From Field to Faucet: Nutrient (N/P) Management and Source Water Protection

Lesson: 14

National Science Education Standards for Grades 9-12

Content Standard A: Abilities Necessary to Do Scientific Inquiry

- *Design and conduct scientific investigations.*

Content Standard E: Science and Technology: Understandings About Science and Technology

- *Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety and aesthetics.*

Content Standard F: Science in Personal and Social Perspectives: Science and Technology in Local, National and Global Challenges

- *Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use—which decreases space available to other species—and pollution—which changes the chemical composition of air, soil and water.*

Student Learning Objectives

14. Use components of scientific inquiry to develop research questions about nutrient management and soil drainage tiles.

Resources, Tools, Equipment and Supplies

14. Resources

- Steps for Scientific Inquiry: SW.14.TM slide
- Smoking Drainage Tiles: SW.14.TM videos 1 and 2
- Practicing Scientific Inquiry: SW.14.AS.A worksheet
- Be Safe… Monitor Tile Outlets: SW.14.AS.B. handout:
- Drainage, Ag 101, U.S. EPA: http://www.epa.gov/agriculture/ag101/cropdrainage.html
- *Common Manure Handling Systems*, Ag 101, U.S. EPA: http://www.epa.gov/agriculture/ag101/porkmanure.html
- *Crop Production: Nutrient Management*, Ag 101, U.S. EPA: http://www.epa.gov/agriculture/ag101/cropnutrientmgt.html
- *Manure Management Systems*, Ag 101, U.S. EPA: http://www.epa.gov/agriculture/ag101/beefmanure.html
- Agricultural Drainage: Issues and Answers http://www.extension.umn.edu/distribution/cropsystems/dc7740.html
- Brochure on Managing Drainage for Better Water Quality: http://hostedweb.cfaes.ohio-state.edu/usdasdru/ADMS/ADMSbrochurefinal_nocrops2.pdf
- Website of Agricultural Drainage Management Systems Task Force: http://hostedweb.cfaes.ohio-state.edu/usdasdru/ADMS/ADMSindex.htm

Equipment

Computer

LCD projector

Key Terms

Hypothesis

Macropores

Ponding

Tile drainage system

SUMMARY OF CONTENT AND TEACHING STRATEGIES (BACKGROUND FOR TEACHERS):

Please see the U.S. EPA, Ag 101 websites listed in the Resources section above for related background information.

INTEREST APPROACH:

Farming practices in general and BCPs specifically can involve the planning, installation and maintenance of very complex systems. Engage students in a discussion about their homework reading assignment from Lesson 13. What surprised them about what they read? Did they pick up on the complexity of the systems/problems that farmers are trying to solve? What types of skills would you need to build, run, and maintain these systems? What types of skill would you need to investigate new systems or solve problems in existing systems? Ask students to make a list.

As the class discussion has demonstrated, farmers and other ag professionals use a variety of skills (math, physics, chemistry, etc.,) in their work. In Lesson 14, students discover how agriculture professionals might apply scientific inquiry skills to investigate and solve a water management problem.

OBJECTIVE BY OBJECTIVE:

Activity Outline and Teacher Support Information:

14. Use components of scientific inquiry to develop research questions about nutrient management and soil drainage tiles.

An inventory or walk-around of an agriculture site can help farmers and other agriculture professionals discover areas of strengths and opportunities for changes that will improve conservation practices. Some water-related issues in agricultural areas are less obvious; however, and professionals must use a variety of investigative processes to try to find explanations and/or solutions. In this activity students will watch two intriguing videos used to demonstrate potential problems related to source water threats from manure applied to croplands. They will then apply their knowledge about soil, infiltration, and land practices from Lessons 1-13 and the steps of scientific inquiry to develop a plan to investigate this subject more thoroughly.

Show slide SW.14.TM and review the basic steps of scientific inquiry with the class:

1. Ask a question
2. Explore background information
3. Create a hypothesis (an idea that can be tested)
4. Develop a plan and test your hypothesis
5. Analyze your finding and draw conclusions
6. Share your results

Explain that the class is going to design studies to answer this question: Does manure loss into tile lines constitute a threat to source water resources?

Explain that in 2008 a group of farmers, scientists and agriculture specialists were thinking about the same question. The group wanted to determine whether, and under what conditions, manure loss into tile lines is a concern. They set up a demonstration to illustrate the nature of the problem.

Show the class the Drainage Tile Smoke videos (SW.14.TM. Video 1, SW.14.TM.Video

1.) Ask students to interpret what they saw in the videos.

The smoke demo illustrates the potential for liquid manure to reach tile lines. Video 1 shows the demonstrator putting the smoking material in a machine that blew the smoke into the tile system. Video 2 shows the smoke rising up through the soil in the field.

Tell students their task is to design a scientific study to answer our question: Does manure loss into tile lines constitute a threat to source water resources? Divide the class into small groups and give each group the *Practicing Scientific Inquiry* worksheet SW.14.AS.A to guide them. (Students won't be able to complete steps five and six in the scientific process during this activity. They may, however, be encouraged to work with an area agricultural expert to complete the process as a service learning or stewardship activity.)

Each student should receive and read the handout, *Be safe…Monitor tile outlets* (SW.14.AS.B). Each group will then create a hypothesis and plan for testing its hypothesis.

After groups have finished their assignment ask them to share their hypotheses and their test plans. As students debrief, watch for opportunities to emphasize that the issue here is not just that the pollution can run quickly into the drain tiles, but that once it does it is concentrated, carried away, and discharged directly to surface water without treatment. The surface water may be a source of drinking water for people, livestock and wildlife.

REVIEW / SUMMARY:

Respond to the following questions in your journal.

- What conclusions were you able to draw from the demonstration with the smoke bomb and the tile system?
- What questions are you left with after viewing the videos?
- What are some methods you could use to find answers to the new questions that arose?

EVALUATION AND ANSWERS:

SW.14.ASSESS

1. Name the six steps of the scientific process:

2. Describe the possible implications of the smoking drain tile demonstration for source water protection.

Answers to SW.14.ASSESS

1. Name the six steps of the scientific process:

    1. Ask a question
    2. Explore background information
    3. Create a hypothesis (an idea that can be tested)
    4. Develop a plan and test your hypothesis
    5. Analyze your finding and draw conclusions
    6. Share your results

2. Describe the possible implications of the smoking drain tile demonstration for source water protection.

Smoke rising from the fields highlight that there are multiple pathways manure can follow to contaminant surface water resources. The smoke demo also illustrates soil quality. Earthworm activity and loose soil tilth are desirable.

ACTIVITY WORKSHEET(S) – AS NEEDED:

SW.14.AS.A. Worksheet

Practicing Scientific Inquiry

1. Ask a question: Does manure loss into tile lines constitute a threat to source water resources?

_____

Do you feel the question should be refined? If so, write down a new question.

_____

2. Explore background information

Read handout SW.14.AS.B, Be safe…Monitor tile outlets

3. Create a hypothesis (an idea that can be tested)

Examples: Tilling the soil will increase the amount of nutrients that escape through sub-surface drains and enter surface water; or matching nutrient application to plant uptake, and avoiding application before a rain or on frozen ground will decrease nutrients entering surface water.

_____

4. Develop a plan to test your hypothesis

_____

_____

The last two steps in this process, analyzing your findings and sharing your results, cannot be completed as part of this activity. However, they are an important part of investigating evidence in a scientific study.

SW.14.AS.B

Be safe …

Monitor tile outlets[1]

How can you be sure that your field tile drains are not carrying manure or chemical fertilizer to surface waters if you don't monitor them? If there is a problem, you need to be the first to know. The peace of mind from knowing manure is staying in the field is priceless.

Under certain conditions, land-applied manure and chemical fertilizer can quickly enter sub-surface drains by preferential flow through macropores—large, continuous openings in soil formed by plant roots, cracks, earthworms and other natural processes.

Nutrients that escape from application sites through sub-surface drains are not recycled to crops. The resulting contaminants degrade surface waters by stimulating aquatic plant growth, decreasing water clarity, and destroying desirable fish habitat, and threatening sources of drinking water and public health. In extreme cases, a fish kill may occur, or infants may become ill from ingesting nitrate in drinking water.

Recently, Jim Hoorman, Ohio State University Water Quality Educator, reviewed 98 manure violations in Ohio from 2000-03. About two-thirds occurred on wet ground or in rainy weather. Reported application rates ranged from 1,400 to 47,500 gallon/acre, but in cases where soil and water conservation districts were able to verify rates, operators had applied about twice the rate reported to investigators. Violations occurred most often because of:

1) Excessive rain or saturated soil
2) Over-application
3) Poor management of storage facilities that left little flexibility in when hauling could occur
4) Ponding of surface applications or excessive irrigation
5) Tile lines already flowing at the time of application or a tile plug that failed.

Beware of conditions that may signal potential problems:

- Manure reaching tile lines is more likely with a combination of high application rates and highly flowable liquids such as parlor wash water and flush systems.
- The agronomic manure rate may be too high for dilute slurry that is low in nutrients.

1 From Tim Harrigan, MSU: http://www.animalagteam.msu.edu/uploads/files/20/tile%20outlets.pdf

SW.14.AS.B. *(continued)*

- Clay soils (soil management groups 0, 1, 1.5 and 2.5) tend to shrink and crack. Soil cracks may provide a direct route to sub-surface drains.
- No-till fields often have more worm holes and root channels. An abundance of such large pores increases the likelihood of manure loss through tile lines. Therefore producers need to take hydrologic loading capacity into account, not solely nutrient needs of the crop.

Keep it in the Root Zone

Soil moisture, weather conditions and other factors that influence the ability of soil to retain manure or chemical fertilizer in the root zone change continuously, so monitoring of tile outlets is essential when manure or chemical fertilizer is applied on tile drained land. Some practices that are helpful include:

- Do not apply manure to tile drained fields when the tiles are flowing. Avoid spreading in the rain or when rain is forecast or on frozen or snow-covered ground.
- Manure with high solids content is less likely to move off-site. Separate lot runoff, parlor wash water and other water sources from the manure stream and handle them separately.
- Several applications at a lower rate will likely be safer than a single high application rate that exceeds the ability of the soil to hold and retain the manure.

Above all, monitor tile outlets before, during, immediately after manure applications, and after the next rain event. Keep records of the observations. Visit www.rootzone.msu.edu for record keeping forms.

SW.14.AS.B. *(continued)*

- Monitor tile outlets and stop spreading if there is any indication of manure movement to tile lines.
- Flow control structures and tile plugs can sometimes be used for an added margin of safety, but should not be used in place of low application rates and outlet monitoring.
- Should a discharge occur, have a plan for dealing with manure that may reach tile lines, such as blocking outlets or ditches. Large round bales are effective for temporarily blocking ditch flow.

POWERPOINT SLIDES – AS NEEDED:

SW.14.TM.Video 1: Go to www.xxxx.gov to download a copy of the smoke drain tile video 1. Use Windows Live Movie Maker or other movie viewing program to open the file.

SW.14.TM.Video 2: Go to www.xxxx.gov to download a copy of the smoke drain tile video 2. Use Windows Live Movie Maker or other movie viewing program to open the file.

SW.14.TM

Steps for Scientific Inquiry

1. Ask a question
2. Explore background information
3. Create a hypothesis (an idea that can be tested)
4. Develop a plan and test your hypothesis
5. Analyze your findings and draw conclusions
6. Share your results