrate organisms.
- explain how population diversity provides insight into the health of an ecosystem.
- identify environmental factors that can influence macroinvertebrate organisms.

Materials

Warm Up

- *Samples of macroinvertebrate organisms* (optional)
- *Resources* (texts, field guides, encyclopedia)
- *Photos of* ***Unimpaired Streams*** ©
- *Photos of* ***Impaired Streams*** ©

Part II

- ***Identification labels*** *for macroinvertebrate groups, one per student* © (Divide the number of students by seven and make that number of copies of each macroinvertebrate picture. One side of each label should have a picture of one of the seven macroinvertebrates. The other side of each label [except those for midge larvae and rat-tailed maggots] should have a picture of either the midge larva or rat-tailed maggot. For durability, the cards may be laminated and categories can be color-coded for ease. Use clothespins or paper clips to attach labels to students' clothing.)
- *Pillowcases or burlap bags*
- *Chart paper or a chalkboard*

NOTE: To adapt this activity for your area, contact the state Department of Land and Natural Resources or Fish and Wildlife Service for information.

Making Connections

People may be able to assess the water quality of a stream by its appearance and smell. Sometimes, however, a polluted stream looks and smells clean. Students may have already learned certain ways to test water quality and may have conducted macroinvertebrate stream studies. Simulating how environmental stressors affect macroinvertebrate populations helps students relate the concept of biodiversity to the health of aquatic ecosystems.

Background

Macroinvertebrates (organisms that lack an internal skeleton and are large enough to be seen with the naked eye) are an integral part of wetland, spring and stream ecosystems. Examples of macroinvertebrates include mayflies, stoneflies, dragonflies, rat-tailed maggots, scuds, snails and leeches. These organisms may spend all or part of their lives in water; usually their immature phases (larvae and nymphs) are spent entirely in water. Larvae do not show wing buds and are usually very different in appearance from the adult versions of the insects. (Maggot is the term used for the larva of some flies.) Nymphs generally

resemble adults but have no developed wings and are usually smaller.

A variety of environmental stressors can negatively impact macroinvertebrate populations. Urban and/or agricultural runoff can produce conditions that some macroinvertebrates cannot tolerate. Sewage and fertilizers added to streams induce the growth of algae and bacteria that consume oxygen and make it unavailable for macroinvertebrates. Changes in land use from natural vegetation to a construction site or to poorly protected cropland may add sediment to the water. Sedimentation destroys habitats by smothering the rocky areas of the stream where macroinvertebrates live. The removal of trees, alteration along the banks of a river and alteration of stream change can change normal water temperature patterns in the stream. Some organisms depend on certain temperature patterns to regulate changes in their life cycles. Other stressors include the introduction of alien species and stream channelization.

Some macroinvertebrates, such as the mayfly and stonefly nymphs, and caddisfly larvae, are sensitive (intolerant) to changes in stream conditions brought about by pollutants. Some of these organisms will leave to find more favorable habitats, but others will be killed or will be unable to reproduce. Macroinvertebrates (e.g., rat-tailed maggots and midge larvae) that can thrive in polluted conditions are called tolerant organisms. Other organisms, called facultative organisms (e.g., dragonfly and damselfly nymphs), prefer good stream quality but can survive polluted conditions.

Water quality researchers often sample macroinvertebrate populations to monitor changes in stream conditions over time and to assess the cumulative effects of environmental stressors. Environmental degradation will likely decrease the biodiversity of a community by eliminating intolerant organisms and increasing the number of tolerant organisms. If the environmental stress is severe enough, species of intolerant macroinvertebrates may disappear altogether. For example, if a sample of macroinvertebrates in a stream consists of rat-tailed maggots, snails and dragonfly nymphs, the water-quality conditions of that stream are probably poor (e.g., low oxygen level, increased sediment, contaminants). If, on the other hand, the sample contains a diversity of organisms, the stream conditions are likely good. However, baseline data is essential because some healthy streams may contain only a few macroinvertebrate species. A variety of food sources, adequate oxygen levels and temperatures conducive to growth all characterize a healthy stream.

Procedure

▼ *Warm Up*

- Review the conditions that are necessary for a healthy ecosystem. Ask students to describe what could happen to an ecosystem if these conditions were altered or eliminated. What clues would students look for to determine if an ecosystem was healthy or not?
- Remind students that a stream is a type of ecosystem. Ask them how they would assess the health of a stream. Students may suggest conducting a visual survey of the surrounding area and answering the following questions: What land use practices are visible in the area? How might these practices affect the stream? Is there plant cover on the banks of the stream or are the banks eroded? What color is the water? What is living in the stream?
- Identify several environmental stressors (e.g., urban and agricultural runoff, sedimentation, introduction of alien species) and discuss how they can affect the health of a stream. Review the many types of plants and animals, including insects, that live in streams. How might environmental stressors affect these organisms? Would all organisms be impacted in the same way? Why or why not?

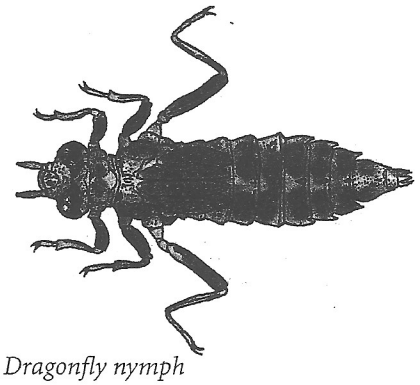
▼ *The Activity*

Part 1

1. **Introduce the practice of sampling macroinvertebrate populations to monitor stream quality.** Show students pictures or samples of macroinvertebrates used to monitor stream quality.
2. **Divide the class into seven groups and assign one macroinvertebrate (from *Macroinvertebrate Groups*) to each group. Have group members conduct research to prepare a report for the class about their organism.** The report should include the conditions (e.g., clean water, abundant oxygen supplies, cool water) the organism must have to survive.
3. **Have students present their reports to the class and compare each organism's tolerance of different stream conditions.**

Part II

1. **Tell students they are going to play a game that simulates changes in a stream when an environmental stressor, such as a pollutant, is introduced. Show students the playing field and indicate the boundaries.**
2. **Have one student volunteer to be an environmental stressor (e.g., sedimentation, sewage or fertilizer). Discuss the ways that a stream can become polluted and how this can alter stream conditions.** With a large class or playing field, more students will need to be stressors.



Dragonfly nymph

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A Sample of Data From Macroinvertebrate Mayhem

ORGANISM	TOLERANCE	NUMBERS (AT START AND AFTER EACH ROUND			
		START	ROUND ONE	ROUND TWO	ROUND THREE
Caddisfly larva	Intolerant	5	2	2	2
Mayfly nymph	Intolerant	5	4	1	0
Stonefly nymph	Intolerant	4	4	4	2
Dragonfly nymph	Facultative	5	5	4	4
Damselfly nymph	Facultative	4	4	4	3
Midge larva	Tolerant	4	6	7	9
Rat-tailed maggot	Tolerant	4	6	9	11
TOTAL		**31**	**31**	**31**	**31**

Intolerant Macroinvertebrates and Hindrances

ORGANISM	HINDRANCE	RATIONALE FOR HINDRANCE
Organism: Caddisfly	Hindrance: Must place both feet in a bag and hop across field, stopping to gasp for breath every five hops.	Rationale for hindrance: Caddisfly larvae build cases and attach themselves to rocks for stabilization and protection; caddisflies are intolerant of low oxygen levels.
Organism: Stonefly	Hindrance: Must do a push-up every 10 steps.	Rationale for hindrance: When oxygen levels drop, stoneflies undulate their abdomins to increase the flow of water over their bodies.
Organism: Mayfly	Hindrance: Must flap arms and spin in circles when crossing field.	Rationale for hindrance: Mayflies often increase oxygen absorption by moving gills.

3. **Divide the rest of the class into seven groups to play the game. Each group represents one type of macroinvertebrate species listed in Macroinvertebrate Groups. Record the number of members in each group using a table similar to *A Sample of Data From Macroinvertebrate Mayhem.***

   NOTE: Try to have at least four students in each group. For smaller classes, reduce the number of groups. For example, eliminate the stonefly nymph and the damselfly nymph groups.

4. **Distribute appropriate identification labels to all group members.** The picture of each group's macroinvertebrate should face outward when labels are attached.

5. **Inform students that some macroinvertebrates have hindrances to crossing the field. (See *Intolerant Macroinvertebrates and Hindrances.*)** These obstacles symbolize sensitive organisms' intolerance to pollutants. Have students practice their motions. Remind students that the game is not designed as a race but to show how tolerant and intolerant species react to stressors.

6. **Assemble the macroinvertebrate groups at one end of the playing field and the environmental stressor(s) at midfield. When a round starts, macroinvertebrates will move toward the opposite end of the field and the stressor will try to tag them. To "survive," the macroinvertebrates must reach the opposite end of the field without being tagged by the environmental stressor.** The environmental stressor can try to tag any of the macroinvertebrates, but will find it easier to catch those with hindered movements.
7. **Begin the first round of the game. Tagged macroinvertebrates must go to the sideline and flip their identification labels to display the more tolerant species (i.e., rat-tailed maggot or midge larva). Tagged players who are already in a tolerant species group do not flip their labels.**
8. **The round ends when all of the macroinvertebrates have either been tagged or have reached the opposite end of the playing field. Record the new number of members in each species.**
9. **Complete two more rounds, with all tagged players rejoining the macroinvertebrates who successfully survived the previous round. Record the number of members in each species of macroinvertebrates at the conclusion of each round.** Because some players will have flipped their identification labels, there will be a larger number of tolerant species in each successive round.

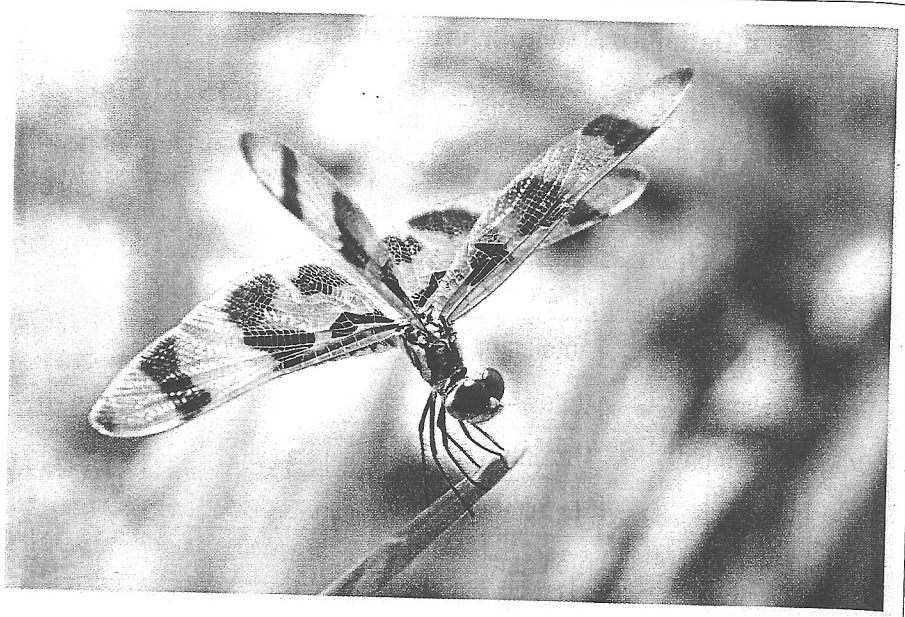

PHOTO CREDIT: © iStockphoto–Thinkstock Photos

Dragonflies can be an indicator of a healthy riparian area.

▼ *Wrap Up*

- The game is completed after three rounds. Discuss the outcome with students. Emphasize the changes in the distribution of organisms among groups. Have students compare population sizes of groups at the beginning and end of the game and provide reasons for the changes. Review why some organisms are more tolerant of poor environmental conditions than others. Have students compare the stream environment at the beginning of the game to the environment at the end.
- Challenge students to apply the concepts from the activity by having them research or actually collect a sample of aquatic macroinvertebrates from a nearby stream (local watershed monitoring groups may have data sets). If this data is unavailable, create a mock set for a healthy stream and an impaired stream to share with your students. Have them identify the relative health of the streams based on the data or even speculate where the sample was taken (headwaters, below a city, etc.)

▼ Project WET Reading Corner

Carson, Rachel. 2002. *Silent Spring*. 40th Anniversary Edition. New York, NY: Mariner Books.^

Published in 1962, Silent Spring was the ground-breaking book that brought attention to the problems of pollutants in our environment.

Heinz, Brian J. 2000. *Butternut Hollow Pond*. Brookefield, CT: Millbrook Press.^

Students read about the relationships of organisms in a pond with emphasis on food webs.

Project WET Foundation. 2005. *Discover Stormwater*. Bozeman, MT: Project WET Foundation.

If you have ever wondered where the rain or melted snow on your street goes and what it affects, you will discover it through the activities in this booklet.

Rhinehart, Susie Caldwell. 2004. *Eliza and the Dragonfly*. Nevada City, CA: Dawn Publications.

Eliza becomes interested in dragonflies and her entomologist aunt helps her to understand the dragonfly and other life in a pond.

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Ross, Michael Elsohn. 2000. *Pond Watching with Ann Morgan*. Minneapolis, MN: Carolrhoda Books/Lerner.^

Readers follow Ann Morgan (early 20th century naturalist) as she uncovers the mysteries of life in a pond.

Stille, Darlene R. 2005. *Erosion: How Land Forms, How It Changes*. Mankato, MN: Compass Point Books.

Learn about erosion and its effects not only from natural, but also manmade sources.

^Listed on one or more state reading lists.

Assessment

Have students:

- analyze a stream based on a visual assessment (***Warm Up***).
- describe macroinvertebrate organisms and identify what stream conditions they need to survive (***Part I,*** steps 2 and 3; ***Wrap Up***).
- explain how some organisms indicate stream quality (***Wrap Up***).
- interpret stream quality based on the diversity and types of organisms found there (***Wrap Up***).

Upon completing the activity, for further assessment have students:

- develop a matching game in which pictures of streams in varying conditions are matched with organisms that might live there.

Extensions

Supplement the students' macroinvertebrate survey of a stream with chemical tests and analyses. (See **Teacher Resources.**)

In their macroinvertebrate groups, have students explore their organism's role in the aquatic food chain. What does their macroinvertebrate eat? And what eats them?

Have students design their own caddisfly case.

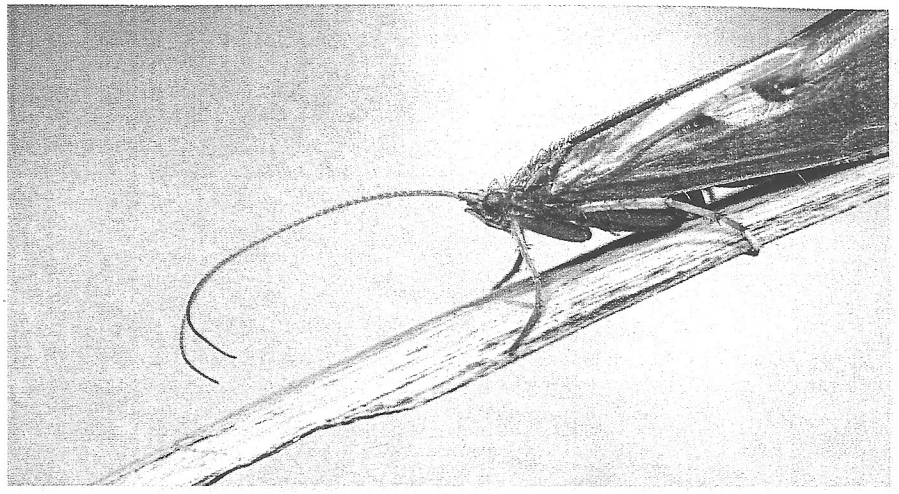


PHOTO CREDIT: © Hemera–Thinkstock Photos

Caddis can hatch in great numbers and are a major food for fish species.

Have students study aspects of biodiversity by adding another round to the game. For example, add a fourth round in which all organisms are caddisflies. This round will demonstrate how a few intolerant species or a single species can be quickly eliminated.

Teacher Resources

Books

Soukhome, Jennifer, Graham Peaslee, Carl Van Faasen and William Statema. 2009. *Watershed Investigations: 12 Labs for High School Science.* Arlington, VA: National Science Teacher Association.

The downloadable chapter "Aquatic Macroinvertebrate Identification" details what and how to identify these creatures.

The Watercourse and Project WET Foundation. 2003. *Healthy Water Healthy People, Water Quality Educators Guide.* Bozeman, MT: The Watercourse.

Journals

Ayyavoo, Gabriel. 2004. "The Measuring River Pollution." *Science Teacher*, 71 (5), 50-51.

Bodzin, Alec M. 2008. "Integrating Instructional Technologies in a Local Watershed Investigation with Urban Elementary Learners." *Journal of Environmental Education,* 39 (2), 47-58.

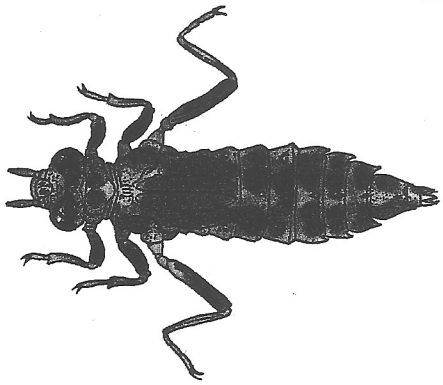
Gordon, Jessica. 2008. "How Do Our Actions Affect Water Quantity and Quality?" *Science Scope,* 31 (6), 26-31.

Hodgson, Ted, Lyle Andersen, Jim Robinson-Cox, and Clain Jones. 2004. "Water Quality Statistics." *Teaching Statistics: An International Journal for Teachers*, 26 (1), 2-8.

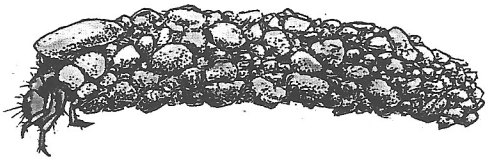
Kenney, Jane L., Heidi Price Militana, and Mary Horrocks Donohue. 2003. "Helping Teachers to Use Their School's Backyard as an Outdoor Classroom: A Report on the Watershed Learning Center Program." *Journal of Environmental Education,* 35 (1), 18-26.

Overholt, Erin and Ann Haley MacKenzie. 2005. "Long-Term Stream Monitoring Programs in U.S. Secondary Schools." *Journal of Environmental Education*, 36 (3), 51.

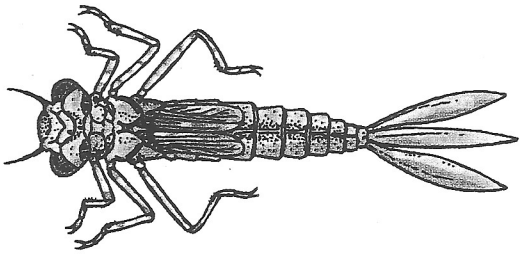
Shepardson, Daniel P., Bryan Wee, Michelle Priddy, Lauren Schellenberger and Jon Harbor. 2007. "What Is a Watershed? Implications of Student Conceptions for Environmental Science Education and the National Science Education Standards." *Science Education,* 91 (4), 554-578.



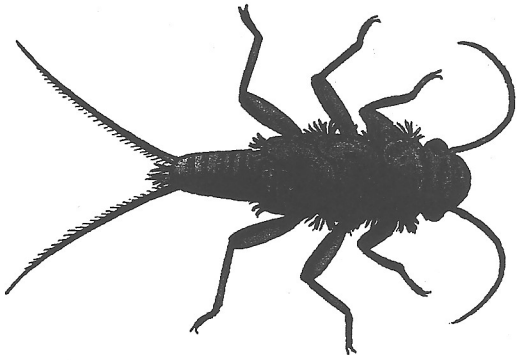
Dragonfly Nymph



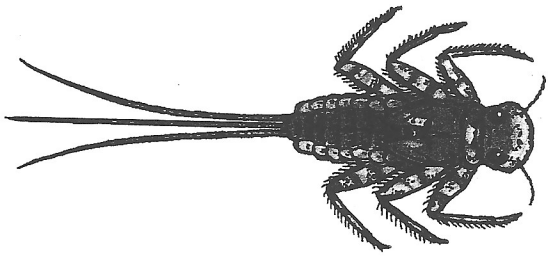
Caddisfly Nymph



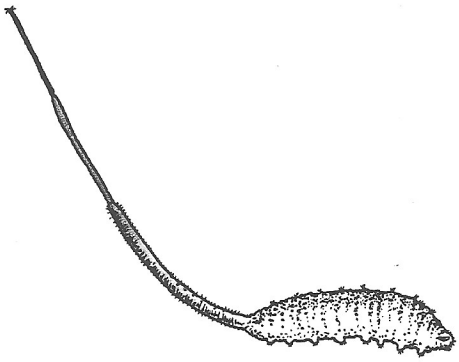
Damselfly Nymph



Stonefly Nymph



Mayfly Nymph



Rat-tailed Maggot

Midge Larva

Environmental Stressor

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Healthy stream conditions can support a diverse population of macroinvertebrates.

PHOTO CREDIT: © Comstock–Getty Images

Rocks and detritus, such as decomposing leaves, can provide macroinvertebrates with good living conditions.

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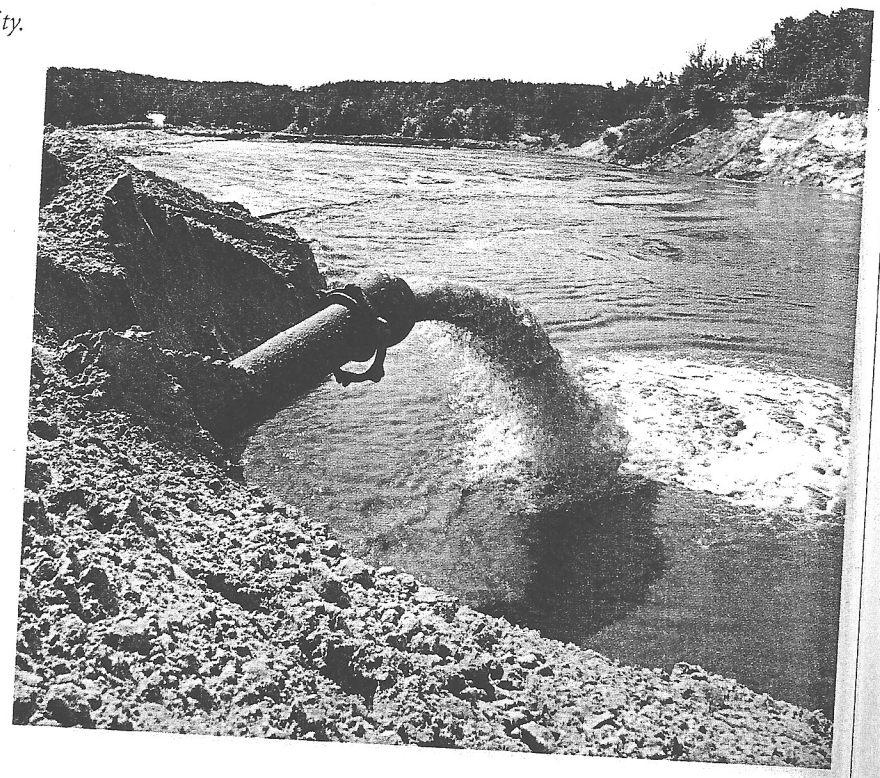
Untreated sewage and sediment can end up in rivers, causing poor water quality.



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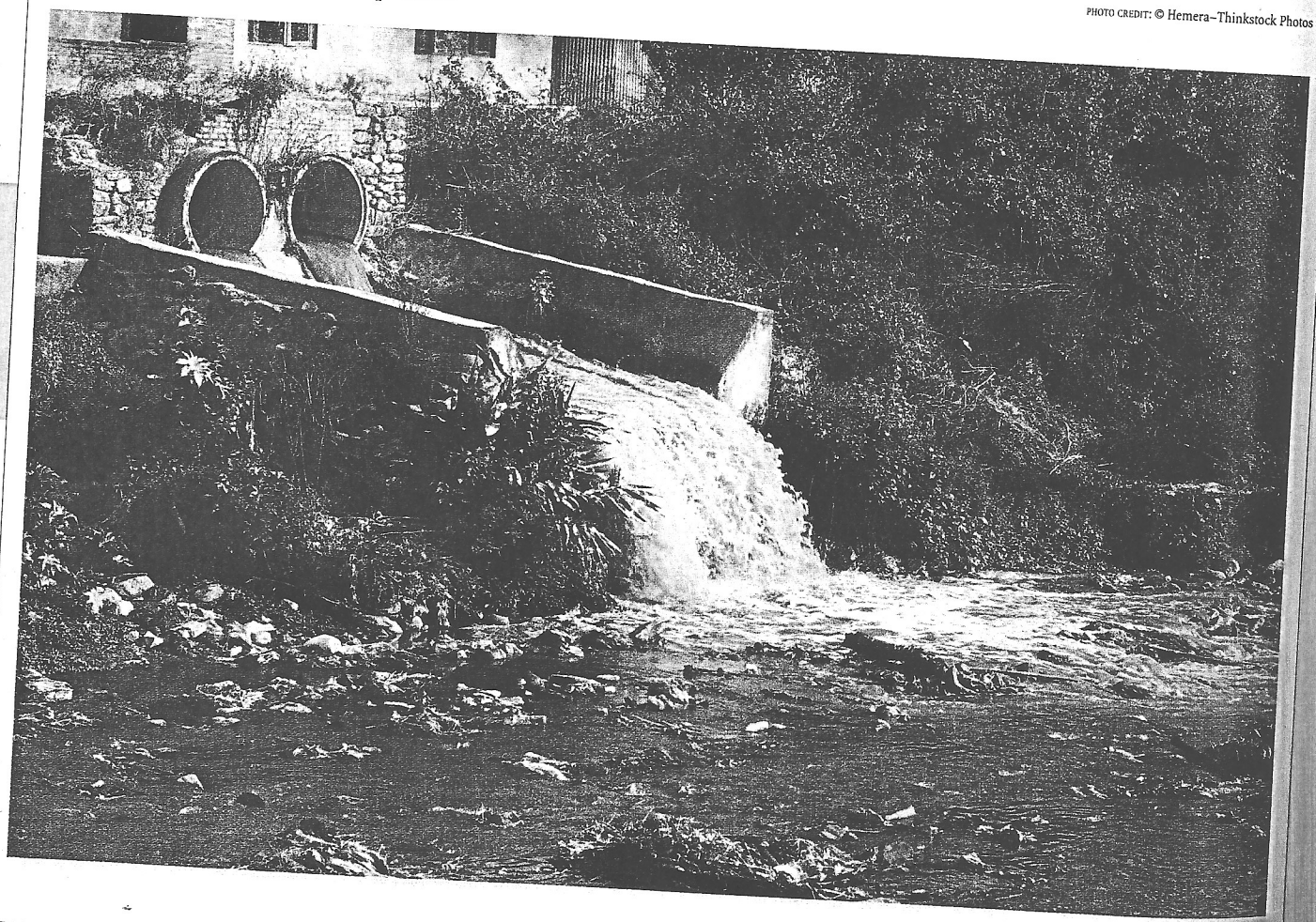
Urban runoff and indicators such as trash can be signs of stream conditions that are polluted.



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