Lesson Two: Land and Water Uses that Affect Water Quality
Activity One: Old MacDonald's Farmland Fertilizer Dilemma

Overview
This section of the curriculum offers several different exercises that address specific pollution concerns. It is unlikely that there will be time for all of these activities, but at least one should be performed in the class after students have read the chapter *Land And Water Uses That Affect Water Quality* from *Conducting a Watershed Survey.*

Grade Level
6-8

Time Required
Individual exercises are designed to be approximately ½ hour to 45 minutes long. These exercises are also ordered progressively: each builds on concepts introduced in the previous.

Materials
Worksheets included

TEKS

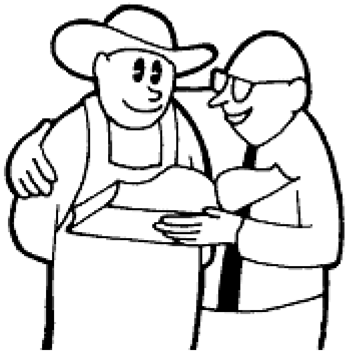
Science
Grade 6 6.14
Grade 7 7.2, 7.12, 7.14
Grade 8 8.3, 8.11, 8.12, 8.14

Mathematics
Grade 6 6.2, 6.3, 6.4, 6.9, 6.11, 6.12
Grade 7 7.2, 7.3,7.9, 7.10, 7.13, 7.15
Grade 8 8.2, 8.3, 8.5, 8.9, 8.14, 8.15

Social Studies
Grade 6 6.6, 6.7, 6.22
Grade 7 7.10, 7.22
Grade 8 8.10, 8.12, 8.32

Objectives
Students work through calculations to determine how much fertilizer is needed to meet a plant's nutrient requirements. From these calculations, students draw conclusions about the most cost-effective and environmentally sound farming practices.

Academic Questions: How much fertilizer is needed to meet a plant’s nutrient requirements?



Why Worry About Old MacDonald?

Old MacDonald has some big decisions to make. In this exercise, you will help him decide how much fertilizer his crops need. At the same time you will help him to keep costs down and prevent nutrient runoff into nearby lakes and streams.

Old MacDonald's Farm

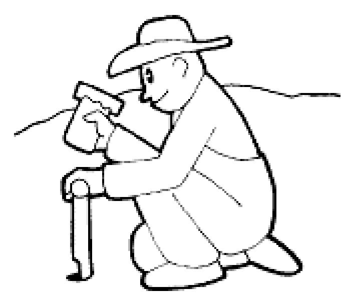
Old Macdonald has a small farm. The cows graze in a 15-acre pasture, and he grows corn to feed his chickens, pigs, and cows in a 35-acre field. Altogether, Old MacDonald's animals produce about 170 tons of manure every year! That manure contains 1,200 pounds of nitrogen and 800 pounds of phosphorus.

Old MacDonald knows that manure is an unbalanced fertilizer for corn because it has too much phosphorus and not enough nitrogen. Corn plants use 5 to 20 times more nitrogen than phosphorus, and there is less than 2 times nitrogen than phosphorus in manure. Farmers usually apply manure to fulfill the nitrogen requirements for crops. Because crops do not use up the phosphorus in the manure, the result is an over application of phosphorus. This phosphorus then builds up in the soil until a rainstorm washes it into nearby streams or rivers, where it can cause water quality problems and threaten aquatic life.

Solving the Problem

Old MacDonald wants to fertilize his pasture and cornfields with the manure that his cows, chickens, and pigs produce. After all, it's free, and he doesn't have to haul it from somewhere else! And commercial fertilizer is expensive-nitrogen costs 15 cents per pound and phosphorus costs 50 cents per pound.

However, his choice is not easy. Either he spreads enough manure so that the crops get enough nitrogen (leaving large amounts of leftover phosphorus that could run off into streams and lakes), or he spreads only enough manure so that the crops get the right amount of phosphorus (but not enough nitrogen).



After testing the soil, Old MacDonald is able to determine that the pasture requires 80 lb/acre of nitrogen and 5 lb/acre of phosphorus for the best growth. He also discovers that his corn crop needs 125 lb/acre of nitrogen and 25 lb/acre of phosphorus for the best growth.

Fill in the table below with information from the preceding paragraphs.

	Number	Units
Pasture size		
Cornfield size		
Manure produced		
Nitrogen in manure		
Phosphorus in manure		
Cost for extra nitrogen		
Cost for extra phosphorus		
Nitrogen needed to fertilize pasture		
Phosphorus needed to fertilize pasture		
Nitrogen needed to fertilize corn		
Phosphorus needed to fertilize corn		

Doing the Calculations . . .

Part I. Find the amounts of nitrogen and phosphorus required on the farm:

1. How much nitrogen does Old MacDonald need to fertilize his farm?

☐	acres pasture x	☐	lbs nitrogen per acre =	☐	Lbs
+					
☐	acres cropland x	☐	lbs nitrogen per acre =	☐	Lbs
				☐	Lbs = nitrogen requirement

2.

> Remember your order of operations.
> Multiplication is done before addition.

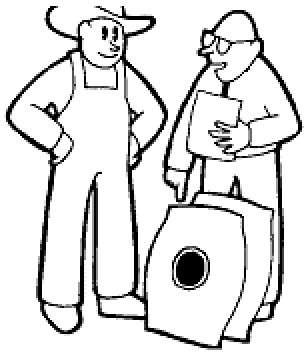
3. Now compare the amount of nitrogen required on the farm to the amount of nitrogen in the manure. Is there enough nitrogen in the manure to fertilize both the pasture and corn?
4. How much more nitrogen does he need?

5. How much phosphorus does Old MacDonald need to fertilize his farm?

☐	acres pasture x	☐	Lbs phosphorus per acre =	☐	Lbs
+					
☐	acres cropland x	☐	Lbs phosphorus per acre =	☐	Lbs
				☐	Lbs = phosphorus requirement

6. Now compare the amount of phosphorus required on the farm to the amount of phosphorus in the manure. Is there enough phosphorus in the manure to fertilize both the pasture and corn?

7. How much more phosphorus does Old MacDonald need?



Part II.

Option 1: Fertilize with enough manure to meet nitrogen needs

From the calculations in Part I, we discovered that the pasture needs 1,200 pounds of nitrogen. This is exactly the amount of nitrogen contained in the manure produced on Old MacDonald's farm. So, let's assume that Old MacDonald uses all the manure to fertilize his pasture. This will completely satisfy the pasture's need for nitrogen and phosphorus. However, he still needs to fertilize his corn crop.

Because Old MacDonald used all the manure produced on his farm to fertilize his pasture, he must buy commercial fertilizer for his corn. He needs to buy both nitrogen and phosphorus.

8. How many pounds of nitrogen would Old MacDonald need to buy? Hint: Look at your calculations in #1.

9. How much would Old MacDonald have to pay to buy enough commercial nitrogen?

10. How many pounds of phosphorus would Old MacDonald have to buy? Hint: Look at your calculations in #3.

11. How much would Old MacDonald have to pay to buy enough commercial phosphorus?

12. How much would Old MacDonald spend in all on commercial fertilizer for Option 1?

Option II. Fertilize with enough manure to meet phosphorus needs
Old MacDonald does not have to use all the manure from his farm to fertilize his pasture. From the calculations in Part I, we found that if Old MacDonald puts some of the manure on the pasture and some on the corn field according to the amount of phosphorus each field needs, he will need to buy only 150 pounds of phosphorus. However, he will then have to put nitrogen on both his pasture and his cornfield. Will this method of distributing fertilizer be worth it? Let's find out.

13. After spreading manure according to the phosphorus needs of each field, how many pounds of phosphorus would Old MacDonald need to buy?

14. Find the total price that Old MacDonald would have to pay for commercial phosphorus.

15. How many pounds of nitrogen would Old MacDonald have to buy? Hint: Subtract the total amount of nitrogen Old MacDonald needs from the amount of nitrogen in the manure that he spread.

16.Find the total price that Old MacDonald would have to pay for commercial nitrogen.

17. How much would Old MacDonald spend in all on commercial fertilizer for Option 2?

Other Farmer-ly Considerations...
Manure also contains other nutrients such as manganese, calcium, sulphur, boron, and iron that plants need to survive. If Old MacDonald applies manure only to his pastureland (as was the case for nitrogen-based application), he might still have to buy and apply these additional nutrients to satisfy crop needs.

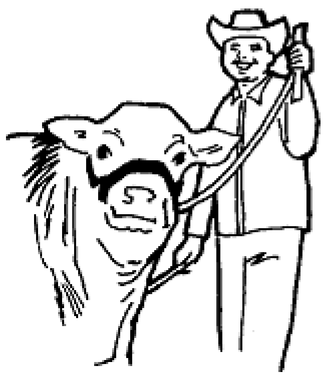
Manure application will also increase the health of the soil because manure contains organic matter that is used as food by worms and other organisms in the soil. The result is a healthier soil that grows healthier crops while, at the same time, reducing the environmental damage of excess nutrient runoff into lakes and streams.

18. Which is cheaper for Old MacDonald, Option 1 or Option 2?

19. How much would Old MacDonald save if he used the cheaper method?

20. Which method of fertilization would lead to less excess phosphorus accumulation in the soil? (Remember that excess phosphorus in the soil is washed away by rainwater and leads to pollution in nearby waterways.)

Part III. Mooving Those Cows



Why Worry About Old MacDonald?

Old MacDonald has a second dilemma. A small stream runs between the cow pasture and the barn, as shown in the picture (next page). Your job is to draw a plan that will allow the cows to roam between the barn and the pasture and will also provide water for the herd. Label any devices that you use and their purpose. When you are finished with your drawing, write a paragraph about the benefits and drawbacks of your design.

Things to think about

- How would you get your cows water but keep them out of the stream?
- What problems can you cause for the stream if you let the cows drink directly from it?
- How else can you get water from the stream to the cows?
- How will the cows get across the stream to their barn?
- What streamside practices would you use to make sure water quality, the physical stream structure, and the fish and organisms living in the stream are protected?

Some Examples

For years, farmers have been working on new ways to keep cows out of nearby streams. They have come up with a number of practices that help reduce the damage cows can do to a stream. You can use some of these practices to help Old MacDonald with his cows, or you can come up with some practices of your own.

Wire fences (left) keep cows from walking on stream banks and digging them up with their hooves. Planting vegetation (right) along stream banks can help filter out nutrients and bacteria from rainwater that runs off cow pastures.

- A watering trough is a place where cows can drink away from the stream. Use a water pump to get water out of the stream and into the trough.
- Wherever cows gather together in a large group, they dig up the ground with their hooves. Rainfall washes the loose dirt down the stream as sediment. Use cement in places where cows are expected to gather to keep this from happening.
- Put up a wire fence to prevent cows from getting into the stream or breaking up mud along streamside areas with their hooves.
- Plant grasses or bushes to protect the stream from mud and sediment washing into it off the banks.
- Remember that cows poop wherever they stand around for a long time. If rain falls on these high-use areas, it will wash manure down into the stream. Plant grasses, shrubs, and trees along the stream bank to capture and filter some of that runoff.
- Catch water from high use areas in a settling pond. This practice allows bacteria and pollutants from the manure to settle out of the water before it runs into the stream.
- Ever heard of a cow path? Cows typically find a path and stick to it. They will find their way back to the barn from the stream. But they might crowd around trying to get back into their pens! Create an outdoor holding area/exercise area outside the barn door that is fenced off.
- You can expect cows to poop in the exercise area. A water ditch can divert water to wash manure out of this area. Then the water should be directed into a settling pond before flowing back into the stream.
- Create a bridge over the stream so that cows will be able to cross over the stream without trudging in it or pooping in it.

Lesson Two: Land and Water Uses that Affect Water Quality

Activity Two: Phosphates in Your Water

Overview

This experiment looks at how fertilizer runoff affects waterways.

Grade level:
6-8

Time Required:
Two-week project

Materials:
- Access to a nearby pond or stream
- Dissolved oxygen test kit
- 10 jars
- Towel
- Water, plants (get some with roots), and mud from a pond
- Detergent containing phosphates
- Fertilizer in powder form
- measuring spoons

TEKS

Science

Grade 6: 6.1, 6.2, 6.3, 6.4
Grade 7: 7.1, 7.2, 7.3, 7.4, 7.8, 7.12
Grade 8: 8.1, 8.2, 8.3, 8.4

Mathematics

Grade 6: 6.1, 6.8, 6.11, 6.12, 6.13
Grade 7: 7.3, 7.4, 7.9, 7.13, 7.14, 7.15
Grade 8: 8.5, 8.14, 8.15

Social Studies

Grade 6 6.6, 6.7
Grade 7 7.10
Grade 8 8.32

Objectives

- Through experimentation, observe effects of additives to water quality.
- Test for dissolved oxygen in water samples.
- Determine the relationship between pollutants and dissolved oxygen in water.
- Collect and interpret data.

Academic Question

What effects do detergents and fertilizers have on aquatic life?

Procedure

1. Label jars 1 through 10. Cover the bottom of each jar with mud and plants (roots and all). Fill each jar with pond water.
2. Place the appropriate amount of fertilizer or detergent in each jar using the amounts listed in the following chart.
3. Following test kit directions, measure the amount of dissolved oxygen in the pond water.
4. Put all the jars in a sunny location.
5. Make observations daily for 2 weeks.

6. Measure the amount of dissolved oxygen, according to the kit directions, on day 7 and day 14 of the experiment.
7. Discuss your observations.

Observation Sheet

Jars	Treatments	Dissolved Oxygen		
		Day 1	Day 7	Day 14
1.	CONTROL			
2.	CONTROL			
3.	1/8 tsp detergent			
4.	1/4 tsp detergent			
5.	3/8 tsp detergent			
6.	1 tsp detergent			
7.	1/8 tsp fertilizer			
8.	1/4 tsp fertilizer			
9.	3/8 tsp fertilizer			
10.	1 tsp fertilizer			

Product/Application

At the end of the experiment, which jar had the most vigorously growing plants?

Which jar had the least dissolved oxygen?

Assessment

What would happen in a stream that has an excess of phosphates, warm temperatures, and good sunlight?

How are phosphates in the water important?

Look around your home and school and list possible sources of phosphates that might be entering local streams.

Lesson Two: Land and Water Uses that Affect Water Quality

Activity Three: Oil and Water Don't Mix

Overview

This activity demonstrates oil pollution and its effect on water quality and aquatic life.

Grade Level:
6-8
Time Frame:
1 50-Fifty Minute Period
Materials:
- feathers
- paper towels
- cups of water
- motor or vegetable oil
- microscope
- eyedroppers
- spoon

TEKS

Science	Social Studies
Grade 6 6.3, 6.14	Grade 6 6.6, 6.7
Grade 7 7.3, 7.14	Grade 7 7.10
Grade 8 8.1, 8.3,8.14	Grade 8 8.32

Objectives

1. Students will make observations about oil-polluted water.
2. Students will be able to describe the effects of oil pollution to wildlife.
3. Students will be able to suggest possible solutions to prevent oil pollution.
4. Each student will write a letter about oil pollution, thus increasing public awareness.

Background

Explain to students that each year more than 240 million gallons—nearly 60 percent—of the used motor oil generated by do-it-yourself oil changers is dumped in ways that damage the environment. That represents 20 times the amount of oil spilled by the 1989 Exxon Valdez in Alaska. One quart of used motor oil dumped near a lake can create an oil slick nearly two acres in size.

Academic Question

What major effects water and wildlife are caused by oil pollution?

Activities/Procedure

1. Students will have one cup of water, an eyedropper of oil, and paper towels on their desks.
2. Students will submerge a feather into water and then dry it off.
3. Next, the students will place a drop of oil into the water. (Notice only a drop of oil changes the entire cup of water)
4. Students will then place the feather back into the water and try to dry the feather again. The students will not be able to dry the feather, therefore demonstrating how oil can alter an aquatic habitat.

Product/Application

The students will discuss what resulted after feathers were placed in the oil. In groups, students will discuss how other wildlife can be impacted by oil pollution. Have students attempt to clean up the oil spill using a spoon. Is this possible? In closing, discuss the proper technique for disposing of and recycling oil, for it is easier to not pollute than to clean-up.

Assessment

Have the students make a classroom bulletin board about oil pollution. The bulletin board can include pictures and articles collected from magazines, newspapers, and the Internet. The bulletin board can also include a list of local area oil recycling centers. Each student will write a letter about oil pollution and proper recycling and send it to the editor of a local newspaper. In their letters, students may describe the hazards associated with oil spills and improper oil recycling. Assess the letters according to the students' knowledge of material and content, along with proper letter writing format.

Lesson Two: Land and Water Uses that Affect Water Quality

Activity Four: Role of Plants in Water Filtration

Overview

The purpose of this experiment is to demonstrate the role of plants in filtering the water that moves through the watershed.

Time Frame: 2 50-Fifty Minute Periods

Grade Level 4-7

Materials:
Six potted plants, with pots roughly six to eight inches in diameter, and holes in the bottom. These plants need to moderately dry, as if they had not been watered for a couple days. Plants with saturated soil will not absorb water, and very dry plants will absorb it all.

Six clear containers, such as cups, which will support the plants and allow drainage to be viewed. You will need separate plants and cups for each of the materials in the water.

Soil from outside (anywhere). The best soil is loamy, with smaller particles than sand.

Unsweetened grape or cherry powdered drink mix.

Vegetable oil.

Household cleaners (such as Comet/Ajax and Dish or Laundry soap). One should be liquid and the other powder.

TEKS

Science

Grade 4 4.1, 4.2, 4.3, 4.4
Grade 5 5.1, 5.2, 5.3, 5.4
Grade 6 6.2, 6.3
Grade 7 7.1, 7.2, 7.3, 7.14

Social Studies

Grade 4 4.22
Grade 5 5.25
Grade 6 6.6, 6.7, 6.21
Grade 7 7.10, 7.21

Objective

Understand the role of plants in filtering the water moving through a watershed.

Background

Experiments can be done to show how a plume of dissolved materials can move through soil and enter a groundwater aquifer. But soil and plants have something of a dual role in this process. Depending on whether materials are dissolved or suspended in the water, soils and plant roots can remove some or all of this material as the water moves down through soil.

Most suspended materials will adhere to the soil. These may then be broken down and used as food by the plants. Dissolved nutrients, such as nitrogen or phosphorus, chemically bond with some types of soil particles. The plants absorb the nutrients, thus removing them from the soil before they can enter an aquifer. For the plants, these elements are food, for an aquifer, they are pollution.

Sediments from eroding soil, nutrients in human and animal wastes, and some components of household wastewater ("graywater") are excellent plant nutrients. Plants also use different nutrients at different rates, so that the amount of material they take up will depend on how much is dissolved in the water and how fast the water moves through. However, some materials/nutrients are neither absorbed by plants nor considered nutrients for plants. This experiment is a very simplified way to show whether plants will take up certain kinds of materials from water moving relatively quickly through their root systems.

Academic Question
What happens to pollutants in the soil as water moves through the watershed?

Preparation Set up the potted plants, each in its own cup. Slowly pour six to eight ounces of clean water through the pot, and check the percolation rate through the pot. Loosen or tighten the soil so that water percolates at about one ounce per minute. The rate should be fast enough to prevent long waiting periods, but slow enough not to carry very much soil through the pot.

Procedure
1. Place the potted plants into the top of their cups. Pour clean water slowly through one of the pots and watch it percolate through the bottom of the pot. The water should look as clean as what was poured.
2. Add a gram or so of soil to 6-8 ounces of water and stir so that the soil is well suspended and distributed in the water. Pour slowly into another flowerpot. The water percolating through should look *much* cleaner than the dirty water poured.
3. Add about one ounce of vegetable oil to 6-8 ounces of water, stir (they won't mix completely) and pour into a third pot. See if the vegetable oil percolates through or is caught up by the plant roots.
4. Add some powdered drink mix to 6-8 oz. of water and pour through a fourth pot. See if the water percolating through retains the color.
5. Add some powdered cleanser to 6-8 oz. of water and pour through a fifth pot. Is the cleanser retained in the soil?
6. Add some liquid soap to the water (an ounce or so in 6-8 oz. water). Does the soap percolate through the soil?
7. Using the “contaminated” plants, pour some clean water at the same rate through each one (simulating a rain shower). Is more of the “pollutant” rinsed away from the soil by the clean water?

Procedure/Application

1. In what ways can plants and soil benefit drinking water quality?
2. We saw plants and soil remove some types of impurities from water. How might the plants remove larger quantities?
3. Can plants and soil remove any type of impurity from water?
4. What other organisms in the soil-plant system might aid the uptake of water pollutants?
5. What is the role of rainwater moving through contaminated soil?

Assessment

Have students write a one page explanation about what they thought would happen versus what did happen. The explanation should include why things happened differently than expected.