2.3 Perform an Activity: Factors Affecting an Aquatic Ecosystem

Time

45–60 min

Skills

Planning
Controlling Variables
Performing
Observing
Analyzing
Evaluating
Communicating

Equipment and Materials

per student:
- eye protection
- lab apron

per group:
- large spoon or stirring rod
- 1 L beaker
- funnel
- hand lens
- graduated cylinder
- electronic balance
- eye dropper and Petri dish
- four 2-L plastic pop bottles
- marker
- 4 L pond water containing aquatic organisms
- liquid plant fertilizer (any general houseplant liquid fertilizer like 10:10:10)
- dropper bottle of dilute sulfuric acid
- weighing papers
- table salt

Assessment Resources

Assessment Rubric 4: Application
Assessment Rubric 6: Perform an Activity
Assessment Summary 4: Application
Assessment Summary 6: Perform an Activity
Self-Assessment Checklist 2: Perform an Activity

Other Program Resources

Skills Handbook 3. Scientific Inquiry Skills
Science Perspectives 9 website www.nelson.com/scienceperspectives/9

OVERALL EXPECTATIONS

- demonstrate scientific investigation skills in the four areas of skills
- assess the impact of human activities on the sustainability of terrestrial and/or aquatic ecosystems, and evaluate the effectiveness of courses of action intended to remedy or mitigate negative impacts
- investigate factors related to human activity that affect terrestrial and aquatic ecosystems, and explain how they affect the sustainability of these ecosystems
- demonstrate an understanding of the dynamic nature of ecosystems, particularly in terms of ecological balance and the impact of human activity on the sustainability of terrestrial and aquatic ecosystems

SPECIFIC EXPECTATIONS

Scientific Investigation Skills

- formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research
- apply knowledge and understanding of safe practices and procedures when planning investigations, with the aid of appropriate support materials
- conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data
- analyze and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty
- draw conclusions based on inquiry results and research findings, and justify their conclusions
- communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats

Relating Science to Technology, Society, and the Environment

- assess, on the basis of research, the impact of a factor related to human activity that threatens the sustainability of a terrestrial or aquatic ecosystem

Developing Skills of Investigation and Communication

- use appropriate terminology related to sustainable ecosystems, including, but not limited to: *bioaccumulation, biosphere, diversity, ecosystem, equilibrium, sustainability, sustainable use, protection,* and *watershed*
- plan and conduct an investigation, involving both inquiry and research, into how a human activity affects water quality, and, extrapolating from the data and information gathered, explain the impact of this activity on the sustainability of aquatic ecosystems

Understanding Basic Concepts

- compare and contrast biotic and abiotic characteristics of sustainable and unsustainable terrestrial and aquatic ecosystems
- identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

KEY CONCEPTS

- Terrestrial biomes and aquatic ecosystems are largely determined by their abiotic characteristics.

EVIDENCE OF LEARNING

Look for evidence that students can

- identify and describe what happens when the abiotic factors in an aquatic ecosystem are changed
- describe how humans are changing ecosystems
- explain how changes to an ecosystem can make it unsustainable

SCIENCE BACKGROUND

Effects of Fertilizer

- In aquatic systems nitrogen and phosphorous are usually in short supply, which limits the growth of aquatic plants. When nitrogen or phosphorous are added to an aquatic system in the form of fertilizer run-off, it stimulates rapid growth of algae (e.g., algal blooms). Some of the algae die and sink to the bottom where they begin to decompose. This increases bacterial decomposers that consume dissolved oxygen in the water. The lower oxygen levels harm other species such as fish and aquatic insects. In some cases, bacteria and algae growth can cause aquatic systems to lose all dissolved oxygen, and become so-called dead zones of anaerobic bacteria and very limited biodiversity.

Effects of Acid Rain

- Acid precipitation can be devastating to a freshwater ecosystem. When the acidity of water gets lower than pH 5, many adult fish species are killed and most fish eggs will not hatch. Fish are not the only organisms affected by acid precipitation. Other less noticeable species can also be eliminated by acid precipitation, including many insect species that fish, frogs, and other species rely on for a food supply.

Effects of Salt

- Almost 5000 kilotonnes of road salt are used on Canadian highways each year. As a result, runoff from melting snow contains salt that contaminates small nearby watersheds. When salt-laden water enters a pond or lake it sinks to the bottom disrupting the normal water composition, and depriving organisms of a fresh supply of oxygen.

TEACHING NOTES

Student Safety

- Have students wear eye protection and lab aprons.
- If students get acid on their hands, have them rinse with cold water for 10 minutes and notify the teacher.
- Note that sulfuric acid is particularly damaging to cotton clothing.

- Students are likely to be very interested in the aquatic organisms they find in their ecosystems. Some may be concerned that these small organisms may die when exposed to unfavorable conditions during this activity. For this reason, it is best to avoid including larger organisms like fish, tadpoles, and perhaps snails.
- Use this experiment as an opportunity to discuss science experiments that involve the use of living organisms. Ask students if people should be concerned about these same organisms when they utilize fertilizer and road salt.

Related Resources

Gizmos: Water Pollution, Pond Ecosystem

Desonie, Dana. *Biosphere: Ecosystems and Biodiversity Loss*. Chelsea House, 2007.

Science Perspectives 9 ExamView® Test Bank

Science Perspectives 9 Teacher eSource SUITE Upgrade

Science Perspectives 9 website www.nelson.com/scienceperspectives/9

Purpose

- In this activity, students will observe the effects of acid precipitation, salt, and excess nutrients on aquatic ecosystems.

Equipment and Materials

- Use clear (not coloured) bottles for the four 2-L plastic pop bottles.
- The dilute sulphuric acid should be 0.5 mol/L.
- Note that the pond water should be collected from a natural source. Including some fresh aquatic plants and material from the bottom of the pond will create a natural mix of assorted organisms—algae, small underwater plants, decaying vegetation, mud, and benthic organisms. This concentrated sample can be diluted with *non-chlorinated* water (or tap water that has been sitting for 24 hours).
- The total number of ecosystems prepared by the class can also be reduced to match available quantities, and students groups can rotate between four stations (control, salt, fertilizer, and acid) to conduct observations.
- This activity is best performed at a time when natural pond water is available and contains active living organisms—early fall or late spring are best.
- If measuring devices (electronic balance and graduated cylinder) are not available, students can use measured doses of different materials with a scoop, dropper, or spoon.

Procedure

- Explain to students that in this activity they will observe what happens to an aquatic ecosystem when it is exposed to fertilizer, acid rain, or salt. Invite students to make predictions about what they may discover during this investigation. Ask, *What happens to the salt used on roads during the winter? Where do you think it goes? How do you think fertilizer would affect aquatic life?*
- Before beginning Step 1, students should spend some time discussing the amount of each substance that they will add to each sample. Advise students to try to make their samples simulate actual conditions. They should not use amounts that are likely to be toxic to all life forms. Several millilitres of acid and fertilizer are reasonable and they should add no more than a few grams of salt. You may want to gather some data about amounts yourself and share with students; for example, 0.5 mL of sulfuric acid will lower the pH to a given level, 0.75 mL will lower the pH to a different level, and so on.
- You may want to suggest that groups coordinate the amount of substances they add. For example, one group could add 2 scoops of plant fertilizer, a second group could add 3 scoops, and so on. This will give the entire class multiple sets of data and conditions that they can compare with one another.
- Sample data for Table 1:

Table 1

Treatment	Contents	
	Starting material	**Added material**
control	1 L of pond water	none
plant fertilizer	1 L of pond water	10 mL liquid plant fertilizer
acid rain	1 L of pond water	1 mL of dilute sulfuric acid
salt pollution	1 L of pond water	4 g salt

- In Step 2, students are asked to design a sampling method to estimate abundance of the organisms in their treatments. Allow students time to examine the natural pond water before asking them to design a sampling method. This will allow them to see the variety and number of organisms that can be found in their sample and to anticipate the challenges they may face when trying to identify and compare numbers. (Note: Students will not be able to properly identify all the species—but they should be able to at least document their presence. Emphasize to students that describing the actual appearance and/or behaviour of an organism is much more scientifically valuable than knowing its name.)
- Ask, *How will you compare the variety and numbers of different organisms?* Guide students to realize that their sampling method must include three aspects: types of organisms to be counted (e.g., algae, plants, animals), a method of counting or estimating (e.g., taking a small sample of material from each bottle, or observing the bottles for 1 minute, or turning the bottles while observing), and a way to record the observed amounts (e.g., ranking the amount of organisms on a scale of 1 to 5, with 1 being the fewest and 5 being the greatest).
- The following Sampling Method is one possible design that can be used:
  - Students observe each bottle for 1 minute and rank the number of organisms in the bottle on a scale from 1 to 5 with 1 standing for "few to no organisms" and 5 standing for "a large number of organisms." You can suggest that students use the initial control as a ranking of 3. The students record their rankings in their observation table.
  - Observe and record the variety of species in your ecosystems. Students do not have to identify each species but should list them in a table and describe each with a few point form comments. For example:

Species #	Description	Characteristics
1	Aquatic plant species	2–6 cm long; bright green; many small narrow leaves
2	Aquatic plant species	1 cm across; only two leaves; floating on surface (might be duck weed)
3	Small diving beetle	5 mm in length; black shiny body; air bubble attached to body

- For Step 13, remind students that they must create a table in which they can record all their sets of data. Their table must be designed in such a way as to allow them to record three variables for each of the 4 bottles: number of organisms, algal growth, and variety of organisms (see sample table provided here). Alternatively, students could create 3 separate tables—one for each variable.
- Sample data for Step 13:

Day	Control			Fertilizer			Acid rain			Salt		
	Organisms	Algae	Variety	Organisms	Algae	Variety	Organisms	Algae	Variety	Organisms	Algae	Variety
start	3	2	8	3	2	9	3	2	8	3	2	8
3	3	2	8	3	3	8	1	1	5	2	2	3
6	3	3	7	3	4	6	1	1	4	2	1	3
9												

- Discuss the final results of the activity as a class. Ask *What might humans do to protect aquatic ecosystems?* (Students might recognize that using fewer fertilizers or less harmful fertilizers could help reduce algae blooms and other harmful effects on aquatic ecosystems. Using less salt on roads could reduce salt runoff, and decreasing emissions from factories could help reduce acid rain.)

Analyze and Evaluate

(a) Students should find that the ecosystem with added fertilizer had the greatest algae growth.

(b) Students should find that the control ecosystem maintained the greatest diversity of organisms. The ecosystem with the added fertilizer might yield the largest number of organisms—but it is likely to have fewer species.

(c) Student answers will vary, depending on the quantity of material added. The ecosystems with the greatest amount of added material will probably fare the poorest.

(d) Students should compare their results to their control sample, and recognize that how they altered the ecosystem affected its biodiversity.

(e) Students should compare results with other teams, and discuss any patterns that emerge from their data. Sample data might feature an increase in the total number of organisms in the fertilizer sample, but a decrease in the diversity of organisms. The acid sample might show that all large animal life was killed off with little damage to plant life, whereas the salt sample might show a similar but less drastic result.

Apply and Extend

(f) Sample answer: I think the control sample could sustain life over long periods of time because the number of organisms remained steady during the investigation. In the other samples, the number of organisms varied, which can lead to an imbalance and an ecosystem that cannot be sustained.

(g) A scientist might use a small model because it is easier to alter just one variable than in a large, complex ecosystem. If only one variable is altered at a time, it is easier to see the effect of that one change.

(h) Fertilizer, salt, and acid rain have a negative effect on the sustainability of aquatic ecosystems because the diversity and quantity of life decreases.

(i) Human activity: fertilizer use. (i) Fertilizers help farmers and homeowners grow food and maintain nice lawns. (ii) Fertilizers threaten water quality and sustainability by causing an overgrowth of algae and weeds that chokes out other plant life, produces toxins, and depletes the oxygen supply in the water. (iii) Using more natural forms of fertilizers could help, as well as using beneficial insects to control pests, and hand weeding. (iv) Yes, in my model ecosystem, fertilizer caused algae to grow, which over time caused other organisms to die out.

At Home

Have students investigate the use of fertilizers in their home or neighbourhood, addressing such questions as: *Where do you apply fertilizer—on house plants, flowers, lawns? What kind of fertilizer do you use? How much fertilizer do you use? What do you think happens to fertilizer once you put it on a lawn? Do you think the plants use all the fertilizer? What effects might the fertilizer you use have on local environments?* Encourage students to contact local environmental groups for additional information.

DIFFERENTIATED INSTRUCTION

- Logical/mathematical learners might enjoy the task of researching how much fertilizer, acid, and salt to add to their containers. Students can consult Internet sources that include environmental websites that specialize in acid precipitation, salt pollution, and fertilizer run-off. Once approximate concentrations of these substances are known, students can use their math

skills to formulate a plan for each substance. Encourage students to share their findings with the class so others can benefit from the research.

- Visual/spatial learners should take the lead in the observations for this activity. If available, these students might employ a microscope to examine each sample for organisms. Students may also take digital photographs of their observations.
- Verbal/linguistic learners can use what they learned in this activity to write newspaper editorials that attempt to answer the question, *What might humans do to protect aquatic ecosystems?* Students can post their editorials on the class blog, wiki, or website and/or submit them to actual newspapers for publication.
- Provide visual/spatial learners with a map of Canada and have them identify the areas with the highest industrialization. Ask, *Which areas are most prominently affected by acid rain?* Verbal/linguistic learners can contribute to this activity by presenting the information to the class. Ask, *What is the correlation between highly-industrialized areas and the acid rain affected areas of the country?*

Technology Connection

Have students investigate ways that factories can reduce emissions that cause acid rain. Have them investigate scrubbers and other technologies that can be used to combat this problem. Ask, *What are the pros and cons of these technologies? What can governments or people do to help implement these changes? Should governments or people intervene in how factories are run?*

ENGLISH LANGUAGE LEARNERS

- Pair up ELL students with non-ELL students during this activity. Partners should work together to recast each procedure step as a simple sentence.
- Difficult procedural steps can be broken down into simpler parts. For example, step 1 of the procedure can be broken down into smaller steps: *(a). Decide how much acid to add to the first container. (b). Decide how much salt to add to the second container.* Continue with other steps. Students can then use the steps they created to carry out the activity.
- ELL students can create a story board showing the procedure and results of their experiment. Students may wish to make an anecdotal comparison of the local water quality and that of their country of origin and share with the class the possible differences.