Standards-Based Module
(Lesson/Unit Plan)

Cover Page

Content Area: Life Science

Grade Level: 6, 7, and 8

Title of Lesson/Unit: Using Abiotic and Biotic Parameters to Monitor Water Quality: A Field Experiment

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SC LIFE

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Content Area(s): Life Science **Grade Level:** 6, 7 and 8

Time to Complete: (3) 50 minute class periods plus a field trip

Title of Lesson/Unit: Using Biotic and Abiotic Parameters to Monitor Water Quality: A Field Experiment

1. South Carolina State Standards Addressed

Grade 6

The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

6-1.1 Use appropriate tools and instruments (including a spring scale, beam balance, barometer, and sling psychrometer) safely and accurately when conducting a controlled scientific investigation.

6.1-4 Use a technological design process to plan and produce a solution to a problem or a product (including identifying a problem, designing a solution or a product, implementing the design, and evaluating the solution or the product).

6.1-5 Use appropriate safety procedures when conducting investigations.

Grade 7

The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.1 Use appropriate tools and instruments (including a microscope) safely and accurat ely when conducting a controlled scientific investigation.

7-1.2 Generate questions that can be answered through scientific investigation.

7-1.3 Explain the reasons for testing one independent variable at a time in a controlled scientific investigation.

7-1.4 Explain the importance that repeated trials and a well-chosen sample size have with regard to the validity of a controlled scientific investigation.

7-1.5 Explain the relationships between independent and dependent variables in a controlled scientific investigation through the use of appropriate graphs, tables, and charts.

7-1.6 Critique a conclusion drawn from a scientific investigation.

7-1.7 Use appropriate safety procedures when conducting investigations.

Grade 8

The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.1 Design a controlled scientific investigation.

8-1.2 Recognize the importance of a systematic process for safely and accurately conducting investigations.

8-1.3 Construct explanations and conclusions from interpretations of data obtained during a controlled scientific investigation.

8-1.4 Generate questions for further study on the basis of prior investigations.

8-1.5 Explain the importance of and requirements for replication of scientific investigations.

8-1.6 Use appropriate tools and instruments (including convex lenses, plane mirrors, color filters, prisms, and slinky springs) safely and accurately when conducting a controlled scientific investigation.

8-1.7 Use appropriate safety procedures when conducting investigations.

2. Lesson/Unit Description:

Students will identify the abiotic factors that influence a river or stream and the organisms that live in it. Abiotic factors include: water flow, temperature, pH, turbidity, dissolved oxygen, biological oxygen demand, nitrates, phosphates, and fecal colliform bacteria. They will then measure several abiotic and biotic parameters to gauge water quality. Students will examine the biotic environment by identifying the aquatic organisms they collect and, by using the Pollution Tolerance Index (from the Izaak Walton League of America and the Ohio Department of Natural Resources), determine the water quality value for that body of water. Students will write a scientific paper which will include an Introduction, Materials and Methods, Results, Discussion, and References section describing their biotic and abiotic assessments of water quality and explain their results.

3. Focus Question(s) for Students:

1. What are abiotic characteristics of a stream or river?
2. What is Biomonitoring?
3. What was the water quality of the water body you sampled?
4. How can you explain your results?

4. Culminating Assessment:

1. Discuss abiotic (dissolved oxygen, pH, temperature, stream bed description (sand vs. rocks vs. pebbles, etc.) water flow, sediment deposition patterns, etc.) features of a stream or river (refer to PowerPoint presentation).
2. Discuss organisms that live in the stream or river (refer to PowerPoint presentation).
3. Discuss biomonitoring (refer to PowerPoint presentation).
4. Measure the abiotic characteristics of the stream or river using the water quality kit provided and record the results.
5. Using the Pollution Tolerance Index, determine the water quality of the stream sampled.
6. Write a paper describing the results and provide explanations for getting those results. Include in that paper an Introduction, Materials and Methods, Results, Discussion, and References section.

<u>Student Directions:</u>

1. Have the students identify the different zones found in a stream or river.
2. Collect abiotic information from several different sites along the river (student handout #1).
3. Collect aquatic insects from those same sites, label them, and, using the Pollution Tolerance Index Images, measure the water quality at your site (student handout #1 and #2).
4. Write a paper describing the results and explain those results. Include in that paper an Introduction, Materials and Methods, Results, Discussion, and References section.

5. **Materials/Equipment/Resources:**

   Per Class:

   Kick net and white pans (*in SC LIFE equipment footlocker*)
   Temperature and pH probe (*in SC LIFE equipment footlocker*)
   Water quality test kit (*in SC LIFE equipment footlocker*)
   Field guides of aquatic insects (see *Additional Resources*)
   Stop watch (*in SC LIFE equipment footlocker*)
   Plastic or foam ball

   Per Group:

   Collection vials to view insects
   Forceps (*in SC LIFE equipment footlocker*)

   Per Student:

   Student handout #1
   Student handout #2
   Student handout #3
   Shoes they don't mind getting wet and dirty

6. **Teacher Preparation:**
   1. Read background information and be prepared to explain: what are abiotic properties of the stream and how to measure them, how to identify aquatic insects using the Pollution Tolerance Index image sheet, and what a pollution tolerance index means.
   2. Make sure PowerPoint presentation is ready and make copies of the student handouts.
   3. Identify a river area suitable for students to observe and collect aquatic insects. Be sure to check out any restrictions on specimen collection.
   4. Prepare and obtain materials/equipment (refer to teacher supplement if needed).
   5. Separate students into working groups of four. Arrange for at least one chaperone that is trained in First Aid and Community CPR and Outdoors Safety and bring a first aid kit.

Background Information

1. **Abiotic Stream Factors** (any contribution to the environment that is of a non-living nature)
   A. Areas of a stream
      i. **Riffles** (white water area usually with rock substrate protruding through the surface of the water)
      ii. **Runs** (area in between white water, without obstructions to water flow, usually with rock substrate, but can be sandy)
      iii. **Pools** (areas out of the main flow, backwater areas, eddies, usually with a sand or leaf debris substrate)

B. Water flow
   i. Water flow can affect what organisms live in the stream and can even influence body shape
   ii. Organisms that live in a fast moving stream evolve physical adaptations to compensate for the fast moving current. Adaptations include flattened bodies, ways of adhering to the substrate, claws or long legs for holding on, and even "suction cups".

C. Water temperature
   i. Temperature affects the amount of dissolved oxygen in the water, rate of photosynthesis by the plants, and sensitivity of organisms to toxic wastes, parasites, and disease
   ii. Canopy cover, elevation, latitude all affect water temperature

D. pH
   i. pH is the measurement of the amount of hydrogen ions in solution.
      a. For example: there are 1 x 10^{-7} moles per liter of H^+ ions in pure water and an equal concentration of OH^- ions (1 x 10^{-}7 moles per liter), so the pH is 7.
      b. A solution that has a concentration of 1 x 10^{-4} moles per liter of H^+ ions has a pH of 4 and a solution that has 1 x 10^{-2} moles per liter of H^+ ions has a pH of 2.
   ii. The scale ranges from 0 to 14, with 7 being neutral, below 7 being acidic, above 7 being basic
   iii. A pH of 5 to 8.5 is optimal for most organisms
      a. Rain water usually has a pH of 5.5 to 6.0
      b. Alkaline soils can have a pH of 8.0 to 8.5
      c. Sea water usually is close to 8.0

E. Turbidity
   i. Turbidity is the measurement of relative clarity of water. Turbidity is caused by suspension of organic (plant and animal material) and inorganic (sand, soil, silt) matter within the water column
   ii. Turbidity should not be confused with color, the water may be dark, but can still be clear (opaque vs. transparent)
   iii. Soil erosion, algal blooms, run-off from rain all affect turbidity

F. Dissolved oxygen
   i. Oxygen from the atmosphere dissolves readily into water until the water becomes saturated
   ii. Oxygen is also produced as a by-product of photosynthesis by aquatic plants, algae, and phytoplankton
   iii. Dissolved oxygen concentrations less than 3ppm (parts per million) causes stress, less than 2ppm will not support life, at least 5ppm is required for growth and activity of most organisms.
   iv. Cold water can hold more dissolved oxygen than warm. For example, at 28˚C, water is saturated with oxygen at 8ppm, but at 8˚C the water will be saturated at 12ppm oxygen. Fluctuations in water temperature during the day can also affect dissolved oxygen concentrations.

v. Excessive amounts of bacteria from sewage or large amounts of rotting plants can also decrease the saturation amount.

G. Biological oxygen demand

i. Biological Oxygen Demand is a measure of the amount of oxygen bacteria uses as they break down organic waste

ii. If most of the oxygen is used by the bacteria, there may not be enough left to sustain other aquatic organisms

H. Nitrate

i. Nitrate is a nutrient that acts as a fertilizer for aquatic plants

ii. Concentrations greater than 40ppm are considered unsafe to drink, unpolluted waters usually measure below 4ppm

iii. Nitrate can cause excessive growths of plant and algae, creating water quality problems

iv. Nitrate concentrations in water are affected by human and animal wastes, decomposing organic matter and run-off of fertilizers from farms and lawns

v. High concentrations of nitrate can affect the ability of our blood to carry oxygen

I. Phosphate

i. Phosphorus is also a nutrient that acts as a fertilizer for plants

ii. Concentrations greater than 0.03ppm contribute to increase plant growth

iii. Phosphorus can cause excessive plant and algae growth creating water quality problems

J. Fecal Coliform bacteria

i. Fecal coliform bacteria are naturally present in the human digestive tract.

ii. The presence of coliform bacteria in a water sample indicates sewage or fecal contamination

iii. When fecal coliform bacteria are found in well water or other of drinking water, they serve as indicators of fecal contamination and the possible presence of other bacteria that could pose a threat to human health

2. Introduction to Biomonitoring

A. Biomonitoring is the use of living organisms and their responses to different pollution levels to determine the quality of the aquatic environment

B. History of Biomonitoring

i. Began in Germany in the early 1900s where they looked at the decrease in oxygen and its affect on the insect makeup of the stream in response to contamination by sewage

ii. Came up with a list of indicator species. For example, tubificid worms were pollution tolerant, whereas caddisflies were not.

C. Used mainly in two ways:

i. Surveys before and after an impact

ii. Regular sampling or toxicity testing to measure compliance with mandated water quality standards

D. Why use aquatic insects for biomonitoring?

i. Aquatic insects are found in all areas (microhabitats) within the stream

ii. Various aquatic insect species exhibit a specific tolerance levels to

iii. environmental stress

iv. They do not move as much as fish, for example, so it is easier to determine an affected stream or river
v. Aquatic insects have long life cycles relative to other organisms so an idea of time can be determined
vi. Aquatic insects provide a movie vs. a snapshot of the water quality
vii. They are easy to collect without expensive equipment
viii. There are some problems in using aquatic insects for biomonitoring:
   a. Aquatic invertebrates do not respond to all types of impacts
   b. Insect distribution and abundance can be affected by other factors (i.e. current velocity and substrate type)
   c. Their abundance can vary seasonally
   d. Dispersal activities can carry them into areas where they do not normally occur

E. For this water quality test, certain indicator species have been placed in three groups with each group given a numeric rating
   i. Group 1 taxa is pollution intolerant and given a rating of 3
   ii. Group 2 taxa is not as pollution intolerant and given a rating of 2
   iii. Group 3 taxa is pollution tolerant and given a rating of 1
   iv. To determine a numerical assessment of a Pollution Tolerance Rating for a stream, you would identify the aquatic insects in your sample and determine how many types are in each of the three groups. A type is counted only once.
      a. For example, even though you collected 4 caddisflies, you can only count them once.
   v. After determining the number of types of insects in each group, the numbers for each group are added together. This value is compared to the Pollution Tolerance Index (student handout #1) to determine the water quality of the stream.
      a. See student handout #1 for an example of how to use the Pollution Tolerance Index

7. Procedures:

1. Introduction to the Topic:
   A. Use the PowerPoint presentation to introduce abiotic components of a stream or river.
   B. Use the PowerPoint presentation to introduce the students to aquatic insects and why they can let us know about the quality of the water in which they live.
2. Teacher Directed Discussion:
   A. As you view the presentation, ask the students to help identify abiotic characteristics of a stream or river.
   B. Discuss why water quality is so important.
3. Equipment and Skills Demonstration:
   A. Demonstrate how to use the various probes and test kits to collect data on abiotic stream conditions and how to record this information on the data sheet provided (student handout #1).

B. Demonstrate how to use the kick net to collect specimens from the stream.
C. Show the students how to transfer specimens to collecting vials for viewing.

4. Student Activity:
   A. Field Trip:
      i. Place students in their groups, identifying the principal investigator, materials manager, reporter and other roles.
      ii. Have the students take abiotic data and biotic observations (use student handout #2) for each of the locations and record them on the data sheet (student handout #1).
   B. Experimental Design:
      i. After identifying which group the insects collected belong in, plug in the numbers to the Pollution Tolerance Index equation, and look up the stream quality assessment based on the Cumulative Index Value.
      ii. What was the water quality?
   C. Independent Practice:
      i. Each student will write a paper explaining their results and discuss possible explanations for their results. They will also include an introduction, materials and methods, and reference section.

8. Differentiation of Instruction:

1. Gifted and talented students can access web sources from the recommended list to enrich their learning experience.
2. Students unable to participate in field experiences can access virtual field trips through various websites and CDs.

9. References

Cummings, Richard.W. and Kenneth W. Cummins. 1978. An Introduction to the Aquatic Insects of North America. Kendal Hunt Publishing Company, Dubuque, Iowa.

Lehmkuhl, Dennis M. 1979. How to Know the Aquatic Insects. Part of the Pictures Key Nature Series. WCB/McGraw-Hill, Boston, Massachusetts.

10. Additional Resources

Web Sources:

http://virtual.clemson.edu/groups/SCLife/weblinks/Animal%20Links.htm
http://www.nearctica.com/
http://www.zo.utexas.edu/faculty/sjasper/beetles/index.htm
http://www.ipm.iastate.edu/ipm/hortnews/1992/5-6-1992/water.html
http://www.ent.iastate.edu/list/k-12_educator_resources.html
http://www.streamnet.org/
http://entweb.clemson.edu/database/trichopt/
http://www.insect-world.com/insects/six.html

http://www.famu.org/mayfly/
http://www.iwla.org/sos/

Books:

Borror, Donald J., Charles A. Triplehorn, and Norman F. Johnson. 1989. An Introduction to the Study of Insects. Harcourt Brace College Publishers, New York.

Brigham, Allison R., Warren U. Brigham, and Arnold Gnilka, editors. 1982. Aquatic Insects and Oligochaetes of North and South Carolina. Midwest Aquatic Enterprises, Mahomet, Illinois.

Bland, Roger G. and H.E. Jacques. 1978. How to know the Insects. 3rd Edition. WCB/McGraw Hill.