## Contents

Introduction........76
Notes for the Instructor........76
Materials........77
Student Outline........77
Appendix A: Vocabulary List........84
Appendix B: Methods for Stream Sampling........86
Appendix C: Methods for Interpreting Data........87
Appendix D: Resource Materials........88

## Introduction

The Save Our Streams (SOS) program was originally developed in the 1960s in Maryland by Malcom King, who realized that clean streams were vital to the welfare of Chesapeake Bay. although study of the Bay itself may require a boat and expensive equipment, every school and camp in Maryland is within 1/2 mile of a stream. Since the most serious threat to America's surface waters is "non-point source pollution" (see Appendix A), the Izaak Walton League's SOS Program stresses educating people about how our everyday practices affect water quality by influencing what is carried into streams and waterways by storm water runoff.

In summary, there are three major reasons to focus on stream quality:

1. Monitoring of stream quality can be accomplished by ordinary citizens with minimum of cost.

2. Poor quality may indicate practices that can lead to contamination of water supplies or to damage to lakes and rivers.

3. Involvement of citizens in monitoring of stream quality may influence them to take action to preserve and enhance stream quality.

## Notes for the Instructor

The Student Outline that follows is an exercise we use in a 3-semester-hour spring course in Environmental Science designed to meet the General Education requirements. We currently schedule nine (9) 2-hour laboratory sections per week, with 25–30 students per laboratory. Each section is staffed by one course instructor and one undergraduate Teaching Assistant.

We "rig" the water samples to simulate conditions listed in Table 5.3. We collect aquatic insects from local streams and preserve them in 70% ethanol for student "sorting." Having samples of live organisms promotes interest, but is not always possible.

In some of our other courses, with a longer lab period and fewer students, we have the students collect water samples and benthic macroinvertebrates. Ideally, they should be able to visit at least one "good" site before studying polluted sites.

The techniques described in Appendices B and C lend themselves for use in Honors projects and independent student research. For campuses located on or near streams, Adopt-A-Stream programs offer a way to involve students in meaningful long-term collection of data.

This exercise was developed primarily using SOS materials from The Izaak Walton League of America (IWLA). We began looking for resources because we were distressed at the inadequate coverage of aquatic ecology in the course textbook and wanted to supplement it. As we examined the SOS materials, we realized that the empowerment they offer students is as important as the content.

Table 5.3 is from the SOS's *A Stream Watcher's Guide*. Table 5.7 is from Richard Klein's three guides: *Hands-on Streams and Rivers*, *Preservation and Enhancement of Stream Quality*, and *Stream Quality Assessments*. All of these guides can be obtained from: The Izaak Walton League of America, Inc., 1401 Wilson Blvd., Level B, Arlington, VA 22209. Resource materials are described in Appendix D: print materials on benthic macroinvertebrates and collection techniques, sources for audiovisual materials, and information on monitoring equipment.

## Materials

Photocopies of topographic maps of watersheds (1 per student)
Colored map pencils (1 per student)
Water samples in quart jars (4 per lab)
Samples of stream insects
Forceps (1 per student)
Sorting trays (1 per pair of students)
Dissecting microscopes (1 per pair of students)
Insect identification sheets (1 per pair of students)

## Student Outline

**“Save Our Streams”**
[Slogan of the Izaak Walton League of America]

### Objectives

Having completed the exercise, you should be able to:

1. Explain why sampling of the types of aquatic insects in a stream is a recommended means of assessing the water quality.
2. Use “biological assessment” to monitor the water quality of a stream.
3. Recognize unusual conditions in a stream and identify possible causes.
4. Justify concern over the status of streams.
5. Describe the goals of the Izaak Walton League's “Save Our Streams” program.

## Major Causes of Concern in Regard to Stream Quality

### *Sediment Pollution*

The presence of excessive amounts of soil in water can smother aquatic life, clog fish gills, and cut off light to underwater plants. Two major causes of sediment pollution are the uptake of exposed soil by rainwater and the eroding of stream banks by an excessive volume of runoff.

Excessive volume of runoff results from lack of absorption of rain into the ground and may negatively affect aquatic life in two different ways. During dry weather, stream levels tend to be lower due to lack of underground water, but, during rainy periods, aquatic organisms are exposed to flow rates that may scour the stream bed.

### *Oxygen Depletion*

Decomposition of excessive amounts of organic substances by microbes uses oxygen and may reduce oxygen levels to the point that other aquatic organisms suffocate. The major causes of oxygen depletion are "organic enrichment" and the addition of plant nutrients to the water. Organic enrichment refers to the introduction into the stream of organic material. Sources of organic material are listed in Table 5.1.

**Table 5.1.** Sources of organic material in streams.

| Source | Example of organic materials present |
|---|---|
| Sewage treatment plants | Treated sewage |
| Disposals | Ground-up food scraps |
| Overflowing sewers | Untreated sewage |
| Feedlots | Manure |
| Sanitary landfills | Food waste, leaves, grass clippings |
| Urban runoff | Pet feces, grass clippings |
| Agricultural runoff | Manure |
| Septic system failure | Sewage |
| Natural sources | Leaves, feces |

Introduction of plant nutrients can cause excessive growth of algae, whose eventual decomposition can also contribute to oxygen depletion. The nutrients may be a by-product of decomposition of organic materials, or may be the result of fertilizers in runoff or of phosphates in detergents.

*Toxic Substances*

The most common toxic substances are listed in Table 5.2.

**Table 5.2.** Common toxic substances.

| Substance | Source |
|---|---|
| Sulfuric acid | Abandoned mines |
| Chlorine | Release of “treated” water |
| Pesticides | Runoff |
| Petroleum products | Runoff, “do-it yourself” oil-changing (motor oil, gasoline, kerosene, etc.) |
| Salt | Salting of roads |

*Physical Alterations*

Problems in this category could include channelization, damming, addition or removal of bed material, removal of water, or changing water temperatures.

## Activities

*A: Mapping the Watershed of a Stream*

1. Examine the topographic map provided, noting the location and direction of flow of the assigned stream.
2. Starting at the downstream end of the stream, trace a line along the hilltops, ridgelines, and other high points separating the watershed of the stream from that of adjacent watercourses. (When finished, the line should encircle the stream.)

*B: Physical Assessment of Stream Quality*

1. Consult Table 5.3 (from the *A Stream Watcher's Guide* flyer).
2. For each of the water samples on display, identify a possible cause of the unusual color or odor; enter your results in Table 5.4.

**Table 5.3.** Unusual colors and odors in water.

| Condition | Possible causes |
|---|---|
| Muddy water | Erosion of soil in upstream areas; in tidal waters it could also be caused by high winds. |
| Green color | Microscopic plant cells called algae. Algae growth may be caused to exceed normal limits due to excessive water. Nutrient sources include: fertilizers, pet waste, grass clippings, leaves, etc. |
| Yellow-brown to dark brown | Acids released from decaying plants. Naturally occurs each fall when dead leaves collect in the stream. Also common in streams draining marsh, or swampland. |
| Orange to red coating on bed | Results from bacterial action upon iron. May indicate a high erosion rate or industrial pollution. |
| Colored sheen on surface | May indicate oil has entered the stream, particularly if there is also an oily odor. |
| Foam | When foaming occurs in only a few scattered patches and is less than 3 inches high and cream-colored it is probably natural. If the foaming is extensive, white in color, or greater than 3 inches, it may be due to detergents entering the stream. |
| Rotten egg color | Indicates sewage pollution. Odor may also be present in marsh or swampland. |
| Yellowish coating on bed | May indicate polluted water draining from a coal mine. |
| Musky odor | May indicate presence of untreated sewage, livestock waste, algae, or other conditions. |
| White cottony mass | Could be “sewage fungus.” The presence of this growth indicates sewage or other organic pollution. |
| Blue-green algae (Cyanobacteria) | Could indicate sewage or other pollution if growth is excessive. |

**Table 5.4.** Possible causes of unusual color or odor of water samples.

| Sample | Possible causes of unusual condition |
|---|---|
| A | |
| B | |
| C | |
| D | |

## *C: Biological Assessment of Stream Quality*

One measure of stream quality is the diversity, abundance, and kinds of organisms present (see Table 5.5). Although any group of organisms might be surveyed, a survey of aquatic insects has several advantages.

Aquatic insects may be collected from a stream site in several ways. A simple way is to hold an old window screen against the bottom while someone kicks up the bottom just upstream, allowing the dislodged insects to be caught on the screen. Another way is to place a Hester-Dendy sampler, a stack of fiberboard plates, into the stream for 6 weeks or longer. Insects that attach to the "insect condo" can then be sampled.

Insect identification can be difficult, but the Izaak Walton League has developed an insect identification card to assist in the process. Once the "catch" is identified, the results can be interpreted.

**Table 5.5.** Relationship of water quality and diversity, abundance, and kinds of organisms.

| Water Quality | Expected results of insect survey |
|---|---|
| Polluted* | Pollution-tolerant types only, little variety |
| Excellent | Species that require high water quality, diverse |

organic enrichment. If no insects are present, or a few of several kinds, suspect toxic pollution.

1. Obtain a sample of stream insects.
2. Separate the insects into "look-alike" groups, using body shape, number of legs, number of tails, etc., as the basis for grouping.
3. Refer to the drawings of aquatic insects to try to identify the kinds of insects.
4. Record the number of each of the following present in the sample in Table 5.6.
5. Interpret your results.

**Table 5.6** Number of aquatic insects in stream sample.

| Pollution-intolerant | Intermediate | Pollution-tolerant |
|---|---|---|
| ___ caddisfly larvae<br>___ dobsonfly larvae<br>___ mayfly larvae<br>___ stonefly larvae | ___ beetle larvae<br>___ crane flies<br>___ damselflies<br>___ dragonflies | ___ blackfly larvae<br>___ midge larvae |

## Making Connections

Table 5.7 shows the effects of various land uses and activities. Table 5.8 describes harmful practices. Refer to these tables, as required, to answer the following questions:

1. Explain why relatively little rainwater is able to "soak into the ground" in urban areas, leading to high volume of runoff.

2. List the land uses or activities that tend to result in high sediment pollution of streams.

3. Other than undisturbed forestland, which of the land uses poses the *least* potential threat to stream quality in an area?

4. Which of the land uses poses the *greatest* potential threat to stream quality? What could be done to reduce the risk in this situation? (See Table 5.8)

**Table 5.7.** Potential pollutant quantities delivered to streams from various land uses and activities.

| Land use/activity | Sediment | Organic substance | Nutrient | Pesticides | Heavy metals | Storm water* |
|---|---|---|---|---|---|---|
| Natural, undisturbed forestland | low | low | low | none | low | low |
| Managed forest | low | low | mod | mod | low | low |
| Timber harvest | high | mod | mod | mod | mod | high |
| Pasture | low-mod | mod | mod | low | low | low |
| Cropland | mod | low-mod | mod-high | mod-high | low | mod |
| Urban | high | high | high | mod-high | mod | high |
| Construction sites | very high | low-mod | mod-high | mod-high | mod | high |
| Surface mines: Coal | very high | low-mod | low-mod | low-mod | high | high |
| Surface mines: Sand and gravel | high | low-mod | low-mod | low-mod | mod | high |
| Sanitary landfills | high | mod-high | mod | low | high | high |
| Feedlots | low-mod | very high | high | low | low | mod |
| Golf courses | low-mod | mod | mod-high | mod | low | mod |

* Runoff quantity

**Table 5.8.** Potentially polluting practices.

| Practice | Environmental Effect | Alternate |
|---|---|---|
| Pouring oil drained from cars onto a street or into a gutter. | When oil enters stream it can kill aquatic life. | Take oil to a service station. Most managers will allow customers to pour used oil into the station's storage tank. |
| Dumping grass clippings or leaves into a stream or gutter. | When leaves or grass enter water they will decay and use oxygen. | Either material may be composted or bagged and put out with the trash. Leaves could be mulched by running a mower over the lawn with the vent closed. Grass may be left on the lawn or raked up only after every third cutting. |
| Fertilizing the lawn. | Fertilizers, when washed into a body of water, can cause algae to grow too much. | Most lawns need only nitrogen. This eliminates the need for stronger phosphorous fertilizers that encourage algae. Direction on fertilizer bags should be followed. |
| Spraying pesticides about the home and garden. | Pesticides can kill fish and other life when washed into our waters. | Maintaining a healthy lawn with proper cutting and careful fertilizing is the best way to prevent weeds. Bugs that attack garden plants can usually be washed off with a hose or picked off by hand. |
| Allowing pets to run free. | The manure pets deposit on the ground can spread disease or use oxygen when washed into our waters. | Pets should be kept within a fence or on leash. A thoughtful person would collect his/her pet's waste. |

APPENDIX A

*"Save Our Streams" Vocabulary List*

**Algae:** Simple plants which do not grow true roots, stems, or leaves and live mainly in water, providing food for the food chain.

**Biological assessment:** Assessing water quality by determining the diversity, abundance, and kinds of organisms that inhabit the stream.

**Chemical assessment:** Assessing water quality by performing various chemical tests to characterize the chemical composition of the water.

**Culvert:** A closed passageway (such as a pipe) under roadways and embankments which drains surface water.

**Dump:** A land site where trash is left exposed in a way which does not protect the environment.

**Effluent:** An out-flowing branch of a main stream or lake; waste material (i.e., liquid industrial refuse, sewage) discharged into the environment.

**Erosion:** The wearing away of land by wind or water.

**Floodplain:** A low area of land, surrounding streams or rivers, which holds the overflow of water during a flood.

**Flow:** The direction of movement of a stream or river.

**Groundwater:** A supply of freshwater under the earth's surface which forms a natural reservoir.

**Leaching:** The process where materials in the soil (such as nutrients and pesticide chemicals) are washed into lower layers of soil or are dissolved and carried away by water.

**Monitoring:** To watch and care for a stream on a regular basis.

**Non-point source pollution:** A type of pollution whose source is not readily identifiable, such as pollution caused by car exhaust carried off city streets as rainwater.

**Nutrient:** Substance which is necessary for growth of all living things (i.e., oxygen, nitrogen, and carbon).

**Pesticide:** A chemical that kills insects and rodents.

**Physical assessment:** Assessing water quality by the appearance and/or odor of a sample.

**Point source pollution:** A type of pollution that can be tracked down to an easily noticeable cause, such as discharge pipes and people putting chemicals and trash into water.

**Pollutant:** Something that makes land, water, and air dirty and unhealthy.

**Pollution:** The presence of waste that makes the world around us dirty and contaminated.

**Pond-riffle:** In a stream or river, areas of deep slow-moving water (pools) or areas of shallow fast-moving water.

**Riffle:** A shallow area of water with a fast current.

**Runoff:** Water, including rain and snow, which is not absorbed into the ground, instead it flows across the land and eventually runs into streams and rivers; runoff can pick up pollutants from the air and land, carrying them into the stream.

**Sediment:** Soil, sand, and materials washed from land into waterways.

**Sedimentation:** When soil particles (sediment) settle to the bottom of a waterway.

**Slumping:** Sections of soil with or without vegetation that have come loose and slipped into the stream.

**Stagnation:** When there is little water movement and pollutants are trapped in the same area for a long period of time.

**Toxic Substance:** Poisonous matter (either chemical or natural, which causes sickness, disease, and/or death to plants or animals).

**Undercutting:** A type of erosion which occurs when fine soils are swept away by the action of the stream, especially around curves; the result is an unstable overhang.

**Watershed:** All the land that serves as a drainage for a specific stream or river.

**Watertable:** The upper level of groundwater.

**Waterway:** A natural or man-made place for water to run through (such as a river, stream, creek, or channel).

**Wetland:** An area of land that is regularly wet or flooded, such as a marsh or swamp

# APPENDIX B
## *Methods for Stream Sampling*

**Using a D-Frame Net** (After Mitchell and Stapp, 1988)

*Note:* This method has the advantage of being potentially a one-person job, and is recommended for muddy-bottom streams.

1. Standing facing downstream, hold the net upright with the bag resting on the bottom and open upstream.
2. Shuffle your feet vigorously along the bottom while moving sideways across the stream, keeping the net in front of you to catch dislodged organisms.
3. In soft substrates, repeatedly run the net along the bottom, washing excess mud and organic material from the net.
4. Transfer collected organisms to a wide-mouth jar containing 70% ethanol, or sort and release.

**Using a Kick-seine** (After IWLA SOS materials)

*Note:* This method works best when three persons team together.

1. Select a fast-moving area of the stream 3–12 inches deep and with stones 2–10 inches or larger. (This is ideal habitat for aquatic insects.)
2. Two persons are to position the kick-seine downstream of the riffle, making sure the bottom edge fits tightly across the substrate. (Use rocks to hold it down if necessary.)
3. The third person is to disturb a 3-foot × 3-foot area of the stream bottom directly upstream of the kick-seine. This involves brushing all rock surfaces to dislodge insects and stirring up the bed with your hands and feet.
4. For 60 seconds, kick the streambed with a sideways motion toward the net to bring up ground-dwellers.
5. Remove the seine with a forwards scooping motion, trying not to allow any insects from being washed off the surface of the net.
6. Place the net on a flat, light-colored area and use tweezers to remove all specimens to the collecting jar.

**Using a Surber Stream-bottom Sampler** (After Brewer and McCann, 1982)

*Note:* This method uses one person in the stream and two or more on the bank.

1. Select a riffle deeper than the frame of the Surber sampler.
2. Wade to the site from downstream and position the sampler firmly on the bottom with the mouth facing upstream.
3. Pick up all rocks from within the frame and pass them to shore, where two or more persons are to use nail brushes and forceps to dislodge and remove insects.
4. Use a trowel to stir up the substrate and float organisms into the net.
5. Remove the Surber sampler from the stream and transfer the organisms to the collecting jar, turning the net inside out to remove any clinging animals.
6. Replace the rocks into the sampled area of the streambed.

# APPENDIX C
*Methods for Interpreting Data*

**Sequential Comparison Index** (After Brewer and McCann, 1982)

*Note:* This method was developed by J. Cairns in 1968 for use by non-biologists doing stream-pollution studies and is rather subjective. Mitchell and Stapp (1988) recommend sampling from all substrate types at a site, including mud and aquatic plants, when this evaluation method is to be used.

1. Dump the *well-mixed* contents of a collection jar into a "sorting tray" with lines marked off in it.
2. *Randomly* line up the specimens in rows.
3. A *"run"* is defined as a series of animals that look alike (same size, color, shape).
4. Compare each animal to the one next to it in line, moving from left to right on one row, then from right to left on the next row, grouping the specimens into "runs" of one or more animals. (Even if two adjacent specimens are just different stages of the same species, consider them as belonging to different "runs".)
5. The *"sequential comparison index"* (SCI) is equal to the total number of runs divided by the total number of organisms ($n$).
6. SCI ranges from $1/n$ (no diversity) to 1 (none alike).

**Subjective Index of Water Quality**
(Adapted from the materials from the Tennessee Scenic Rivers Association)

*Note:* This method depends only on the number, color, and variety of organisms present and does not require identification of species.

1. Sort the specimens in the sample into look-alike groups on the basis of body shape and numbers of legs and tails.
2. Estimate water quality by referring to the table below:

| Water Quality | Number of kinds of organisms | Coloration |
|---|---|---|
| Good | 6 or more | More than 30% are tan, brown, black, or green |
| Fair | 3 to 6 | 11 to 30% are tan, brown, black, or green |
| Poor | 1 or 2 | 90% or more are red, white, or gray |

# APPENDIX D
*Resource Materials*

## Print Materials on Benthic Macroinvertebrates and Collection Techniques

Brewer, R. and McCann. 1982. Lab and field manual of ecology. Holt, Rinehart, and Winston, NY. [This manual explains calculation of the Sequential Comparison Index, use of a Surber stream-bottom sampler, and construction of a home-made Hester-Dendy sampler.]

Caduto, M.J. 1985. Pond and brook: A guide to nature study in freshwater environments. Prentice-Hall, Englewood Cliffs, NJ. [According to the Preface, this book "takes a holistic-ecological view of the complex world of freshwater life." After building a conceptual framework in the first two chapters, each succeeding chapter concludes with a section titled "Explorations and Activities" which describes simple techniques for studying freshwater environments. Chapter 5 has a good description of stream insects and the environmental conditions they experience.]

Klein, R. Three guides: *Hands-on Streams and Rivers* (31 pages), *Preservation and Enhancement of Stream Quality* (34 pages), and *Stream Quality Assessments* (23 pages). [Available from: The Izaak Walton League of America, Inc., 1401 Wilson Blvd., Level B, Arlington, VA 22209. For current prices ask for the Save Our Streams publication list.]

Mitchell, M.K., and W.B. Stapp. 1988. Field manual for water quality monitoring: An environmental education program for schools. Thirds Edition. Thomson-Shore, Dexter, MI.
[This manual describes the monitoring procedures used in the 1987 Interactive Rouge River Water Quality Project, in which 32 high schools and middle schools in Michigan, linked by a computer network, used nine physical-chemical tests to calculate an Index of Water Quality at their assigned sites. For persons interested in biological monitoring, Chapter 4 provides a 43-page comprehensive introduction to "benthic macroinvertebrates" and the major environmental factors which affect them. Available from: William B. Stapp, 2050 Delaware, Ann Arbor, MI 48130.]

## Sources for Audiovisual Materials

Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905 (800-526-4264).
[The 1990 catalog lists several slide sets on aquatic ecology and aquatic invertebrates.]

The Izaak Walton League of America, 1401 Wilson Blvd,. Level B, Arlington, VA 22209.
[A 28-minute video on the Save Our Streams program is available on loan from local IWLA chapters, or for $15.00 from the national office.]

## Information on Monitoring Equipment

Accent! Science, P.O. Box 1444, Saginaw, MI 48605.
[Ask for the Field Biology Catalog, which lists Hester-Dendy samplers, and D-Frame nets.]

Brewer and McCann (1982). [See citation above.]

The Izaak Walton League of America. [See address above. The IWLA is a source for custom-made kick-seines and for instructions on home-made kick-seines and D-Frame nets.]