



## Classroom Lesson Development

Title of Lesson **Bioremediation at Quesada Ranch, Coffee Plantation, Quesada Community, Guatemala**

RET Project Connection Remediation of soil and groundwater, Dr. Akram Alshwabkeh

RET Teacher Jessica E. Quinn

School Revere High School

Town/District Revere

Subject(s) taught Biology

Subjects covered in lesson Scientific Inquiry and Ecology

Grades appropriate 9, 10

Lesson duration 8 50-minute periods or 6 50-minute periods and 1-80 minute period

Goals/Objectives of lesson Students will be able to:

- apply terms such as trophic levels, autotroph, producer, heterotroph, herbivore, carnivore, omnivore, decomposer, and detritivore
- learn about nitrate, its sources, and problems associated with nitrate contaminated water
- generate an hypothesis and design an experiment to test the affect of two carbon sources on biological nitrate reduction
- make sample dilutions and test samples for nitrate with LaMotte chemical test kits
- measure properties of water: dissolved oxygen, pH, and nitrate
- quantify data to compare hypothesis and experimental data
- write a report which will explain and summarize the results of the experiment

Background information During the 2006-2007 school year, students at Revere High School raised \$250 to purchase a water buffalo for a family in Quesada Community, Guatemala.

While studying the best procedure for the bioremediation of water, environmental engineers often create microcosms of contaminated soil and water for observation. Nitrate contaminated soils require a carbon source because groundwater usually lacks organic matter. Students will create microcosms to test the affect of two different carbon sources on the success of bioremediation of the nitrate-contaminated water.

Students will be given a letter from an oxen farm asking them to analyze soil and groundwater samples from an aquifer that is polluted with nitrate. Questions are provided to guide students through designing an independent experiment. Explicit instructions are provided as well, most are new procedures to the students.

This curriculum also allows students to engage in a real life environmental engineering investigation. Students will study microbial processes that can be related to bioremediation of groundwater. Students will gain experience in designing an experiment, graphing and analyzing data, and drawing conclusions related to environmental engineering and ecology.

- Essential questions
1. How does the idea of trophic levels relate to bioremediation?
  2. Why is nitrate such a problem in soil?
  3. Can all contaminants be 'cleaned-up' the same way (i.e using bioremediation)?
  4. Do laboratory conditions differ from environmental conditions?

Links to Frameworks and Standards

## National SCIENCE AS INQUIRY

Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations.

Designing and conducting a scientific investigation requires introduction to the major concepts in the area being investigated, proper equipment, safety precautions, assistance with methodological problems, recommendations for use of technologies, clarification of ideas that guide the inquiry, and scientific knowledge obtained from sources other than the actual investigation. The investigation may also require student clarification of the question, method, controls, and variables; student organization and display of data; student revision of methods and explanations; and a public presentation of the results with a critical response from peers. Regardless of the scientific investigation performed, students must use evidence, apply logic, and construct an argument for their proposed explanations.

### THE INTERDEPENDENCE OF ORGANISMS

Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.

Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

### MATTER, ENERGY, AND ORGANIZATION IN LIVING SYSTEMS

As matter and energy flows through different levels of organization of living systems--cells, organs, organisms, communities--and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.

## State Scientific Inquiry

SIS1. Make observations, raise questions, and formulate hypotheses.

SIS2. Design and conduct scientific investigations.

SIS3. Analyze and interpret results of scientific investigations.

SIS4. Communicate and apply the results of scientific investigations.

## Ecology

Central Concept: Ecology is the interaction among organisms and between organisms and their environment.

6.3 Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels. Describe how relationships among organisms (predation, parasitism, competition, commensalism, mutualism) add to the complexity of biological communities.

6.4 Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem, and how oxygen cycles through photosynthesis and respiration.

Local Revere High School's curricula reflects Massachusetts State Frameworks and Standards

Materials required Microcosms:

- 10 250mL bottles with caps
- 2.5L 'polluted water' with a nitrate concentration of 100mg/L NO<sub>3</sub>-N
- 1.5Kg soil
- Sugar
- Apple cider vinegar
- Beakers
- LaMotte nitrate test kit
- DO probe/test kit
- pH probe/test kit

Observations/Discussions:

- Digital camera
- Journal (Ecology) notebook

\* Preparation of Nitrate Polluted Water

Before students prepare the microcosms the teacher will need to prepare 2 liters of nitrate polluted water. To prepare the polluted water, add 1.2 grams of sodium nitrate (NaNO<sub>3</sub>) to 2 L of water to obtain approximately 100 ppm NO<sub>3</sub>-N. 100 ppm together with enough carbon source (e.g. sugar) should allow adequate growth of pseudomonas and subsequent nitrate removal.

Lesson development This lesson is adapted from 'Bioremediation of Groundwater' by Deborah Sills, Cornell Science Inquiry Partnerships (CSIP) Graduate Student Fellow, Cornell University

Student Information

- How Organisms Obtain Energy (student reading)
- Trophic Levels Ecology Dictionary
- Letter from Quesada Ranch, Coffee Plantation, Quesada Community Guatemala
- Background information of Nitrate in Groundwater (student reading)
- \*\*\* still need to develop
- List of materials and procedure
- Data analysis
- Letter to Quesada Community
- \*\*\* still need to develop rubric for ... data tables, graphs, analysis, letter to ranchers

References <http://www.doe.mass.edu/frameworks/current.html>  
<http://www.speedway.k12.in.us/hs/projects/SStevens/Biology>  
<http://exploratorium.edu>  
<http://csip.cornell.edu>