How does the agricultural water cycle affect water quality?

EDIBLE GARDEN PROGRAM (6-8)

Water Quality

(ILS 12E, 13B, 16E)

Overview

The key question for this Activity is, "How does the agricultural water cycle affect water quality?" And there is no better way for students to answer that than to grow and cook their own food. Using the Garden and Kitchen as the learning laboratories, they will inspire student inquiry and teach them about Sustainable Agriculture, specifically, local food production and consumption.

For the purpose of this curriculum sustainable agriculture shall be defined as follows: "Sustainable Agriculture is a system of food production, supported by consumers, where farming operations, practices and technologies *work in harmony* with the natural systems that sustain life on earth."

Suggested Grade Level

This curriculum is designed for middle school/junior high levels. The topics covered can be built upon in complexity throughout that age range.

Approximate Time

Session 1 requires approximately 1 hour and 30 minutes; session 2 requires about 30 minutes, spread over several observation periods. This activity is meant to follow the Water Cycle activity from this curriculum.

Objectives

1. The students will learn to determine water quality by testing for pH, nitrates and turbidity.
2. Students will learn that poor water quality in runoff water from a farm field, can cause damage and even death to flora and fauna in the bodies of water to which it flows.

Activity Abstract

After review of the agricultural water cycle (that was introduced in the Water Cycle activity, this activity helps students to discover the impacts that agriculture can have on the planet's water supply. Using a soil table, students will create water runoff using a simulated farm situation. This water will be tested for pH, nitrates and turbidity and finally used to water the plants from the evaporation-precipitation experiment in the Water Cycle activity. This final step will allow the students to witness the affects of water quality on living plants.

Background Information
Surface water and groundwater contamination from agricultural practices is a particular concern. Lakes, rivers, streams and wetlands are used for recreation, wildlife and plant life and groundwater is used for drinking water. These uses demand pure water and therefore it is imperative that farmers follow agricultural practices that protect these water sources.

Keeping Nutrients on the Field. For farmers, nutrient management is an integral part of business, and there are important steps that can be taken to reduce their nutrient loss to streams and lakes. The three main ways of reducing the nutrients that enter our waterways from agriculture are 1) decreasing the amount of nutrients applied to the landscape, 2) preventing spills, runoff, and erosion from transporting those nutrients to our waterways and 3) knife fertilizers into the soil in narrow bands.

Careful nutrient management planning can help farmers determine how much nitrogen and phosphorus is in their manure and how much the crops on each field require to be productive. This planning can help farmers apply only as much nitrogen and phosphorus as their crops will use, preventing excess runoff. In areas that already have phosphorus buildup in the soil or impacted waterways, farmers may need to manage specifically to reduce phosphorus levels.

Fertilizer was also more susceptible to runoff when it was spread evenly and then incorporated into the soil by tilling than when it was knifed into the soil surface in narrow bands.

Keeping Pesticide/herbicides on the Fields: How much pesticide/herbicide or fertilizer runs off farm fields to pollute streams and rivers may depend less on the amount of the chemicals applied and more on other factors such as soil characteristics, farming systems, and how soon it rains after the chemicals are applied, according to studies by scientists. Some herbicides, such as atrazine and alachlor, are more prone to runoff in a no-till farming system than when they were incorporated into the soil in a minimum-tillage system.

The scientists have found that herbicide concentrations are much lower in streamwater from watersheds with soils having good structure and pore space.

Keeping Soil on the Field. (This can be studied in more detail by implementing the "Soil Conservation: Erosion from Water" Activity.) Prevention of erosion and runoff is essential for keeping soil out of our lakes and streams. Maintaining contour farming and good plant cover are the most effective ways to reduce the amount of soil that runs off into the water. Plant roots stabilize the soil and help reduce erosion. Buffer strips of grasses or trees along stream banks catch runoff and sediments flowing from upland fields and trap them before they enter waterways. Well-vegetated uplands and buffers are critical for water quality.

Damaged Wetlands from Contaminated Water. Wetlands are a key depository for surface water runoff. They help reduce flooding because they retain and absorb high volumes of water.

They also behave as a purification filter for water so that when the water leaves the wetland and enters surface water drainage systems or groundwater it is clean for use by humans, flora and wildlife. If water entering a wetland is heavily contaminated with fertilizers, pesticide/herbicides or particulate matter, this water may put the wetland at risk and reduce its filtration capabilities. The following terms are common parameters measured to determine water quality.

pH: the intensity of the acid or alkaline(basic) condition of a solution. A pH of 7 indicates neutral conditions on a scale of 0 (acidic) to 14 (alkaline). pH stands for power of hydrogen, and refers to the concentration of positively charged H ions (acids) or negatively charged OH ions (bases). Most aquatic life needs to live within a pH range on 5.5 to 8. For more information on pH, see http://jshep.users.ftech.net/ph.htm.

Conductivity: the ability of water to conduct an electrical current. It is directly related to the total dissolved salts (ions) in the water.

Nitrate (NO3): the most completely oxidized state of nitrogen found in water. High nitrate levels can occur naturally, but may indicate biological wastes in the water, or run-off from heavily fertilized fields. High nitrate levels reduce the ability of blood to transport oxygen to body tissues.

Total Dissolved Solids (TDS): the total dissolved substances (i.e. salts and minerals) in water remaining after evaporating the water and weighing the residue.

Turbidity: the clarity of water. It is measured by the degree to which light is blocked because the water is muddy or cloudy.

<u>Materials (Session 1)</u>

For each group of 4 students:

- 2 Tbl. 10-10-10 fertilizer
- 2 Tbl. powdered Drano to assimilate a pesticide
- Soil Table: This could simply be a cookie sheet, preferably with sides, OR a 18”x24” box trimmed to 3/4” high sides lined with a garbage bag
- Work Table for Soil Table placement
- Moist garden or farm field soil to fill soil table.
- Block or some item to raise soil table 2 inches high on the short side to create a slope.
- Water
- 2, 16 oz. Cups
- pH paper (4 strips)
- Nitrate Test Strips
- LaMotte Turbidity test kit (price: $5.50/call: Frey 1-888-222-1332/kit#: F22366) or other turbidity tube
- 2 containers for water runoff from soil table
- Pail for testing turbidity
- 2 labels to label water containers and a marker

For each student:

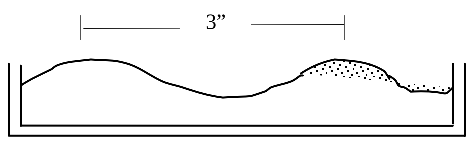
- Science Log Book

Set-up

This activity is designed to take place outside. Set up the tables in the designated area ahead of time.

Procedure (Session 1)

1. **Tap prior knowledge.** Review the agricultural water cycle and impacts from the Water Cycle activity.
2. Take class and all materials outside and divide into groups of four students. Distribute materials to each group.
3. **Hands-on experience.** Have the students set up their Soil Table lined with a garbage bag. Fill to top with moist soil. Have the students firmly pack down the soil. Place Soil Table at edge of Work Table.
4. Elevate the short side of the Soil Table 2 inches using a block, so the water will drain off of the Soil Table and into the runoff container.
5. Have each group create furrows in their soil running in the direction of the slope (the long direction of the soil table). Make sure the furrows are firmly compressed. (Furrows should be approx. 3 inches apart measuring from the top of each furrow). See Figure.



FIGURE

Distance between furrows.

6. Place the runoff container at the lower end of the Soil Table to capture the water runoff.
7. Fill two cups with water and pour the water down the furrows until the water runs off of the Soil Table into the runoff container.
8. In lab sheet, have students label this test as “The Control: No chemicals added to soil”.
9. Have students test the runoff water for pH, nitrogen and turbidity and document the results in their lab sheet. Water test procedures can be found in the Appendix.
10. Save the water in a container labeled, “The Control: No chemicals added to soil”, which will be used to water the plants planted in Session 1 of the Water Cycle activity.
11. Repair any damage furrows (add soil if necessary).
12. Sprinkle both the Drano and fertilizer evenly on the soil so that it thinly covers the surface. Explain to students that they are simulating the practices followed by conventional farmers by adding synthetic soil amendments to the soil surface.
13. Fill two cups with water and pour the water down the furrows until the water runs off of the Soil Table into the runoff container.

> **Teacher Note:** The water testing procedures, found in the Appendix, will be repeated with both “no chemical” water (step 9) and “chemical” water (step 15).

14. In lab sheet, have students label this test as “Chemicals Added to Soil”.
15. Have students test for pH, nitrates and turbidity and document the results in their lab sheet. Use the same procedures as before (see Appendix).
16. Save the water in a container labeled, “Chemicals added to soil”, which will be used to water the plants planted in Session 1 of the Water Cycle activity.

Materials (Session 2)

For each group of 4 students:

- Two potted plants (use the plants from Session 1 of the Water Cycle activity!)
- 2 water containers, one each of "Chemical" and "Control" water from Session 1 of this activity.
- Tray under pots to prevent water from getting everywhere
- Labels for pots, marker

For each student:

- Science Log book

Procedure (Session 2)

1. **Tap prior knowledge.** Review the water quality test results from session 1. Ask the students if they think differences in water quality will have an effect on how plants grow.
2. Break students into groups of four.
3. **Share with Neighbor.** Have each student create a hypothesis explaining what they think will happen to the plants being watered with the water created in Session 1. Have each person share their hypothesis with their group.
4. **Hands-on Experience.** Have each group label their two pots, one saying "Chemical" and the other saying "Control".
5. Have each group on a periodic basis, over a one to two week period, water the plants using the "Chemical” and “Control" water, using only the respective water for the plants. Plants need not be watered daily, unless they are in full sun all day. When the soil dries up, they should be watered.
6. Water the plants until there is a sign of stress in one of the plants for each group. When stress is evident, the experiment is over.
7. **Conclusion/Wrap-up.** Have students complete their experimental write-up, including the implications for farmers. Have the students turn in their completed lab sheets. As a final assessment for the Water Cycle – Water Quality activities have the students extend their farm story they wrote for the Water Cycle activity answering the following question: “How can your farm improve its agricultural practices to protect the quality of water that leaves the farm?” Share the completed stories with the class.

Extensions

Have the students run another water quality test using the soil amendments (chemical) and either the felt filter strip or contour furrows as described in the “Soil Conservation: Erosion from Water” Activity contained within this curriculum. Or they can create the furrow and embed the soil amendment under the soil in a line along the furrows – this will simulate knifing in the fertilizer, a method proven to retain soil amendments on the farm field.

References

http://www.wavcc.org/wvc/cadre/WaterQuality/water_quality_testing.htm Web site for Water Testing curriculum and test kits.

http://www.ars.usda.gov/is/pr/2000/001117.htm. Article about agricultural water runoff research done by the USDA.

http://www.dnr.state.wi.us/org/water/wm/nps/about.htm Article about agricultural water runoff research done by the WI Dept. of Agriculture.

http://www.fao.org/docrep/W2598E/w2598e04.htm Charts that show specific farming methods and how to manage them to prevent nonpoint source pollution.

http://www.agr.gc.ca/pfra/water/wtesting_e.htm Water testing parameter definitions.

http://www.agr.gc.ca/pfra/flash/robocow/en/robocow_e.htm Web site used to enhance the Scientific Principle for **Session Two: AFFECTS AGRICULTURAL WATER RUNOFF HAS ON THE QUALITY OF SURFACE WATERS AND WETLANDS.**

http://www.friendsoftherivers.com/monitoring_equipment_instruction.htm#tube Turbidity procedures.

Appendix. Water Testing Procedures.

Turbidity. In deep water, a secchi disc is the preferred method to measure turbidity. However, to measure turbidity of water in a bucket, a turbidity tube is the best method. If you purchase a turbidity tube, it should come with instructions. If you want to make your own turbidity tubes, there are Turbidity Tube Construction Directions at http://clean-water.uwex.edu/wav/monitoring/turbidity/tubedirections.htm.

The concepts behind a turbidity tube and a secchi disc are the same. You look through the water at a black and white pattern. The clearer the water, the more clearly you will be able to see the pattern. As the pattern gets in deeper and deeper water, it begins to disappear. Some tests measure clarity be matching the pattern to a card of pictures; others rely on how deep you can lower the circle before it disappears.

Whatever test kit you use or make should come with instructions for measuring turbidity. The web page http://www.lalc.k12.ca.us/target/units/river/lessons/turbid_handout.html contains an excellent lesson on turbidity, with a student handout.

Some information on secchi discs:
http://www.phys.ocean.dal.ca/slw/makeSecchi.jpg
http://www.mlswa.org/secchi.htm

pH and Nitrates. Both pH and nitrates can be tested quickly using test strips, which, when emerged in the liquid, change color that corresponds to a value on a chart. Strips will come with charts and instructions. These strips are affordable and available at many locations, including Carolina Biological at http://www.carolina.com/.