Water Quality Module

Good water quality in a watershed is a function of good physical, chemical, and biological properties which can sustain all uses; it is critical to sustain life. Human activities can definitely affect water quality in watersheds.

Introduction

Water quality is defined as the chemical, physical, and biological characteristics of water with respect to its suitability for a particular use. The quality of water in a river is a reflection of land uses and natural factors found in its watershed. Understanding a river's water quality and quantity involves investigating the condition of the watershed. If the watershed is polluted, the river will likely be polluted.

Physical parameters defining water quality include color, odor, temperature, solids (residues), turbidity, oil, and grease. Inorganic chemical parameters include salinity, hardness, pH, acidity, alkalinity, iron, manganese, chlorides, sulfates, sulfides, heavy metals (mercury, lead, chromium, copper, and zinc), nitrogen (organic, ammonia, nitrite, and nitrate), and phosphorus. Biological parameters include coliforms, fecal coliforms, specific pathogens, viruses, and diversity indexes.

Water quality plays an important role in the health, abundance, and diversity of aquatic life. Excessive amounts of some constituents, algae, nutrients, and suspended particles, or the lack of others, including dissolved oxygen, can result in imbalances in water chemistry. Episodic or prolonged imbalances can potentially degrade aquatic life enough to harm the food chain, our fishing and recreational industries, and even the air we breathe.

The increasing impacts of human activities on aquatic resources have spurred a renewed sense of stewardship. The Volunteer Water Quality Monitoring Program of Missouri STREAM TEAMs is valuable to government monitoring programs. Volunteers trained and equipped to monitor various physical, chemical, and biological factors are providing high quality data. Trained citizens groups are collecting credible data and are making significant contributions to our knowledge of water quality.

Successful citizen water quality programs include: a basic understanding of how physical, chemical, and biological test methods work, which helps avoid confusion and errors in monitoring. An understanding of significant levels of various water quality parameters puts in perspective the health of a stream. Interpreting results from water quality monitoring is important to formulate plans for improvement of a stream's health.

Water pollution problems are defined as the overabundance of one or more natural or human made substances in water. These are divided into two major types:

1) Point source pollution is traced to a single source, like a pipe, culvert, or ditch. Most people can identify point source pollution problems, including discharges from pipes from manufacturing plants, or discharges of sewage.

2) Nonpoint source pollution is a more subtle water quality problem, originating from a much wider area. It often depends on rain or wind to deliver the pollutant to the stream. Soil from eroded fields, acid runoff from old strip mine areas, and runoff from livestock feedlots are examples of nonpoint sources.

A visual inspection of a stream is the first step in determining water quality problems. However, not all water quality problems are detected this way. Color, smell, and the presence of any stream bed coating are indicators of problems.

BIOLOGICAL TESTING

Biological testing is an important means of measuring the water quality of a stream. In biological testing, water quality is evaluated by the presence or absence of macroinvertebrate populations, which indicate the overall health of the ecosystem. Macroinvertebrates are invertebrates, large enough to be seen with the naked eye, that inhabit rivers, streams, lakes, and ponds. These animals are benthic (bottom dwellers) and are associated with bottom substrates such as rocks, logs, sediment, debris, and submerged plants. Macroinvertebrates typically include immature forms of aquatic insects, aquatic worms, crustaceans, and mollusks. As noted on the *Stream Insects and Crustaceans* card provided in a previous lesson, the macroinvertebrates are arranged into three categories or taxa according to their sensitivity to pollution. The three taxa are sensitive, somewhat sensitive, and tolerant. Additionally, an important factor in giving a stream a water quality rating is the diversity of the populations found in the stream system. Healthy and stable ecosystems are characterized by greater diversity of organisms. Pollution tends to reduce species diversity by eliminating organisms that are sensitive to organic and other pollutants entering their environment. The Missouri Stream Team protocol is used to sample macroinvertebrates and rate the water quality in your adopted stream. This method involves disturbing a 3' x 3' riffle (shallow, fast moving area of the stream where water tumbles over rocks) to collect macroinvertebrates living in the substrate. To dislodge the organisms, rocks are rubbed clean and the streambed is disrupted by kicking and shuffling as deep as six inches. The organisms are caught in a kick net or seine, and the types and numbers of macroinvertebrates are sorted and counted. This data is used to calculate a water quality index value. Different times of the year will produce different results. Therefore, it is important to monitor during the four seasons at the very least.

Evaluating water quality requires experience and training. Water quality seminars are available for those wanting to learn more about monitoring. Call 1-800-ST1-1989 for more information or visit the Stream Team website at www.mostreamteam.org and check out the Water Quality Monitoring workshop schedule for a workshop near you. The introductory class covers the macroinvertebrate monitoring techniques.

Captured Critters

Lesson Abstract

Summary:	Students learn some of the common benthic aquatic macro-invertebrates used as water quality indicators and determine how long-term monitoring indicates water quality trends.
GLE:	SC4.1.A.6, 4.1.B.6,4.1.D.6, 4.3.C.6, 5.3.A.6
Subject Areas:	Science
Show-Me Standards:	Goals – 1.3, 1.6, 1.8, 3.5, 4.1 Strands – SC 3, 4, 5, 8
Skills:	Matching, identifying, comparing and contrasting
Duration:	1 class period (50 minutes)
Setting:	Classroom/Stream (optional)
Key Vocabulary:	Benthic, benthos, aquatic, macroinvertebrates, taxa

Rationale:

- The types of insects that live in water reflect the quality of the water.

Student relevance:

- Students will identify common aquatic macroinvertebrates that indicate water quality conditions and understand the taxa grouping as it relates to water quality

Learning Objectives:

Upon completion, students will be able to . . .

- Identify the most common benthic macroinvertebrates determining water quality.
- Recognize that taking multiple samples of benthic macroinvertebrates over a period of time will show changes in water quality.
- Understand the need for scientific protocol in sampling.

Students Need to Know:

- How to match line drawings to macroinvertebrates and read names from a chart.
- Insects and other animals live in surface water.

Teachers Need to Know:

- The basic concepts in using macroinvertebrates as indicators.
- A greater diversity of macroinvertebrates indicates higher water quality, when two similar streams are compared.
- All surface waters in the world have some degree of contamination.

Resources:

McCafferty, W. Patrick. *Aquatic Entomology: The Fisherman's Guide and Ecologists' Illustrated Guide to Insects and Their Relatives.* Jones & Bartlett Publishers, 1983

Mitchell, M.K. and W.B. Stapp. *Field Manual for Water Quality Monitoring – An Environmental Education Program for Schools.* Ann Arbor, MI 1992.
Available from Global Rivers Environmental Education Network (GREEN), 721 East Huron, Ann Arbor, MI 48104, (313)761-8142

DePew, Jeffrey C., Suzanne F. Reed and Jennifer L. Gleason. *Stream Ecology: A Journal for Action.* St. Louis, MO: Missouri Botanical Garden, 1993.

Save Our Streams Program
Information available from the Izaak Walton League of America (IWLA), 707 Conservation Lane, Gaithersburg, MD 20878, 1-800-BUG-IWLA.

Missouri STREAM TEAM Program
Information available from the Missouri Department of Conservation, Stream Team Section, P.O. Box 180, Jefferson City, MO 65102-0180, (573)751-4115 or 800-781-1989

Flyfishing Organizations (see Resource References in the back)

Materials Needed for Lesson: Classroom Activity

Stream Insects & Crustaceans Chart (one copy per student or team) – chart provided in previous lesson
Stream Insects & Crustaceans Chart (cut out individual bugs from four copies)

Scissors
Rulers
Plain paper
Pencils
Large box or container

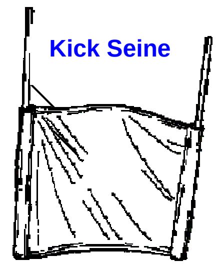
Materials Needed for Lesson: Stream Activity

Stream Insects & Crustaceans Chart (one copy per student or team) – chart provided in previous lesson. If you can laminate these bug cards it is recommended because of the proximity to water.

Macro Invertebrate ID Critter Cards (Color Photos) MDC

White ice cube trays for each group of students to have one.

A kick net seine for each group. Kick nets can be made by stapling a 3'x3' section of fine nylon screen wire to two dowel rods 1 ¼" diameter by 4 ½' long.
Tweezers (per student)
Magnifying glasses



Kick Seine

Procedure: Classroom Activity

- This activity can be done with students working individually or in teams.
- Thoroughly mix critter cut outs in a large box or container.
- Have each team draw out 10 critters and determine the general water quality using a copy of the *Stream Insects & Crustaceans Chart* with a rating of good, fair or poor.
- To determine water quality, students will assign a value to each critter based on taxa group number. Group One taxa critters = 1, Group Two = 2, and Group Three = 3. The lowest sum equals better water quality.
- Tell students to draw a timeline to represent three samplings.
- Record the water quality sum on the timeline for each sampling (determined by three separate drawings).
- Note: Be sure all critters are returned to box for each sampling. On the third sample, take out all Group One Taxa without students' knowledge to show poor water quality.
- Determine the trend in water quality from the time line.
- Have students discuss what factors in the watershed are responsible for trend changes.
- Have groups share their findings.

Procedure: Stream Activity

- Locate a suitable site with a riffle. Be sure to keep safety in mind and don't choose a riffle more than knee deep to your smallest students.
- Collect three net sets of invertebrates from three different

microhabitats. This ensures a complete picture of what lives in your stream and more accurately reflects stream health.

- If possible, take all three net sets from different areas within a stable riffle. Microhabitats to sample include differences in: rock size, flow, leaf packs, and emergent vegetation.
- Always work in an upstream direction so that sampling activities do not disturb portions of the riffle to be sampled later.
- If, and only if, you do not have a riffle at your site, or the riffle is too small to get three net sets out of it, you may also want to sample root mats and/or woody debris.
    - Prioritize sampling of macrohabitats as follows:
        - Riffles
        - Root mats
        - Snags
        - Non-Flow
    - Whatever you decide to sample at your site (e.g.: two riffle net sets and one root mat), always sample those same three microhabitats at the site every time you sample there. This will ensure that the data you collect remains consistent over time.

Sampling Streams With Riffles

Sampling requires at least two people; one to hold the net and the other to dislodge invertebrates from the substrate or two students on the net and two rubbing rocks and (stream dancing) works even better. The rest of the team will pick bugs from the net and sort into the ice trays.

1. **Place** the net in the riffle facing upstream and tilted enough to provide a "pocket."
2. **Ensure the bottom of the net** is on the stream bottom leaving no room between the net and substrate (prevents organisms from washing under net).
3. **Rub all large stones** in the 3'x3' area immediately upstream of the net to dislodge invertebrates and wash them into the net.
4. **Dance** and **kick** with your feet in the 3'x 3' area until you have disturbed all of the substrate 3-6" deep to dislodge the invertebrates into the net.

Streams Without Riffles (or without riffles not large enough for 3 net sets)

Sample collection from Root Mats – Adequate sampling requires two people.

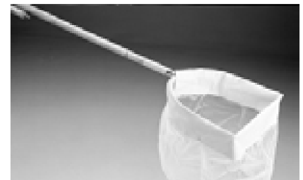
1. Have one student place the kick net against the bank on the downstream side of the root mat.
2. Make sure that the net is anchored at the bottom**.**
3. The other student will then kick the root mat **in a swirling motion** with one foot to create a circular current in order to dislodge the invertebrates from the root mat. The circular motion of the sampler's foot will drive the invertebrates into the net, even if there is not a current.

Sample Collection from Snags – Adequate sampling requires two people.

1. Have one student hold the net in a horizontal position 6-12" under the water.

2. The 2nd student will remove the snag from the water. When removing snags from the water, pull the snag out of the water quickly. If the snag is removed too slowly the invertebrates may swim off.
3. Brush the snag down with a brush above the net to dislodge invertebrates.

Sample non-flow area in the same manner as a riffle, collecting three separate samples. However, the samplers will need to use a swirling motion with the foot to create a current to move debris into the net. Although this habitat can be sampled using a kick net, it is easier with a D-frame net.


D-Frame Net

- Scoop the net forward after disturbing the substrate and take the net to the bank and begin picking the bugs from the net and sort them into the ice cube trays.

- After each method, identify the invertebrates and determine if they are sensitive, somewhat sensitive or tolerant. Based on the absence or presence of the sensitive organisms you can get a general idea of the long term quality of the stream. Any bugs not identified can be taken back to class and researched for identification.

Evaluation Strategies:

- Have students infer where they would find the different pollution tolerant and intolerant insects.
- Have students make a list of watershed land use practices that would increase or decrease intolerant aquatic macroinvertebrates.

Extension Activities:

- Have students adopt a critter, research and create a story about their pick (what their baby pictures were like, their jobs and careers, who came to dinner, an obituary of how they died, etc.).
- Have students write a summary of the field trip and make their own inferences as to the quality of the stream monitored.
- If you have small clear vials and alcohol available the students can start a reference collection by preserving specimens.
- Join Missouri STREAM TEAM Volunteer Water Quality Monitoring Program – adopt a stream, attend workshops, and begin monitoring.

Suggested Scoring Guide:

Captured Critters

Teacher Name: ____

Student Name: ____

CATEGORY	4	3	2	1
Contributions	Routinely provides useful ideas when participating in group and classroom discussions. A definite leader who contributes a lot of effort.	Usually provides useful ideas when participating in group and in classroom discussions. A strong group member who tries hard!	Sometimes provides useful ideas when participating in the group and in classroom discussion. A satisfactory group member who does what is required.	Rarely provides useful ideas when participating in the group and in classroom discussion. May refuse to participate.
Focus on the task	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Other group members must sometimes nag, prod, and remind to keep this person on-task.	Rarely focuses on the task and what needs to be done. Lets others do the work.
Problem Solving	Actively looks for and suggests solutions to problems.	Refines solutions suggested by others.	Does not suggest or refine solutions, but is willing to try out solutions suggested by others.	Does not try to solve problems or help others solve problems. Lets others do the work.
Monitors Group Effectiveness	Routinely monitors the effectiveness of the group and makes suggestions to make it more effective.	Routinely monitors the effectiveness of the group and works to make the group more effective.	Occassionally monitors the effectiveness of the group and works to make the group more effective.	Rarely monitors the effectiveness of the group and does not work to make it more effective.
Preparedness	Brings needed materials to class and is always ready to work.	Almost always brings needed materials to class and is ready to work.	Almost always brings needed materials but sometimes needs to settle down and get to work.	Often forgets needed materials or is rarely ready to get to work.
Working with Others	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together.	Usually listens to, shares with, and supports the efforts of others. Does not cause "waves" in the group.	Often listens to, shares with, and supports the efforts of others, but sometimes is not a good team member.	Rarely listens to, shares with, and supports the efforts of others. Often is not a good team player.

Rubric Made Using: **RubiStar** (http://rubistar.4teachers.org)

Inspector Bright

Lesson Abstract

Summary:	Optical brighteners are present in laundry detergents to make clothes "whiter" after washing. Optical brighteners exhibit fluorescence under a black light. The presence of optical brighteners in surface water or groundwater is a qualitative indicator of contamination from sewage. (This activity was created by Tom Aley of Ozark Underground Laboratory, Protem Missouri.)
GLE:	SC7.1.A.6, 7.1.B.6, 7.1.C.6, 7.1.D.6, 7.1.E.6,
Subject Areas:	Science, Mathematics
Show-Me Standards:	Goals – 1.2, 1.3, 3.1, 3.4, 3.5, 4.7 Strands – SC 5, 7, 8; MA 1
Skills:	Measuring, making comparisons
Duration:	2 class periods (50 minutes), one week apart
Setting:	Field and classroom
Key Vocabulary:	Optical brighteners, black light

Rationale:

- Everyone uses cleaning materials to wash clothes. Advertisements emphasize whiter and brighter are cleaner.
- Students will determine basic contamination of water by household cleaning agents.
- Discovery of optical brighteners can signal a need to monitor for fecal coliform, phosphates, and nitrates in a stream or other water sources.
- Being able to test for contaminants helps determine the safety of surface and ground water.

Student relevance:

- Students will identify if household cleaning agents are getting into streams or springs.
- By studying the effects of household cleaning agents, students have a better understanding of one source of nonpoint water pollution.

Learning Objectives:

Upon completion, students will be able to . . .

- Students will write a hypothesis, summary of the experiment and conclusions derived from the experiment.
- Identify water contaminated by household cleaning agents.
- Determine how individual households impact water quality.
- Understand how product selection for household use can have an effect on the environment.

Students Need to Know:

- Water is an integrated part of life.
- How to conduct an experiment using the scientific methods. (Scientific Inquiry)
- Wastewater must go somewhere.
- Wastewater from a home is a nonpoint pollutant if not properly handled.

Teachers Need to Know:

- All laundry detergents have optical brighteners that range from one to five percent.
- Most laundry waters are discharged to septic fields, lagoons, and sanitary sewers.
- When optical brighteners are found in streams, they are an indicator of sewage contamination.
- Other indicators of sewage contamination are high levels of fecal coliform and phosphates.

Resources:

Thomas Aley, Hydrogeologist, Ozark Underground Laboratory, 1572 Aley Lane, Protem, MO 65733, (417)785-4289.

Materials Needed for Lesson:

White cotton balls (test that cotton balls do not have brighteners by soaking in distilled water and checking under a black light)
Assortment of laundry detergents (students can bring from home)
Distilled water
Black light
Containers
Plastic coated wire
Nylon screen mesh
Plastic sandwich bags
Thread and needle or stapler
Hole punch

Procedure:

- **Introduction to lesson:**
  (1) Discuss laundry detergent ads with students. Ask what the ads emphasize. As a homework assignment, ask students to pay attention to such ads for the next week and write down how many times bright is mentioned.
  (2) Ask students to bring a small sample of the laundry detergent they use at home.
  (3) Mix an equal amount of each type of detergent with tap water in individual containers labeled with the name of each soap. Soak a cotton ball in each cup for a day.
  (4) Place cotton balls under the black light, then rank each for level of brighteners.
  (5) Discuss where laundry water goes after leaving the washer.
  (6) Explain to students that they will make a bug detector device to determine if laundry water with optical brighteners is entering nearby streams.
- **Making the detector bug device:**
  (1) Fold screen material into the shape of a small envelope.
  (2) Place four cotton balls (that have been tested and found to not contain optical brighteners) into screen envelope and sew or staple closed.
  (3) Hole punch at the top and bottom of the bug detector device.
- **Placing the bug detector device in water:**
  (1) Thread a foot of wire through the bottom hole and attach a rock or weight.
  (2) Secure a piece of wire to an overhanging tree limb, deck, etc. and attach to top hole of the device. Position so the device is below the surface of the water and in as much current as possible.
  (3) Leave the device in the water for a week.
- **Recovery and storage:**
  (1) Recover the device after one week and put it in a new and clean ziplock bag to transport it to the place where it will be washed.
  (2) Wash the device in strong jets of water such as a garden hose sprayer. Sprayers on household sinks do not have enough pressure to get the samplers clean.
  (3) You may store the cotton at this point by placing washed cotton in plastic bags and storing in refrigerator for no more than one month.
- **Preparation**:
  (1) Prepare a control negative sample by soaking a cotton ball in distilled water.
  (2) Expose washed cotton and control cotton ball to black light for comparison.
- **Interpreting results:**
  (1) If the washed cotton sample is entirely brighter compared to the control – there is strong contamination in the water.
  (2) If washed sample is not brilliantly white yet whiter than the control – there is moderate contamination.
  (3) If less than 75 percent of the washed sample is white – there is weak contamination.
  (4) No detection of brightness compared to the control sample – there is no detectable contamination.
  (5) Have students write a hypothesis, summary of the experiment and conclusions derived from the experiment.

Evaluation Strategies:

- Have students write a letter to local city council members expressing need and reasons for proper wastewater treatment. Also discuss purpose of protective ordinances.

Extension Activities:

- Repeat this activity in various places and plot results on a watershed map.
- Write a newspaper article about the study.
- Have students bring in fabrics, articles of clothing, gauze, etc., and test each under a black light to determine use of optical brighteners.

Suggested Scoring Guide:

Inspector Bright

Teacher Name: ____

Student Name: ____

CATEGORY	4	3	2	1
Experimental Hypothesis	Hypothesized relationship between the variables and the predicted results is clear and reasonable based on what has been studied.	Hypothesized relationship between the variables and the predicted results is reasonable based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted results has been stated, but appears to be based on flawed logic.	No hypothesis has been stated.
Experimental Design	Experimental design is a well-constructed test of the stated hypothesis.	Experimental design is adequate to test the hypothesis, but leaves some unanswered questions.	Experimental design is relevant to the hypothesis, but is not a complete test.	Experimental design is not relevant to the hypothesis.
Safety	Lab is carried out with full attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual.	Lab is generally carried out with attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual, but one safety procedure needs to be reviewed.	Lab is carried out with some attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual, but several safety procedures need to be reviewed.	Safety procedures were ignored and/or some aspect of the experiment posed a threat to the safety of the student or others.
Analysis	The relationship between the variables is discussed and trends/patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experimental design could be changed.	The relationship between the variables is discussed and trends/patterns logically analyzed.	The relationship between the variables is discussed but no patterns, trends, or predictions are made based on the data.	The relationship between the variables is not discussed.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.

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