What is the agricultural water cycle and how do farmers impact it?

EDIBLE GARDEN PROGRAM (6-8)

Water Cycle
(ILS 12E, 13B, 16E)

Overview

The key question for this Activity is, "How can agricultural practices impact the quality of water in the water cycle, particularly for surface water and wetlands?" 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 15 minutes, with a long break for evaporation to occur; session 2 requires up to 1 hour.

Objectives

1. The students will learn the meaning of evaporation, transporation and evapo-transporation – key terms in the agricultural water cycle.
2. The students will learn about the water cycle on a farm.
3. The students will learn that water runoff from agricultural operations can affect the water quality or a river, surface water body, or a wetland.
4. The students will learn that soil, dissolved nutrients from fertilizers and pesticide residues are major contaminants in agricultural water runoff.

Activity Abstract

This Activity will introduce students to the agricultural water cycle, a cycle that includes the natural component of evaporation and precipitation and also the human elements such as wells, ponds, drainage tiles and the like. They will discover that certain common agricultural practices can be improved upon to reduce or eliminate water contamination within the water cycle. Students will begin the Activity by witnessing the evaporation-precipitation component of the agricultural water cycle through an experiment using pots,

plants and plastic bags. The results of the experiment will be used to learn about the larger agricultural water cycle. Students will then view an internet video, "Robocow," that introduces them to some agricultural practices that affect the quality of water in the agricultural water cycle. The students will then discuss the most common agricultural water contaminants: excessive nutrients from synthetic fertilizers, pesticide/herbicides residues, and soil particulates.

Background Information

A farm is a very small part of a world wide earth-atmosphere system called the **water cycle** or **hydrologic cycle**. Water **evaporates**, or converts from a liquid to a vapor due to the sun's heat, from various water bodies, the ground, and **transpiration** from plants. (Transpiration is the process where leaves give off a watery vapor; **evapo-transpiration** refers to the sum of water that transpires from the leaves and the water that evaporates from the soil.) Water **condenses** to form clouds, which may travel some distance before they return to earth in the form of rain, snow, and other kinds **precipitation**. Water in this cycle can be stored in ice, snow, lakes, oceans, rivers, and as groundwater. It is continually recycled and reused.

A **watershed** is a region or area drained by a river, stream**,** etc. Watersheds function in collecting and moving rain and snow to lower elevations, both as surface water and groundwater. The water cycle isn't contained within one watershed, but all of the pieces operate within each watershed. They are like pieces of the global water cycle.

The agricultural water cycle adds human elements to the earth-atmosphere system. The Agricultural Water Cycle schematic (Appendix C) shows many components present from agricultural features and practices: wells, groundwater, drainage tile, infiltration, pond, evaporation, precipitation, evapo-transporation, surface water runoff, and wetlands. Appendix D provides more information about some of the agricultural elements of the water cycle.

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, usually in regard to how suitable it is for a particular purpose. The most commonly accepted use of "suitable" means that the water is good enough to use at home or in the various aspects of daily life. When talking about natural waters, are they suitable for aquatic plants and animals? Many factors that impact water quality are part of the interconnection of surface water and ground water, atmospheric conditions, the natural configuration of the land, human activities, and aquatic health. Susceptibility of surface and ground water to degradation depends on a combination of natural landscape features including type and origin of the soils and contour of the terrain; climate; and human activities such as land use and management practices.

When water from rainfall or melting snow flows across the landscape, it washes soil particles, bacteria, pesticides, fertilizer, pet waste, oil and other toxic materials into our lakes, streams, and groundwater. This is called "**nonpoint source pollution**" or "polluted runoff." Nonpoint source pollution comes from a diverse number of activities in our daily lives including fertilizing lawns and farm fields, driving and maintaining our cars, constructing buildings and roads, plowing our fields for crops, and maintaining our roads in the winter. Polluted runoff contributes to habitat destruction, especially wetlands, fish kills, reduction in drinking water quality, harbor and stream siltation, and a decline in recreational use of lakes. (**Point source pollution** is when the source of the pollution is readily identifiable, such as a waste pipe that discharges into a river.)

Nonpoint pollution from agricultural land is the leading cause of water quality problems in United States, degrading or threatening an estimated 72 percent of the streams, 56 percent of the lakes. There are three major nonpoint source pollutants contained in runoff water from poorly managed farm fields:

- nutrient loss from applied fertilizers
- pesticide/herbicide residues
- soil.

For important information on these key problems, please refer to Appendix A.

Materials (Session 1)

For each group of four students:

- 2 copies of the Water Cycle Experiment Procedure page (See Appendix B.)
- 3 plastic flower pots (4")
- 3 plastic produce bags in which to put pots
- 3 twist ties to close the plastic bags
- soil to fill each pot
- 2 plants that will fit in the pots. Basil or other herb from grocery store or small potted flowers from garden shop will work well. All plants should be the same species.
- 3 labels for the pots
- Marker

For each student:

- Agricultural Water Cycle Schematic (See Appendix C.)
- Science log book

Procedure (Session 1)

1. **Tap prior knowledge.** Ask the students what they know about a water cycle. Generate a brainstorm list on the chalk board. Orient the brainstorm towards the agriculture water cycle which includes a well, drain tiles, ponds, etc.
2. Divide the class into groups of four and distribute all materials to each group.
3. Review the Water Cycle Procedure page, answering any procedural questions students have.
4. **Share with Neighbor.** Ask each student to generate a hypothesis about the results of the experiment and write it in their log books. Have students share their hypothesis with the other students in their group.
5. **Hands-on Activity.** Complete the experiment, following procedures in Appendix B.
6. Review results; compare hypothesis to results.
7. **Introduce Scientific Principle.** Hand out the "Agricultural Water Cycle" schematic. Discuss the cycle presented in the schematic and have the students try to relate the experiment results to the "agricultural water cycle." Include the following points:
    - Water that condensed on the bag from Pot A was from Evaporation.*

Teacher Note: Detailed experiment procedures for step #5 can be found in Appendix B!

Teacher Note: The definitions for the * terms can be found in Appendix D, question #2.

- Water that condensed on the bag from Pot B was from and Evapo-transpiration.*
- Water that condensed on the bag from Pot C was from transpiration.*

8. **Conclusion/Wrap-up.** Use the questions in Appendix D to lead a discussion of the results and the agricultural water cycle.

Materials (Session 2)

- Computers with internet access – one computer for every four children OR a digital projector and screen so the whole class can watch one computer.
- Science log books

Procedure (Session 2)

1. **Tap prior knowledge.** Ask students if they know what water runoff is? What would be in agricultural runoff besides water? Have students think about the Soil Erosion Activity to answer these questions.
2. **Share with Neighbor.** Have students briefly discuss the following questions with their neighbor: How might runoff water from farm fields affect the lakes and rivers nearby? What are some ways you can determine if the water quality in a river has been affected by nearby farms?
3. **Introduce Scientific Principle.** Watch the video "Robocow" from the Canada Department of Agriculture, and take notes in their science log books. The video can be found at: http://www.agr.gc.ca/pfra/flash/robocow/en/robocow_e.htm. The video is less than 10 minutes long, but the class may want to watch it more than once in order to take good notes on the contents.
4. Review the contents of the video. List and discuss the causes of agricultural water quality problems and their solutions on the board. The list should include nutrient loss from applied fertilizers, pesticide/herbicide residues, animal residue and soil.
5. **Conclusion.** Use the terminology in the Agricultural Water Cycle Schematic to create a story about a farmer's water. The students may start by creating a farm, one that produces vegetables, apples, or raises beef. Water is an integral part of each of these types of farms. Describe how the water is used on the farm, where it comes from, where it goes.

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 A: Background Information on Major Nonpoint Source Pollutants.

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.

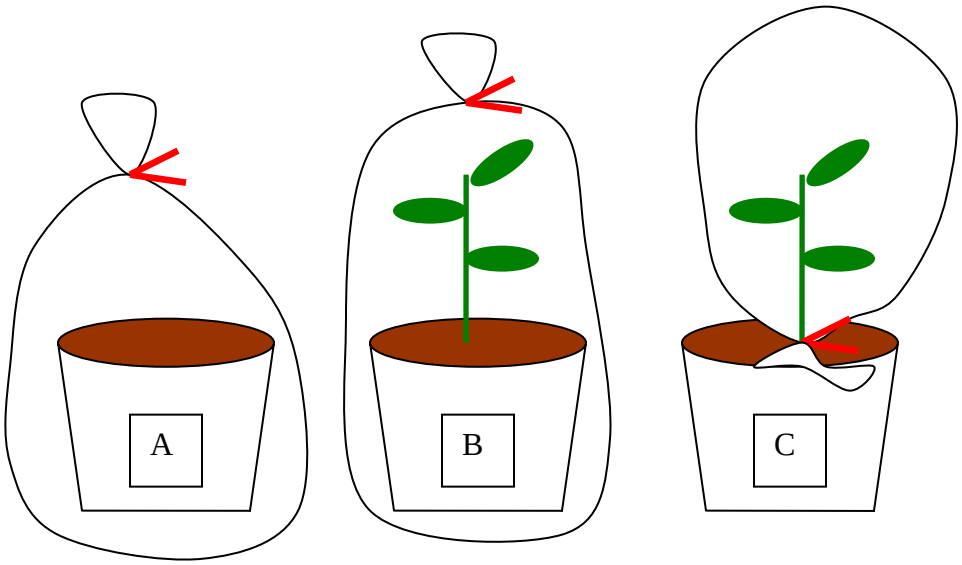
The scientists have found that herbicide concentrations are much lower in streamwater from watersheds with soils having good structure and pore space.

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.

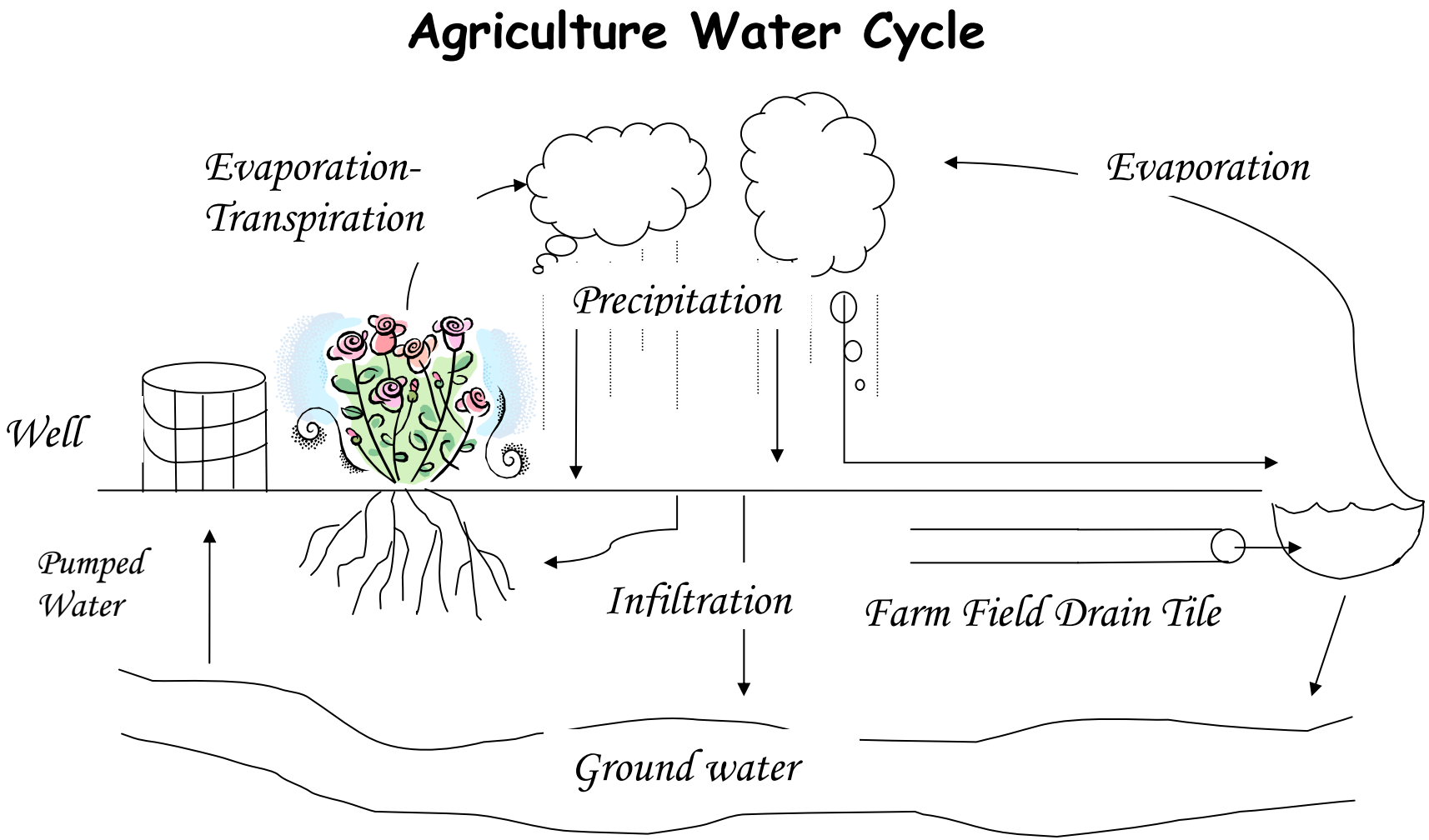
Damaged Wetlands from Contaminated Water. Wetlands are a key depository for surface water runoff. They help reduce flooding because they retain and absorb high volumes of water. They also behave as a purification filter for water so that when the water leaves the wetland and enters surface water drainage 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.

Appendix B: Water Cycle Experiment Procedure

1. Affix a label to each flower pot.
2. Using the marker, label the pots as follows:
   Pot A – no plant
   Pot B – plant
   Pot C – plant
3. Fill pot A with soil.
4. Plant the two plants in Pots B & C. Use the soil the plants came in, but add more so that all three pots are filled with soil to the same level.
5. Water each pot thoroughly so that they are well watered.
6. Put Pots A&B in plastic bags and seal closed with twist tie. See picture below.
7. For Pot C cover only the plant with the plastic bag, using the twist tie to seal the bag closed around the plant's stem where the stem meets the soil. Be sure the soil in Pot C is exposed to the air.
8. If there is sunshine, place the pots in the sun for a few hours. Return to the experiment in the afternoon to draw conclusions. Record in log book.
9. If there is no sun OR time to finish the experiment the same day, then return to the experiment in the following morning to draw conclusions. Record in log book.
10. Clean up!



Appendix C: Water Cycle Schematic.



Appendix D: Discussion Questions (and Answers).

What is the difference between condensation and precipitation? (Condensation is when water has gone from a vapor phase to a liquid phase, generally as small water particles (which make up clouds). Clouds release precipitation when the water particles get so large they can no longer "float" in the cloud and then fall to the earth as rain.)

What is the difference between evapo-transpiration, transpiration and evaporation? (Evaporation is the process where water, either from the soil or an open water body, turns from a liquid to a vapor. Transpiration is the process where leaves of a plant give off a water vapor. Evapo-transpiration is the depletion of water from soil due to the sum water loss from evaporation from the soil surface and transpiration by the plant.)

Can unlimited quantities of water be pumped from the well and what symptoms may arise if done so? (Water can only be pumped from a well at the rate the water is flowing through the ground. The pump will run dry if water is pumped too fast.)

Does groundwater need to be replenished and what happens if it's not? (If groundwater is removed from the ground faster than it is replenished from infiltration from the surface, then a void is created in the ground where the groundwater use to be. This can cause a sink hole, where the ground collapses at the void causing a large surface pit. Florida is known for having many sink holes.)

What is the function of the "farm field drainage tile"? (Drainage tiles were installed throughout flat wetlands across the United States in the early 1900's. The tiles were installed about 3 feet below the soil surface. These tiles give water a conduit for drainage of the soils to three feet below grade, making them adequate for agricultural crop production. Discovery of these tiles led to the demise of many wetlands across the US.)

If plants use up (absorb) all of the water in the root zone of the soil, what happens to the plant and what is required to replenish the water? (When all of the root zone water is depleted the plant no longer has a source of water to keep it growing. Water in soil can be replenished either naturally by rain or through irrigation or hand watering.)