LANDFILLS AND THE POTENTIAL FOR GROUNDWATER CONTAMINATION

9-12

SUBJECTS:
Science (Chemistry, Environmental Science), Math
TIME:
3-4 class periods per procedure homework 1 month (minimum) for leachate collection
MATERIALS:
Plastic garbage can (30 gallon) Clear plexiglas®, +/- 4" x 30" (Be sure to modify this if you choose to use a 13 gallon kitchen trash can.) Membrane filtrate 5 to 10 gallons of soil screw-in, plastic faucet with securing nut a small piece of screened wire +/- 2"square caulking compound waterproof glue for plastic one gallon of distilled water coliform bacteria test laboratory thermometer student work sheets (included) gloves

OBJECTIVES

The student will do the following:

1. Define waste and leachate.

2. Describe a sanitary landfill in terms of its construction and function.

3. Identify some common chemical and physical properties of leachate and the problems these can cause in groundwater.

4. Identify sites in the community that are possible sources of contaminants in runoff waters and groundwaters due to unsupervised, unprotected garbage disposal sites.

BACKGROUND INFORMATION

Most of our household waste is buried in landfills. An important factor in how landfills are built is how they contain waste and prevent waste from contaminating nearby soil and water sources. The possibility of leachate contaminating soil and groundwater exists wherever wastes are disposed.

Leachate is a fluid that has passed through or emerged from the waste in a landfill, picking up a variety of suspended and dissolved materials along the way. Leachate generation depends on the amount of liquid originally contained in the waste (primary leachate) and the quantity of precipitation that enters the landfill through the cover or that which comes in direct contact with the waste (secondary leachate) prior to being covered. Factors that affect leachate generation are: climate (rainfall), topography (run-on/run-off), landfill cover, vegetation, and type of waste.

In unlined landfills, the leachate continues to leach into the ground and may contaminate groundwater. Many old landfills used a simple clay liner for containing leachate (clay is one of the most non-permeable soils). Newer landfills are required to meet federal and state requirements to prevent environmental contamination (Subtitle D landfills). These landfills have sophisticated liner systems often made of heavy-duty, high density polyethylene (HDPE) plastic, where leachate is collected at the bottom. The leachate is typically treated on-site or is pumped out and sent to a local wastewater treatment plant. Treated leachate can be disposed of in a number of ways (e.g., discharged to surface waters or recirculated back into the landfill). Some States also allow continued use of clay liners, if the liner meets federal and state performance standards, and if leachate is properly collected, treated, and disposed of.

In this lesson, the landfill model represents the construction of a Subtitle D sanitary landfill to hold municipal waste.

A common convenient procedure for disposal of household and domestic garbage is to take it to the nearest ravine, hollow, or back road and leave it in a completely unprotected situation. Because this kind of behavior is such an accepted and uncontested way of life for many households, the effect of this garbage upon water quality can be overwhelming. Often there is absolutely no regard for the contamination potential of some of these items. The results of this can be the introduction of very toxic substances into the streams and

groundwater. An understanding of the long-term harmful effects of these actions would influence the future actions of students and their counterparts toward proper garbage disposal. Such an understanding of the part of the community leaders will possibly influence legislation and enforcement.

Terms

aquifer:
porous, water-bearing layer of sand, gravel, and rock below the Earth's surface; reservoir for groundwater.

groundwater:
water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface; water within the zone of saturation.

leachate:
a liquid that results from water collecting contaminants as it trickles through wastes, or soil containing agricultural pesticides or fertilizers

percolate:
to drain or seep through a porous and permeable substance; to filter such as a liquid passing through a porous body (water through soil to the aquifer)

residue:
something that remains after a part is taken away

ADVANCE PREPARATION

A. Make copies of Student Sheet (3).

B. Ask students to come up with some of the materials to construct the sanitary landfill model.

PROCEDURE

I. Setting the stage

A. Discuss with the students the following:

1. What is waste?

2. What does the term “biodegradable” mean? (*Note that some of the elements necessary for biodegradability - air, water, and sunlight - are not available in a landfill. Without air, water, or sunlight, there is no degradation*.)

3. What are the sources of waste? Give examples.

4. What happens to the waste from our homes, schools, and businesses? Then what? (Lead students to the conclusion that most waste is buried in a landfill.)

5. Why is waste disposal an important issue?

6. Have students identify some local sites where household garbage is disposed illegally.

7. Discuss the possible effects of illegal disposal on surface water and groundwater.

B. If possible, make arrangements for students to visit the nearest landfill site or arrange a presentation by a local waste management or public health expert. Explain how a landfill is constructed. Discuss:

1. Site selection.

2. Methods and operations.

3. Chemical and biological reactions occurring in a completed landfill.

4. Methane gas and leachate movement and control.

5. Landfill design criteria and regulations.

C. Ask the students to describe what they think the properties of landfill leachate might be (in terms of pH, bacteria, and suspended solids) and what the processes occurring in its formation might be. (Seeing the landfill operation or hearing a presentation by a landfill operator first will give students a better understanding. As a less-than-

complete-but-effective alternative, have students take a trip to the school dumpster. (This may reveal the early formation of leachate, as liquid wastes have probably started to accumulate in the bottom of the container.) Students could test the pH of leachate from the school dumpster.

D. Ask each student to bring to class a small plastic bag containing household wastes, including foodstuffs (vegetable and fruit peels, no meat or dairy products), yard trimmings or plant residue, metal, paper, plastic, and cloth. As they bring the small bags of waste, have them deposit the bags in a larger bag or other large container.

E. Have the materials and equipment gathered for constructing the landfill model. (See Student Sheet: Construction of a Sanitary Landfill Model.) Divide the class into teams.

II. Activity

A. Give the teams copies of the Student Sheet: Construction of a Sanitary Landfill Model, and proceed with the landfill model construction and waste preparation.

B. To prepare for the simulated rainfall, determine the average annual precipitation for your geographic area. Information is available from the state climatologist or local extension agent of National Weather Service.

1. Divide the average annual precipitation by 52 to calculate the average weekly precipitation.

2. Measure distilled water to equal the amount of the calculated average weekly precipitation and sprinkle it over the soil in the model landfill.

3. Repeat the addition of "average weekly precipitation," keeping a record of the number of "weeks," until water begins to collect in the bottom of the model landfill. (*The liquid that collects in the bottom is a leachate.)* Be prepared to allow several weeks of adding precipitation to obtain enough leachate to perform this activity.

C. Monitor the temperature by inserting a thermometer as far as possible into the center of the landfill model and keeping a daily record of temperature readings. This can be an excellent graphing exercise.

D. One month after the addition of water, withdraw all of the leachate from the model and test for pH, total suspended solids (liquid weight minus weight of solids), hardness, coliform bacteria (optional), and other water quality parameters for which tests are available.

1. Compare the results of these tests with the properties of distilled water and graph the results.

2. Discuss what can be done to prevent leachate from contaminating groundwater and surface waters.

Explain to the class that leachate contamination can be controlled through landfill design and operational requirements (i.e., exclusion or hazardous waste and liquids). For example, landfill liners and leachate collection systems help to control contamination.

E. How Leachate Contaminates Groundwater

To determine how leachate, once it has reached an aquifer, contaminates groundwater, conduct the following experiment:

Material Needed:
4 petri dishes
4 steel nails
Soap
Rubbing alcohol
Paper towels
Universal indicator paper
A sample of the leachate
Household ammonia
Household vinegar
Tap water
Safety goggles

1. Measure the acidity of the leachate from this activity with universal indicator paper. Compare it with indicator dipped in tap water, household ammonia, and household vinegar.

2. Clean the nails with soap and water, rinse with alcohol, and dry with paper towels. Be careful not to touch the nails with bare hands after rinsing.

3. Fill each of the four petri dishes about half full. Place tap water in one, leachate in the second, household ammonia in the third, and household vinegar in the fourth. Place one nail in each dish.

4. After a few days when the liquid has evaporated, observe the nails. Record the observations. Have the nails changed in appearance?

F. How Leachate Affects Plants

To perform another experiment with the leachate sample, ask the students to bring to class an egg carton containing nine eggshell halves.

You will also need the following materials:

3 different types of soil (clay, loam, sand)
Approximately 20 small plants 1" to 2" high (radishes germinate quickly)
Soil testing kit
Student Record Sheets (included)

1. Discuss soil structure and compare soils with three different structure types - heavy (clay), medium (loam), and light (sand).

2. Have the students prepare three seed beds from each of the three soil types, using the eggshell halves as containers. (Have the students prick tiny drainage holes in the bottoms of the eggshell halves.)

3. Have the students sow several radish seeds in each shell half and keep them moist during germination. (Plastic wrap laid on top will hold moisture in the soil.)

4. When the radish plants are one or two inches high, water one bed of each soil type with distilled water (control group), one bed of each soil type with leachate drawn directly from the landfill model, and the other bed of each type with leachate that has been passed through a column of soil. (Discuss the movement and dilution of leachate, including how continued movement changes the degrees of dilution.) Use the same measured volume of liquid on each plant. (Be sure not to overwater.)

5. Have the students record the condition of the plants after one hour, 24 hours, and 48 hours. Observe for signs of obvious ill effects (or, as might be possible, temporarily beneficial effects for added nutrients in the leachate). Record the observations on the Student Sheet: How Leachate Affects Plants.

G. How Leachate Affects Living Things

Measure 1 ml of leachate in a container and add 99 ml of distilled water (to simulate the dilution of leachate due to normal movement through soil.)

1. Place 10 to 20 living Daphnia in the container. (Daphnia are any of a variety of small freshwater crustaceans of the genus Daphnia, some species of which are commonly used as food for aquarium fish.)

2. Record any changes of activity or obvious death after 1 minute, 2 minutes, and 5 minutes.

H. **CAUTION:** MAKE SURE STUDENTS TAKE PROPER PRECAUTIONS, SUCH AS WEARING PROTECTIVE CLOTHING, GLOVES, AND GOGGLES, BEFORE PARTICIPATING IN THE FOLLOWING SEGMENT OF THE EXPERIMENT:

Include hazardous wastes - household chemicals such as hazardous pesticides, nail polish remover, cleaning fluids - in your landfill model. Have leachate samples analyzed at a laboratory. How might this leachate affect groundwater? Should household hazardous wastes be placed in municipal solid waste landfills? If not, what should we do with them?

Continue testing plants watered with leachate samples that have passed through increasingly more soil.

III. Follow-up

Discuss the results of this lesson in terms of the following:

A. The need for monitoring streams, wells, and springs located below the elevation of landfill sites.

B. The importance of reporting unusual odors in drinking water and knowing to whom such information should be reported. Place a listing of agencies to report unusual odors and environmental hazards to students. Teachers can prepare an “Inquiry Sheet” that can be easily completed with necessary information and sent to the appropriate person(s).

RESOURCES

EPA Facts About Leachate Collection, June 1992

Construction of a Sanitary Landfill Model

(using a 30-gallon garbage container)

1. Cut a 2" x 30" vertical strip from a 30-gallon (or larger) garbage container, leaving the container intact 3 inches above the bottom.

2. Glue a 4" x 32" piece of Plexiglas® to the inside of the container and over the cutout. This will allow you to view the contents of the model landfill. This window will show the strata of waste and soil. (The window may be marked in increments of inches to help with layering the soil and waste.)

3. Before inserting a screw-in faucet on the side or the bottom of the elevated model, cover the back of the faucet (the opening inside the tub) with the screened wire. This will help keep waste material from flowing out with the leachate. With caulking compound, seal around the faucet.

Preparation of Waste

In a sanitary landfill, the accepted ratio of soil cover to waste is 1:12 (6" of soil: 72" of waste). In this model, 1" of soil cover will be used for 12" of waste. (*If you use a smaller trash can, try to stick to this ratio, if possible*.)

4. Place one layer of waste in the landfill model.

5. Cover the first layer of waste with 1" to 2" of damp soil. Tightly pack the soil cover by pounding it firmly to simulate a real landfill situation.

6. Continue the layering and compacting until the landfill model is full. The final layer should be 4" of soil.

Control Soil Samples		
Soil Type #1	pH _____ K _____	P NO_3^-
Soil Type #2	pH _____ K _____	P NO_3^-
Soil Type #3	pH _____ K _____	P NO_3^-

Pure Leachate on Soil Samples		
Soil Type #1	pH _____ K _____	P NO_3^-
Soil Type #2	pH _____ K _____	P NO_3^-
Soil Type #3	pH _____ K _____	P NO_3^-

Leachate through Soil on Soil Samples		
Soil Type #1	pH _____ K _____	P NO_3^-
Soil Type #2	pH _____ K _____	P NO_3^-
Soil Type #3	pH _____ K _____	P NO_3^-

Student Sheet

How Leachate Experiment Affects Plants:

Control Soil Samples	**Plant Conditions After:**		
	1 Hour	**24 Hours**	**48 Hours**
Soil Type #1			
Soil Type #2			
Soil Type #3			

Pure Leachate on Soil Samples	**Plant Conditions After:**		
	1 Hour	**24 Hours**	**48 Hours**
Soil Type #1			
Soil Type #2			
Soil Type #3			

Leachate through Soil on Soil Samples	**Plant Conditions After:**		
	1 Hour	**24 Hours**	**48 Hours**
Soil Type #1			
Soil Type #2			
Soil Type #3			