Chapter 3. Mixing and Moving in the Environment

Lesson 3. Contaminant movement in soil and groundwater systems

Overview: Water quality varies with several factors, including:

1. Contaminants and other things that might show up in the water,
2. The standards or limits of water quality we will accept or tolerate, and
3. The history and processes the water goes through before it is used.

In essence, almost anything can be considered a "potential" contaminant. Correspondingly, do not view anything physical, chemical or biological as a contaminant until it is in the water supply. How water behaves affects how contaminants behave.

Purpose:
The purpose of this lesson is to show that the physical environment in which the contaminant is placed strongly influences the contaminant. Water plays a very significant role in contaminant behavior; consequently, contaminant behavior is much different in ground water systems than in surface water systems like lakes, streams, ponds and reservoirs.

Ideas Taught:

- Contaminants do not move very fast in soil and ground water systems; consequently, different contaminants do not readily mix in soil and ground water systems and they persist for a long time.

Materials Needed:

- A supply of paper towels (perforated paper towels from a roll work best)
- Spray bottle (like an atomizer, window washing bottle)
- Clean liquid dish soap dispenser bottle
- Red and blue food coloring
- Supply of water
- Tape
- Cookie sheets or water repellent plates

Procedure: Note: This exercise uses wet and dry paper towels to illustrate contaminant movement in soil systems, effects of water movement on contaminant movement, gravitational effects, contaminant interaction and mixing, and plume behavior. Only a couple examples are given, but with a little imagination and an understanding of the processes in action, you can come up with many other examples.

1. ___ Place an unfolded paper towel flat on top of a cookie sheet or plate.

2. ___ Add a drop of red food coloring from a height of about one inch directly to the center.

3. ___ Watch what happens to the food coloring, making not of how much it moves.

4. ___ Place a second unfolded paper towel flat on another cookie sheet or plate.

5. ___ Using a spray bottle, lightly wet or mist the entire towel, so that it is completely wet, but not dripping.

6. ___ Add a drop of red food coloring to the wet towel, just the same as you did the dry towel.

7. ___ Water what happens to the food coloring, making note of how much it moves and in what direction the food coloring moves.

8. ___ Compare the pattern of movement on the tow towels. It should be apparent that without water, the contaminant moves very little and the towel quickly adsorbs it. However, in the presence e of water, the contaminant is not adsorbed as readily, but is diluted and moved farther from the point of entry.

9. ___ Discuss with the class the implications of wet versus dry soil and how contaminants might be prevented from moving into water systems.

10. ___ Set the towels aside to dry. We will come back and talk about them some more after they have dried.

11. ___ Repeat the process above with tow new towels, but this time you are going to do things just a little differently. Add the drop about one inch from the edge, at a position equivalent to 12 o'clock when you are facing the towel.

12. ___ Spray the wet towel with enough water to nearly saturate the towel. It should be substantially wetter than in the first part of the demonstration. Hang each towel up.

13. ___ Watch and discuss with the class what happens to each drop of food coloring. The drop on the dry towel moves very little, even in the presence of gravity. The drop on the wet towel begins to move downward, because of the movement of the water draining from the towel and the movement of the food coloring in a wet environment. The contaminant moves in a plume. It is a gradual, directional contaminant spreading parallel to the water movement. There is a bulge at the front, a fading on the edges, and a tail behind. The plume will continue to move downward until nearly all the coloring is diffused and diluted. The predominant movement will be downward, rather than to the side.

14. ___ Discuss with the class the importance and role of gravity in contaminant movement. Gravity plays a significant role in lakes, ponds, soil and ground water aquifers. Water movement plays a significant roll; without water movement (which is generally downward), contaminant movement is reduced. Finally, contaminants usually move in plumes, or patterns. A couple of processes control these patterns. The soil and material comprising aquifers is made up of pores of all different sizes and shapes. Consequently, while some contaminant moves, some is held back in smaller pores or dead end pores; it does not all move at once. Secondly, if the contaminant moves by convective forces (water moving), then the contaminant will move in a concentrated plume, along the path of water movement. If the contaminant is moving due to diffusion, then it will generally move uniformly in all directions. If gravity is a factor, then the contaminant will usually move downward with the movement of water.

15. ___ The third part of the demonstration is nearly the same. Now, instead of adding just one drop of food coloring to the dry or wet

towel, add one drop of red food coloring and one drop of blue food coloring to each towel. Add the drops about one inch apart, one at the eleven o'clock position and one at the one o'clock position.

16. ___ Leave one towel dry and the other wet. You can do two variations of this demonstration. You can do the demonstration with the towels left flat on the plates and see the effects of diffusion without gravity; or, to see the effects of gravity, hang the towels up. The wet towel illustrates movement of two contaminant plumes and the limited mixing that occurs between plumes. If you put both drops in the same position, you will see the two contaminants moving together in the same path. Use whichever variations you wish. The point is that you understand gravity, convection, diffusion and plume movement.

17. ___ As a final variation of this demonstration, place one wet paper towel on each of two cookie sheets. Add a drop of red food coloring to a towel at the twelve o'clock position.

18. ___ Place the sheet on an incline of 45 degrees, with the drop of food coloring at the top. Do the same to the second towel.

19. ___ Using the dish soap dispenser, squirt a steady stream or bead of water across the top edge of one towel, so that the water flows down across the towel to the bottom of the cookie sheet.

20. ___ Observe what happens. You will see contaminant movement, plume behavior, and contaminant dissipation due to dilution. One way to solve water quality problems is to dilute them and flush them away.

Lesson Learned: Contaminants do not move very fast in soil and ground water systems; gravity and water content can affect contaminant movement in the soil and in water systems. In addition, different contaminants do not readily mix in soil and ground water systems and they persist for a long time.

The lesson above was adapted from "*What is Water Quality? A Resource Guide for 4-H Leaders and Teachers*," 80 pages of activities and experiments related to water quality. ($5.00) Order from the Montana 4-H Program at Montana State University-Bozeman. Phone 406-994-3501.