

1988

Outlook on Groundwater: Elementary

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Outlook

On Groundwater



Elementary

TABLE OF CONTENTS

FOREWORD

- Activity 1 "Life on Planet X"
- Activity 2 "Dew Drop Inn"
- Activity 3 "Water Magic"
- Activity 4 "Drip Trip"
- Activity 5 "Checking in at Aquifer Acres"
- Activity 6 "Percolation Race"
- Activity 7 "Checking Out of Aquifer Acres"
- Activity 8 "What Goes Down, Comes Up!"
- Activity 9 "Inspect That Drop"
- Activity 10 "Old McDump's Farm"
- Activity 11 "Pumps and Pipes"
- Activity 12 "Who Dumped It?"

DILEMMAS

GLOSSARY

FOREWORD

The quality of groundwater is becoming an increasingly apparent concern. Those charged with responsibilities related to groundwater matters are being called upon by concerned citizens for information and advice about their own water supplies. To the public, the obvious source of groundwater contamination is the application of fertilizers and pesticides to the land. Sources equally important, but less obvious, are underground storage tanks, drainage wells, landfills, and past and present hazardous waste management procedures. Public concern frequently focuses upon agricultural application of chemicals to the land, thus failing to recognize the significant contribution to groundwater contamination by urban use of similar chemicals. In addition, household products such as detergents, cleaning compounds, paint thinners, automotive oil, etc. must be considered. As Pogo, Walt Kelly's cartoon hero of the 1950's and 1960's, once said, "We have met the enemy and it is us."

This educational project has been created to help our youth move from being part of the problem to being part of its resolution. One of the teachers who tested this material in its draft form made the following comments: "When we think of water and its everyday usage, it may be hard to think of it as a reusable resource . . . it seems like a one way trip." He went on to state, "Another idea that is hard to grasp is that there is just as much water on Earth today as there ever was, yet we are constantly reminded of water shortages, water quality, and . . . of water pollution." A teacher who tested the elementary materials reported the shock of her students when they considered that the water they were drinking may be the same water in which dinosaurs swam.

The quality of our groundwater is the responsibility of each member of society. Our behavior must not be one of merely finger-pointing. We must take that responsibility seriously by learning about 1) the phenomenon of ground water, 2) mechanisms by which contamination may occur, and 3) the effects of contamination on all forms of life - not only humankind.

OUTLOOK: On Groundwater was prepared with the support of the U.S. Department of Energy (DOE) Grant No. 01362-87-08. However, any opinions, findings, conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the views of DOE. A select group of teachers were brought together to write the activities at the Institute for Environmental Education on the campus of the University of Northern Iowa. Prior to the writing phase, Ms. Cathy Wilson and Ms. Kathy McKee conducted extensive research seeking technical and educational support literature. Their special dedication to this project was a major contribution to the smooth operation and success of writing OUTLOOK: On Groundwater. The creative teachers selected for the writing phase were Nancy Lockett and Patricia Mead (elementary module), Heidi Andre and Roger Beane (middle school/junior high module), and Joyce Meyers and Bernie Hermanson (senior high module).

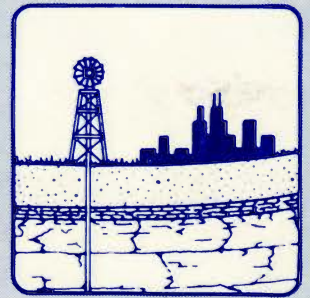
Ultimately, the editing process must take place. In this, Ms. McKee played a major role. Difficult decisions are always a part of editing. More materials were written than could fit into the scope of time allowed for the module. Decisions to eliminate or modify original activities were solely my own and were based on project scope, balance, and time.

David McCalley, Director
Institute for Environmental Education
University of Northern Iowa

Life on Planet X

Activity in Brief

Students predict life conditions on a planet, given its water resources, unaware that it is actually the Earth.



Objective

Students will discover the limited amount of water and the proportion of fresh water which is available to sustain life on Earth.

Site

Classroom

Time

50 minutes

Materials

28" diameter beach ball
eye dropper
1 c. measure

Exploration

Students are asked to predict and describe life on an imaginary planet when given the total amount of water available on that planet.

Invention

Students develop a way for humankind to survive on a planet that fits the criteria offered in the exploration.

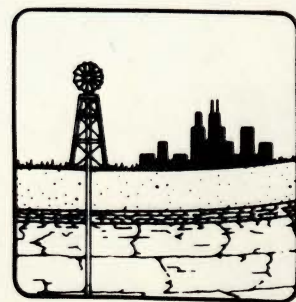
Application

The student will prioritize the uses of water on Earth.

Teacher Notes

For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: The imaginary planet is represented by a beach ball, 28" in diameter. A cup of water is shown to represent the total amount of water available on the surface and in the crust of the planet. However, only a drop of that water is available in river systems and fresh water lakes to support life (use eye dropper.)

FYI Invention: Unknown to the student, the planet is Earth. Discussion questions: Would life exist on the planet? What forms of life might exist on this planet? What would their behaviors be like? What would humans have to do to survive? The teacher then explains that the planet represents our Earth. The relative size of the people on this planet would be that of microscopic specks. (The 28" ball is .00000057% of the actual size of the Earth).

FYI Application: Through discussion, the students will list how the water on this planet would be used and then prioritize the list.

Questions: How will the drop of water be distributed? Where is it most/least needed?

Some of these facts may help the students list their priorities for water use: A 2000 acre farm can use as much water as a city of 50,000. It takes 10 gallons of water to produce 1 gallon of gasoline. It takes 65 gallons of

water to produce 1 ton of steel. It takes 60,000 gallons of water to produce 1 ton of paper, 150 gallons to produce 1 ream, and about 1/3 of a gallon to produce 1 sheet of typing paper. It takes 136 gallons of water to produce a loaf of bread. It takes 100,000 gallons of water to manufacture 1 automobile.

FYI General: All the water that has ever been available to our planet is on or in the Earth right now. There are 326 billion cubic miles of water. If the Earth were the size of a 28" diameter ball, the total amount of its water would fill one cup. Of that one cup, only 0.03% (slightly more than one drop) is in river systems and lakes. That "drop" is being contaminated by chemical, ecological, organic and thermal sources. Humans cause the greatest amount of damage to water resources. If we understand what causes water pollution and how it affects our environment, we can better prepare to take constructive action.

Follow-up Suggestions

Discuss: What do you think happened to the water the dinosaurs bathed in two million years ago? (You could have brushed your teeth with it this morning.) What do you think happened to the water Ben Franklin cleaned his

glasses with? (You could have used it to make lemonade last night.) Students will create posters that express their ideas about the limited amount of water that is available for human use.

Follow-up Activities

Find out where your community water comes from. Trace it back to its source.

OUTLOOK 3-5 activities entitled I Wanna Drink and Water Cut-ups.

Resources

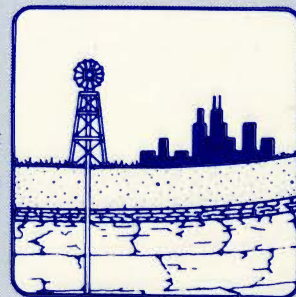
Daug, Donald, and C. Earl Israelson. 1985 Water Education Grades K-6. Utah Water Research Laboratory, Logan, UT. 84322

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Dew Drop Inn

Activity in Brief

Students organize containers of water according to the relative amount of water resource they represent. This activity should focus on the concept of how limited our "useable" water is.



Objective

Students will develop an understanding of the relative distribution of water on Earth.

Site

Classroom

Time

45 minutes

Materials

(7) 1 gallon containers
1 gallon water
5 eye droppers
measuring cup (for liquids)
waxed paper - small piece
flat toothpicks
pencils/crayons
paper to make 6 labels

Exploration

Students will apportion water into containers and predict which amount represents which water source.

Invention

The students will develop the concept of the actual distribution of water on this planet.

Application

Students will assess the use and misuse of water in their homes, suggest ways to reduce the misuse, and carry out a water conservation program.

Teacher Notes

For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: The students are given 1 gallon of water and 6-1 gallon containers. They are asked to distribute the water in this way: One container should have 15 1/2 cups, one container 16 1/2 drops, one container 5 drops, one container 1 drop, one container 1 1/2 drops, and one container 1/10 of a drop.* The following labels should be made: RIVERS, ICE CAPS, ATMOSPHERE, OCEANS, LAKES, and GROUNDWATER. After the water is divided, the students will be told that this represents all the water on Earth. They are asked to come to a consensus about which quantity of water is represented by each label and to place the labels on the appropriate containers.

* Suggestion for finding 1/10 of a drop: Put one drop of water on a piece of waxed paper. Using a toothpick, divide the drop into 10 equal parts.

The actual distributional proportions are:

oceans	15 1/2 cups
ice caps	16 1/2 drops
groundwater	5 drops
lakes	1 1/2 drops
atmosphere	1 drop
rivers	1/10 drop

FYI Invention: Discussion questions: Where is the most/least water? Which source is most/least useable by living things? Which source is the most readily available?

5 gallons would be the total amount of water on Earth, if the Earth were the size of a dome covered football field. If the students have done the activity "Life on Planet X", the different representations of the size of the Earth and quantities of water should be clarified for them to avoid confusion. In this activity, the proportions are adjusted for classroom use, and are approximate. The estimated proportions are:

Reservoir	Volume (10 ⁶ km ³)	Percent of Total
Oceans	1370	97.25
Ice caps and glaciers	29	2.05
Deep groundwater (750-4000 m)	5.3	0.38
Shallow groundwater (<750 m)	4.2	0.30
Lakes	0.125	0.01
Soil moisture	0.065	0.005
Atmosphere	0.13	0.001
Rivers	0.0017	0.0001
Biosphere	0.0006	0.00004
Total	1408.7	100

FYI Application: Now that the students have an idea of the limited amount of water available for human use, lead them to consider water conservation! Have students consider all uses of water in their homes and conduct daily water meter readings over a period of several days. List those uses considered to be "proper" and those considered to be "misuses". Develop a set of water conservation stickers which would be placed near water outlets (faucets, showers, toilets, etc.) to remind others to use the limited resource of fresh water wisely.

Follow-Up Suggestions

Prepare a bulletin board to display the information in the Invention.

Develop posters which show ways to conserve water.

Conduct a survey of water use in the school to determine whether there may be ways to conserve.

Resources

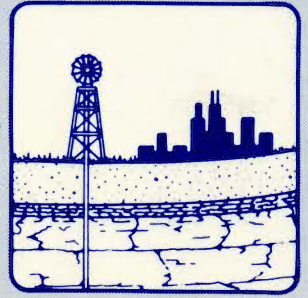
Pesticides and Groundwater: A Health Concern for the Midwest. 1986. Minnesota Dept. of Health and The Freshwater Foundation for the Health and Environment Network.

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Water Magic

Activity in Brief

Models are constructed that demonstrate the process of condensation.



Objective

The student will understand that water exists, in one form, as vapor.

Site

Classroom

Time

20 minutes (2-10 min. sessions each day)

Materials

baby food jars
water
duct tape

Exploration

Students use baby food jars to set up an environment in which to observe the action of water.

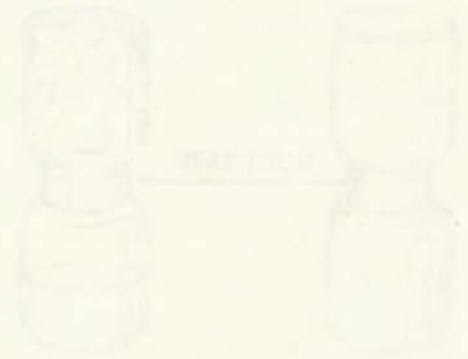
Invention

Students develop the concept that water vapor exists in the air.

Application

Students will draw a picture of themselves encountering water vapor in their everyday lives.

Teacher Notes



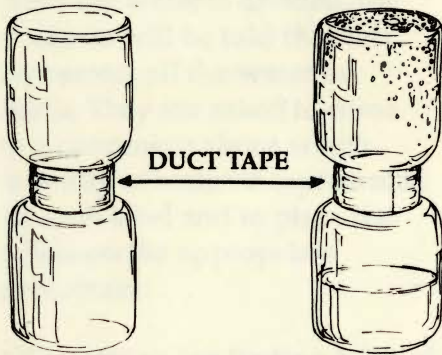
For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: Divide students into pairs and give them 2 baby food jars and enough duct tape to seal the openings together. One half of the groups should seal together empty jars, and one half should put 1" of water in one of the jars before sealing them mouth to mouth. Place the jars in a warm area (the sun or bright light). Observations should be made several times before class meets the next day.



FYI Invention: The students will observe the next day that the water evaporated and condensed on the top of the jar. Discussion questions: How did the water get in the jar? Do the amounts of water in the jars differ? Why? Some students may understand that the top jar represents the atmosphere, the bottom jar the Earth, and the light source represents the sun. Other students may need direction to come to that conclusion.

FYI Application: Examples of water vapor the students might

draw are: dew, water forming on the outside of a glass of cold fluid, frost, eyeglasses fogging over when you come in from the cold, steam on the bathroom mirror after a hot shower, breath in the winter, fog, humidity curling hair, steam from hot food, steam from a utility company's smoke stack, and boiling water eventually boiling away.

Follow-Up Suggestions

To demonstrate transpiration, a plant leaf may be added to a set of jars and the collection of water vapor observed and recorded. Later a terrarium could be made to illustrate the concept more fully.

Resources

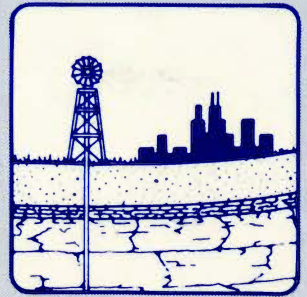
Groundwater: A Vital Resource. Student activities compiled by Cedar Creek Learning Center in cooperation with the Tennessee Valley Authority.

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Drip Trip

Activity in Brief

Students will predict the route that a drop of water takes through the water cycle.



Objective

Students will demonstrate an understanding of the movement of water through the water cycle.

Site

Classroom

Time

45 minutes

Materials

paper
crayons
pencils
copies of sentences provided in FYI

Exploration

Given sentence strips, students will arrange the order of events for a story describing what happens to a drop of water.

Invention

Students develop the concept of how the water cycle works.

Application

Students will construct their own model of the water cycle.

Teacher Notes

For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: The sentences provided below should be photocopied and divided into strips.

THERE IS A DROP OF WATER IN THE OCEAN.

THE OCEAN IS WARMED BY THE SUN.

THE DROP GETS WARM AND EVAPORATES.

THE EVAPORATED DROP RISES INTO THE ATMOSPHERE.

DROPS IN THE ATMOSPHERE JOIN TOGETHER AND CONDENSE.

THE CONDENSED DROPS FALL TO THE GROUND AS PRECIPITATION (RAIN, SNOW, ETC.).

PRECIPITATION SOAKS INTO THE GROUND.

THE DROP TRAVELS (PERCOLATES) THROUGH SOIL AND ROCKS.

THE DROP REACHES THE GROUNDWATER.

THE DROP STAYS IN THE GROUNDWATER FOR A VERY LONG TIME.

THE DROP SLOWLY MOVES THROUGH THE GROUNDWATER AND EVENTUALLY REACHES THE OCEAN.

Mix the strips so they are not in order. Working in small groups, the students are asked to put the sentences in this story in a logical order, making sure they use all of the sentences. The story describes the route of a drop of water through the water cycle. It is important to remember that a cycle has no beginning or end. Wherever students wish to begin is acceptable.

FYI Invention: Have students from each group read their story aloud. Does the story make sense? Are any adjustments needed? Where did the drop start its travel?

Do you think it took a long time? Why? Where did it stay for the longest time? What is precipitation? What does evaporation mean? From the story, can you determine what

condensation is? Where/what is the atmosphere?

FYI Application: Brainstorm and list on the board all the places that the drop traveled in the story: OCEAN, ATMOSPHERE, GROUND, SOIL AND ROCKS, GROUNDWATER. Next have the students list all of the processes (actions): EVAPORATION, CONDENSATION, PRECIPITATION, PERCOLATION. Have the students construct a model of the water cycle, labeling all of the processes with one color and all of the places with another. The model may be either graphic or three dimensional.

Follow-up Suggestions

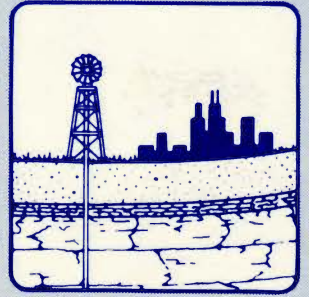
Construct a water cycle showing a pathway such as water traveling through plants and trees (evapotranspiration), or a man drawing well water from the groundwater. Use arrows to show this.

Resources

Water Safety Action Kit. 1983. Compiled by the editors of *The New Farm Magazine*. Ensmas, PA. Rodale Press.

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Checking in at Aquifer Acres



Activity in Brief
Students simulate drops of water traveling to an aquifer through different layers of soil and rock substrate.

Objectives

1. The students will understand that an aquifer is an underground region where water is held.
2. The students will understand that water percolates through the soil, traveling at different rates.

Site

Classroom

Time

30-40 minutes

Materials

classroom desks and chairs
yarn or string
optional - cardboard boxes, large plastic sheets, tape, etc.

Exploration

To check in at Aquifer Acres Hotel, the students must successfully navigate a classroom maze.

Invention

The students will develop the concept of an aquifer and of percolation as a method for aquifer recharge.

Application

Students construct new mazes, each of which illustrates different situations influencing percolation.

Teacher Notes

For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: While the students are absent from the room, arrange a maze using classroom furniture, yarn, etc. The maze will represent the different paths through which water can travel from the surface of the Earth to an aquifer. Obstacles should be placed so that there are some paths which can be easily traveled and some that cannot. Some paths should be narrow to restrict students' movement. Arrange the maze so that the aquifer area is large enough to easily accommodate all of the students. You may wish to include other obstacles such as large cardboard boxes, sheets of plastic, tables, etc. String yarn across some paths. Students will be told that they are traveling drops of water, needing to check into Aquifer Acres Hotel. They must pass through the maze in order to reach the hotel.

FYI Invention: Discussion questions: Which path was the quickest/most time consuming? Why? Which path was the shortest/longest? Was the shortest path the fastest way to reach the aquifer? Which path was the easiest/most difficult? Why? Which path was the most/least used? Why? What made a path easy to travel? Was any space large enough for everyone? What would happen if the "hotel" was

full and not all of the drops could fit? What happened when the students could not travel through the narrower paths? The terms aquifer and percolation should be defined early in the discussion, and used whenever applicable.

Definitions:

Aquifer: A permeable layer of rock, sand, or gravel that stores and transmits large quantities of water.

Aquifer recharge: The replenishment of groundwater by infiltration of atmospheric water (precipitation) through the soil.

Groundwater: The subsurface water supply in the saturated zone below the water table.

Percolate: Downward movement of water through layers of soil and rock.

Permeability: Ability of a substance to transmit liquids.

Porosity: Amount of pore space a material has.

FYI Application: Groups of students will construct new mazes such as a maze allowing only slow movement, or one which allows fast movement. This activity should be followed by Activity 6 - Percolation Race.

Follow-Up Suggestions

The students build soil profiles showing different existing soil types and layers to show key concepts. Display these in the

school or at a science fair.

Write stories about a drop of water and its adventures while traveling through the ground.

Resources

WILD: Aquatic Supplement. Western Regional Environmental Education Council. Salina Star Route, Boulder, CO. 80302

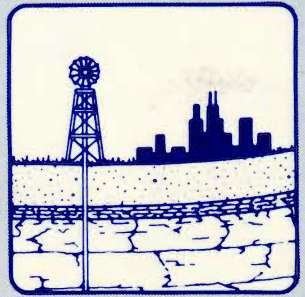
Groundwater Study Guide. Wisconsin Dept. of Natural Resources.

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Percolation Race

Activity in Brief

Students construct a model showing the rate of water as it percolates through different layers toward an aquifer.



Objective

Students will discover that water percolates at various rates through different mixtures of materials commonly found in soil.

Site

Classroom

Time

45 minutes

Materials

decayed peat, 8 qt.

sand, 8 qt.

clay, 8 qt.

gravel, 8 qt.

quart containers, one for each group of 3-4 students

dish pan labeled "Finish Line", one for each group of 3-4 students

milk jug bottoms—8", one for each group of 3-4 students

water

Exploration

The students will have a "percolation race" using a medium of their choice.

Invention

Students will develop an explanation that accounts for the different rates of water movement through the materials.

Application

Students create a medium that they believe would be best suited for plant growth.

Teacher Notes

For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: Divide students into groups of three or four. Give each group a topless milk jug with holes punched in the bottom (each jug should have the same number and size of holes). Provide 5 mediums: Decayed peat; dry sand; clay; gravel; and a mixture of clay, sand and gravel. There are two commercially available forms of peat - decayed and fibrous. For this activity, the decayed form is necessary. Students are asked to fill their jug half full of whatever medium or mixture of mediums they would like. They are given a quart of water and a container into which they will drain water. Tell the students that they are going to have a "Percolating Race"! They have five minutes to see how much water will percolate through their mixture to the container (representing an aquifer) below. Holding their jugs over the containers, everyone begins to pour at the same time. One group member should record the time when the first drop comes through and the time when percolation seems to have stopped, if this occurs before the five minute time limit.

FYI Invention: Questions to consider: Through which mixture did all of the water percolate the fastest (most permeable)? Which mixture still had water left on top (least permeable)? How did gravel

affect permeability? How did clay affect permeability? When the students construct the idea of permeability, it should be identified as such by the teacher. Permeability is the ability of a medium to transmit liquid through pores and cracks. Because of its relatively large size, gravel has considerable space between each piece. Sand, due to its smaller particle size, has correspondingly small intergranular pieces. Clay, which has the smallest sized particles, has practically no space between particles. Because clay is considered impermeable, it may protect an underlying aquifer from contaminants.

FYI Application: A greenhouse may use the following recipe when making a good potting soil for their plants:

Mix 1 part sand and 2 parts loam (fine black dirt).
Add 1 part peat and 1/2 part perlite.

You may wish to use this greenhouse recipe to compare with the potting soils that the students make. However, let the students decide what ingredients they wish to use, accepting all of their ideas.

Follow-Up Suggestions

Produce different soil mixtures and see which is best for plant growth.

Resources

The Adventures of Colonel Kentucky, Natural Resources and Environmental Protection Cabinet, Kentucky Association for Environmental Education.

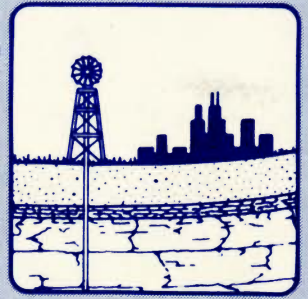
Cancilla, Leslie. 1984. *In-Farm-ation for environmental education. The Communicator*. 10:2. Pittsfield, Mass.

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Checking out of Aquifer Acres

Activity in Brief

Students experience the difficulty of avoiding contamination of aquifers.



Objectives

1. Students will understand that, as water percolates through the soil, it may pick up contaminants.
2. Students will understand that soil is a natural filter and will filter some, but not all, contaminants.

Site

Classroom

Time

30 minutes

Materials

chairs
desks
yarn
construction paper cards—red, white,
and black

Exploration

Students are asked to travel through a maze to reach Aquifer Acres Hotel, picking up contaminant and filter cards along the way.

Invention

Through reflection and discussion, students will develop the concept that water may pick up contaminants and/or be filtered as it moves through the soil.

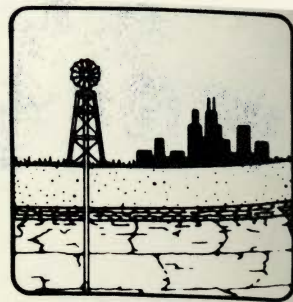
Application

Students will develop plans to reduce aquifer contaminating activities.

Teacher Notes

For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: Set up the classroom as suggested in "Checking in at Aquifer Acres". Mix up previously made contaminant and filter cards and place in stacks, facedown, around the maze. The students are told that they are going to go through the maze to visit the Aquifer Acres Hotel again. They are drops of water. When they come within arm's length of a card, they must pick it up. If the student picks up a white card, it must be matched with a black card that is in hand and discarded. If no black card is in hand, the white is kept until a black card is picked up. Then both may be discarded. Red cards are never discarded. When all students have reached Aquifer Acres, explain that: Black cards represent contaminants that may be cleaned up through filtering. Red cards represent contaminants that can never be cleaned up by filtering. White cards represent the filtering process of soil. Ask the students how many are "cleaned up" drops of water. Try to provide two white cards, two black cards, and one red card for each student in your class. Make sure, however, that these cards are randomly distributed throughout the maze so that each student may pick up a different combination of cards.

FYI Invention: Soil has been

called the natural filter. For example, soil characteristics are very important in determining how a pesticide breaks down and whether or not it leaches into the groundwater. Because most breakdown occurs in the soil, there is greater potential for groundwater contamination. Sandy soils have large pore spaces between individual particles, and the particles provide relatively little surface for sorption, or physical attachment of pesticides. Large amounts of rainfall or excessive irrigation water can percolate through these soils, and dissolved pesticides can move rapidly down through the soil and into groundwater. Clay soils, on the other hand, are composed of extremely small particles that provide a vast surface area for sorption. The small pore spaces between clay particles slow the movement of water and dissolved pesticides through the soil. While held securely to soil particles, pesticides are kept from moving to groundwater and are more likely to be broken down. Breakdown occurs through reaction with the mineral components in the soil, with natural chemicals dissolved in the soil moisture, or by the action of bacteria and fungi in the soil. Most of this chemical and biological breakdown takes place in the

loose, cultivated surface layer, where the soil tends to be warm, moist, high in organic matter, and well aerated.

Soil organic matter is also important in preventing pesticide movement and promoting pesticide breakdown. Organic matter provides additional surface area for sorption and provides an excellent environment for chemical and biological breakdown to occur. Soil moisture and temperature also affect pesticide breakdown. Breakdown is slower in drier soils and at lower temperatures because both chemical and microbial reactions are slower under these conditions.

FYI Application: A common student approach to the problem might be to suggest not using things that contaminate. To deal with this kind of response, suggest several sources of contaminants. Discuss possible ways to eliminate them and the effect that elimination may have on life styles.

FYI General: Once an aquifer has been contaminated, it will take hundreds of years to clean itself. Why? Many contaminants cannot be cleaned by filtering alone. (A gallon of gasoline can contaminate 10,000 gallons of water.)

Follow-Up Suggestions
Have students display or

Checking out of Aquifer Acres

present plans to reduce aquifer-contaminating activities.

Have a letter writing campaign to encourage reduction in the use of sources of contamination.

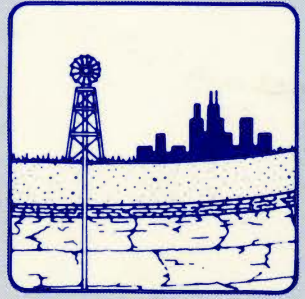
Resources
Drinking Water: A Community Action Guide. Concern, Inc.

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What goes Down, Comes Up!

Activity in Brief

Students contaminate the groundwater as they dump their waste from an art activity on the surface of a simulated aquifer.



Objectives

1. Students will discover that what people do on the surface of the Earth affects the quality of water in an aquifer.
2. Students will understand the need to control what is dumped into our water resources.
3. Students will observe the limited natural filtering process of the soil.

Site

Classroom

Time

60 minutes

Materials

art paper
salad oil mixed with tempera paint
water color paint
container with spigot on the bottom
(sun tea or cooler)
water
clear glass or plastic cup
soil, sand, and pea gravel

Exploration

Students are asked to create an art project and to dispose of all unused material in designated containers.

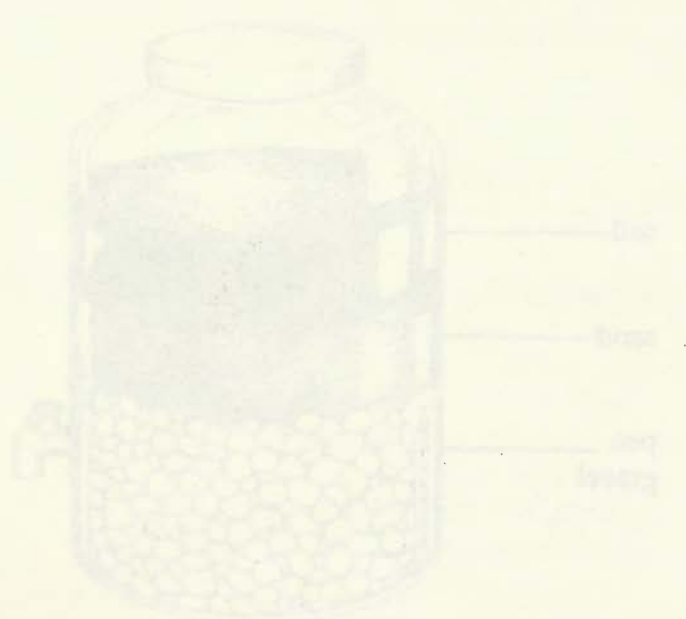
Invention

Students design a procedure which would eliminate the pollution of the water supply.

Application

Students will identify and list materials used in everyday situations which may contaminate groundwater.

Teacher Notes



For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: The teacher should ask the students to create an art project using tempera paints, water colors, etc. Students are to dispose of their liquid waste in the jar provided. They will obtain "clean" water from that jar also. The jar should have a spigot at the bottom (a sun tea jar works well). Fill the jar from the bottom up, starting with 1 1/2 inches of pea gravel followed by three inches of sand and two inches of potting soil. Before adding the layer of potting soil, thoroughly saturate the sand and gravel layers with water. The students will draw their water from this source.

FYI Invention: Things which may be considered as the students seek to eliminate pollution in water supplies would include alternative

disposal procedures and their consequences. A very important aspect for consideration is the search for preventative procedures rather than cures.

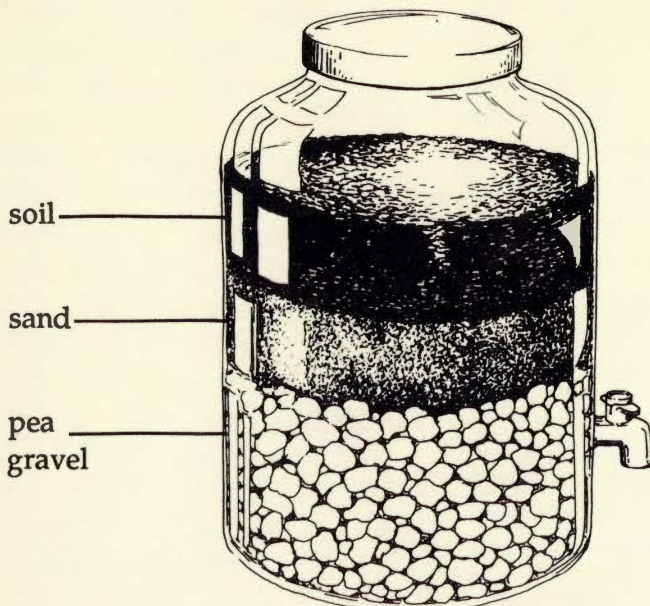
FYI Application: Students should be responsible for clean up following this activity to see the full effect of their "contamination". Brainstorm and list on the board substances used in their homes that may be sources of groundwater contamination.

Follow-Up Suggestions
Collect newspaper articles about groundwater contamination and related issues.

Resources

WILD: Aquatic Supplement. Western Regional Environmental Education Council. Salina Star Route, Boulder, CO 80302

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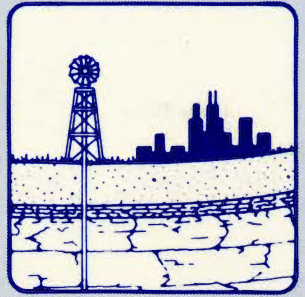


1. initial state - gravel, sand and soil with "clean" water
2. add "waste" to soil surface, continue to obtain water from spigot.
3. Observe gradual contamination of the "aquifer"

Inspect That Drop

Activity in Brief

Acting as water inspectors, students rank the drinkability of water samples.



Objective

Students will understand that contaminants may not be detected visually.

Site

Classroom

Time

30-40 minutes

Materials

- 5 baby food jars with lids
- 1 tsp. salt
- 1 T. white vinegar
- Koolaid (3 colors mixed to make a dark brown)
- 1 T. powdered milk

Exploration

Students will explore, by sight and smell, the potential drinkability of a water sample.

Invention

Through viewing and smelling, students will construct a system for ranking the potential drinkability of a water sample.

Application

Students will design posters to convince others not to judge water drinkability by looks alone.

Teacher Notes

For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: The teacher needs to prepare several sets of the following jars, and label them A, B, C, D, E.

D. water

E. water—add 1 teaspoon salt

A. water—add 1 tablespoon white vinegar

B. water—add 1 teaspoon of 3 colors of Kool-aid

C. water—add 1 tablespoon powdered milk

FYI Invention: Students will try to rank the samples by both appearance and smell. They will discuss why they re-evaluated the rankings and made changes after the smell test.

FYI Application: The students will determine what their findings would mean to their families, themselves, and the people in the community. The students may wish to design a slogan-type poster, or they may illustrate an idea.

Thought provokers for the children might be: When is water safe to drink? Is clear water safe for drinking?

Follow-Up Suggestions

To show that contaminants may be odorless as well as colorless, do the following: Place the contents of jar E in a flat dish and allow the water to evaporate. Ask the students where the residue came from.

Before evaporating the water, could you smell it? See it?

Resources

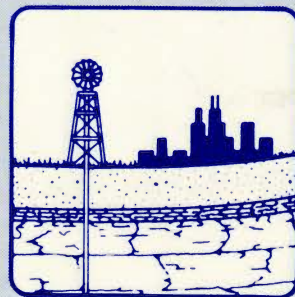
Protecting Our Groundwater—A Grower's Guide. American Farm Bureau Federation.

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Old McDump's Farm

Activity in Brief

Students study run-off in action by constructing a model crop field.



Objective

Students will understand the carrying capabilities of run-off water.

Site

Preferred outdoor site! Can be done indoors if necessary.

Time

30-50 minutes

Materials for Exploration

cake pan (one for every group of 4)
stream table or plastic snow sled (one for every group of 4)
soil
toothpicks
water
wooden blocks (one for every group of 4)
puffed rice
grapenuts
green Kool-aid mix
gravel
plastic sandwich bags
sprinkling can (or cup with holes punched in the bottom)

Materials for Invention

materials gathered from outdoors:

sticks
grass
sod
rocks
leaves

other materials:

cardboard
popsicle sticks
plastic
foil
netting

Exploration

Students will construct hillside crop fields and watch run-off caused by "rain".

Invention

Students re-construct model crop fields to minimize the damage done from run-off to their soil crops, streams and lakes.

Application

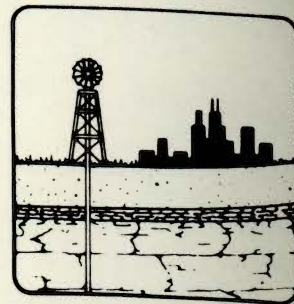
Examine potential sources of soil erosion in rural or urban settings and devise a method for reducing the potential erosion.

Teacher Notes



For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: Divide the students into groups of 4. Each group will be given a cake pan, gravel, soil and toothpicks, and told to construct a field of crops. The gravel should be placed on the bottom of the pan and the pan should be filled with soil. Stick the toothpicks in to represent crops. Put one inch of water, representing a lake, in the bottom of the stream table or toboggan. Tilt the cake pan in stream table or toboggan, using a block of wood, to represent a slope. (One cake pan can be placed at each end of the toboggan) The teacher should have pre-prepared plastic sandwich bags of green Kool-aid labeled INSECTICIDE, and baggies of a mixture of puffed rice and grape nuts labeled PLANT FERTILIZER.

FYI Invention: Students will discuss what happened, and why it happened. How could

the run-off have been avoided? If someone chose not to add insecticide or fertilizer, did it make a difference in the composition of the run-off? Discuss how the lake looked before and after the rain. Would it be easy to clean up? Do you think the run-off had an effect on the plant and animal life in the lake? Students will be asked to fix their field so that there won't be so much run-off damage to the field or lake the next time it rains. If the activity is done outside, students could use leaves, sticks, rocks, grass, sod, or litter found in the yard. If the activity is done inside, the teacher should provide materials on a table, as listed in Materials For Invention. The re-constructed models should be tested with water to see if the run-off problem was solved. Farm practices that minimize run-off damage include:

contouring
strip cropping
grassy waterways
grass headlands
crop rotation
terraces
conservation tillage

FYI Application: Rural soil erosion is frequently discussed, yet erosion from within urban settings is also a problem. Building sites (e.g. roads, homes and commercial buildings) contribute to erosional run-off both directly into bodies of water and indirectly through storm sewer systems which empty into these bodies of water.

An especially good application with this learning cycle would be to find and repair an erosion problem on the school grounds.

Follow-Up Suggestions

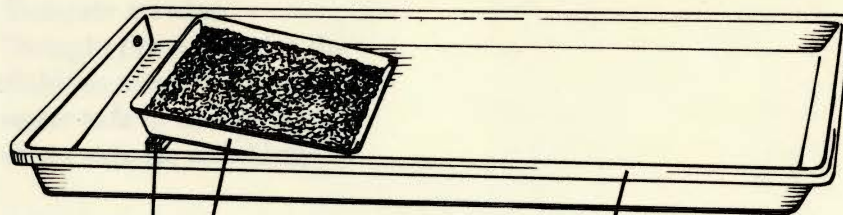
OUTLOOK 3-5 activity entitled "Gourmet Soil"

OUTLOOK K-2 activity entitled "Where Does the Soil Go?"

Resources

Groundwater: A Community Action Guide. Concern, Inc.

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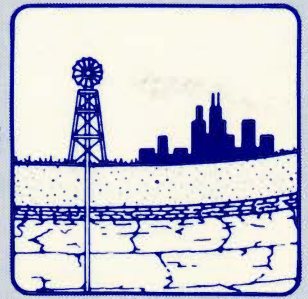


wood block
cake pan
plastic toboggan or commercial stream table

Pumps and Pipes

Activity in Brief

Students play a game which illustrates the difficulty associated with preventing contamination of groundwater.



Objective

Students identify the frustrations experienced in trying to avoid contamination of groundwater while playing Pumps and Pipes.

Site

Classroom

Time

40-60 minutes

Materials

gameboard
tokens
die

Exploration

Students play the game Pumps and Pipes.

Invention

Students will develop generalizations to explain why it is so difficult to avoid contamination of groundwater sources.

Application

Develop strategies to reduce chemical contamination of groundwater through ordinary home and community activities.

Teacher Notes

For the Teacher

Adapted from :
Chutes and Ladders, © Milton Bradley Co.,
by Nancy Lockett and Patricia Mead



For Your Information

Students should be allowed 20-30 minutes to play the game. When the time limit has been reached, discuss the events that affected the travel of their drops of water through the course. Activities which help protect our groundwater enable the player to be "pumped up" during the game, and those activities which contribute to groundwater contamination cause players to be "piped down".

The students will notice that it may be difficult to complete the game. Try to draw an analogy between the difficulty in completing the game and the difficulty in preventing groundwater contamination. This issue should be discussed during the Invention.

PUMPS and PIPES

Object: To be the first player to go from square #1 to square #100, facing the problems presented by potential groundwater contaminants.

To Begin: Notice that the squares on the board are all numbered. Square #1 is in the lower right hand corner. As the game is played, players move back and forth, first to the left to square #10, then to the right to square #20, etc. until square #100 at the top is reached.

To Play: Each player chooses a playing piece. Roll the die to see who starts the game, highest number playing first. Other players follow from left to right. All players start their playing pieces just off the board next to square #1 and move one square for each number on the die. Each player has one turn at a time. Pumps: Should a playing piece land on a situation square at the bottom of a pump, for example on square #14, the player must move up to square #47, at the top of the pump. In the next turn, that player will move along toward square #48. Pumps lead up only.

Pipes: Should a playing piece land on a situation square at the top of a pipe, for example on square #44, the player must move down to square #17 at the bottom of the pipe. The next turn will move the player toward #18. Pipes lead down only. Squares through which parts of pumps or pipes pass are counted as regular squares. Two or more players may stop on any square at the same time if their moves happen to land them in that position.

Completing the game: Square #100 must be reached by an exact roll of the die. The first player to reach square #100 wins the game.

Follow-Up Suggestions

Results of this activity may be summarized and sent home to parents.

Resources

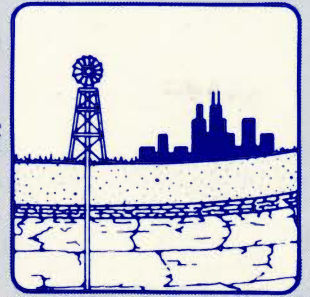
Hazardous Waste In Your Home—Here's What You Should Do! PUBL-WW-003 86
Rev. University of Wisconsin-Madison
Cooperative Extension Service.

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Who Dumped It?

Activity in Brief

Students play a game which reviews ideas developed in the groundwater module.



Objective

Students discover and identify probable sources of groundwater contamination present in their homes.

Site

Classroom

Time

30 minutes

Materials

gameboard
cards
die
tokens
data sheet

Exploration

Through brainstorming, students generate a list of household materials which contain hazardous chemicals and where in the home these can be found.

Invention

Students play the game and discover which suspect, in which room, used a potential contaminant.

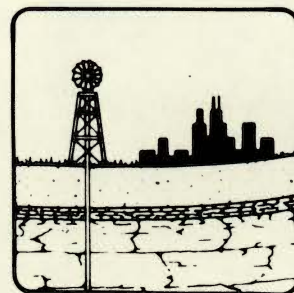
Application

Role play a family meeting to discuss possible actions the family can take to prevent contamination of our water resources.

Teacher Notes

For the Teacher

Created By:
Nancy Lockett
Patricia Mead



For Your Information

FYI Exploration: Some common household products with the potential to contribute to groundwater contamination include: Detergents; alcohol based lotions (after shave, perfume); nail polish and nail polish remover; home cleaning products (furniture polish, drain cleaner, bathroom cleaners, window cleaner, etc.); oil; paint; gasoline; batteries; pet flea sprays and collars; lighter fluid; and glues.

FYI Invention: Follow the adapted directions for the game, which are as follows: The object of the game is to discover the answers to the questions - Who did it? Where? How?

Equipment:
Game board showing eight rooms of a house.

Six tokens representing the suspects in the house;
Mr. Dewey Dumper
Mrs. Dora Dumper
Dempsey Dumper
Daphne Dumper
Aunt Daisy Dumper
Grandpa Dexter Dumper

Pack of 24 cards which includes one card for each room, one for each contaminant, and one for each suspect.

One die

Checklist to aid in the investigation

To play: Place the tokens on the board, each in a room. All six pieces should be on the board, regardless of the number of players. Sort the cards into three groups - room cards, suspect cards, and contaminant cards. Shuffle each group separately. Take the top card from each group and place it in an envelope carefully, so that no one sees the cards. The remaining cards are shuffled together and dealt to the players (some players may receive more cards than others). It is important that no one sees the cards while they are dealt and players must keep their cards to themselves. The die is rolled to determine which player goes first. Players follow to the left. Squares on the board are for movement of players. Tokens may be moved forward, backward, or crosswise, but not diagonally. A token may move more than one direction in one turn, but may not move to a particular space twice in one turn. No two tokens may occupy the same square, but rooms may be occupied by more than one token. There are three ways players may enter or leave rooms: 1) throwing the die and moving through a doorway from or to the squares, 2) via the secret passages, corner to corner, without using the die, and 3) by being transferred to a room by another player making a "suggestion". On the throw of

the die, players may enter a room by door only, and may not leave the room on the same turn. It is not necessary to roll an exact number to enter a room. A room may not be re-entered on the same turn, once it has been left. Doors are not counted as squares.

The "Suggestion": Whenever a player moves into a room a suggestion should be made. This consists of naming a suspect, contaminant, and the room into which the player has moved. When a suggestion is made, the token of the accused player is moved into the room. Example: The player representing Dewey Dumper may reach the bedroom. Dewey may then call a suspect (i.e., Daphne Dumper), into that room and suggest that the contamination originated in the bedroom, was caused by Daphne, and name the contaminant (i.e., detergent). All tokens, even those not being used in the game, fall under equal suspicion and should be considered when making suggestions. No player may forfeit a turn to remain in a room.

When a suggestion has been made, the player to the left of the one making the suggestion checks the cards in hand to see if the suggestion can be proved false. To do this, that player must hold one or more of the cards named. If this is the case, the player shows one of these cards to the player making the suggestion. The other players

Who Dumped It?

must not see the card. If the first player to the left does not have any of the three cards, the next player checks their cards, etc. If any player holds in hand one of the cards named in the suggestion, it proves that those particular cards are not in the envelope. The player making the suggestion may wish to record this information on their checklist. If no one can disprove the suggestion, the player may pass the turn or make an "Accusation".

The "Accusation": If a player is satisfied that they know the three cards in the envelope, they can make an accusation. It must be stated that it is an accusation and the player names the cards believed to be in the envelope. The player then checks the envelope, without allowing any other players to see. If the accusation is correct, that player is the winner. If the accusation is not correct, the player returns the cards to the envelope and play continues. Having seen the contents of the envelope, the player has no further moves in the game and cannot win, but remains as a player to contradict suggestions made by others with the cards in his or her hand. The player's token is moved so it is not blocking a door. A player may make only one accusation during the game, and does not have to be in the room named in the accusation when it is made, as he or she does when making a suggestion. These rules have been adapted

from the Parker Brothers game, "Clue". For more detailed directions and hints, refer to the rules included in that game.

FYI Application: Possible topics for family discussion: What should we look for on labels?

What do the words CAUTION, WARNING, DANGER mean? Why should you leave leftover products in original containers?

What do the words TOXIC, IGNITABLE, CORROSIVE, and REACTIVE mean?

What actions can we take in our homes to reduce the problem of groundwater contamination?

Follow-up Suggestions

Seek alternative materials to replace hazardous household products. Compile a list for distribution throughout the school.

Collect labels from household products containing hazardous chemicals and make a school display.

Resources

Hazardous Waste In Your Home-Here's What You Should Do! University of Wisconsin-Madison. Cooperative Extension Service.

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Dilemmas

The following is a listing of environmental situations which contain dilemmas. Each may be presented to students with instructions to resolve the dilemmas in a manner that considers both the needs of people and the well being of the environment.

1. A 2000 acre farm can use as much water per day as a city with a population of 50,000. If the groundwater supply is not sufficient to support both, how should the water be distributed?
2. You are the mayor of Groundwater Grove. The city has \$10,000 extra in their budget this year. How would you recommend the money be used?
 - A. Build new playground equipment. Present equipment is in poor shape.
 - B. Give each household \$500.
 - C. Test everyone's water
 - D. Sponsor classes at the Community Center to educate people about groundwater contamination.
 - E. Any combination of the above. Explain.
 - F. Other.
3. You have 10 gallons of water to use for the day. List, in order of importance, ways you would use the water. Explain your choices.
4. Mary has just helped change the oil in the family car. Should she:
 - A. Pour the oil on the driveway to keep the dust down?
 - B. Put the oil in a container and put it in the garbage to be taken to the landfill?
 - C. Burn the oil?
 - D. Take it to a gas station to be recycled?
5. You helped clean out the garage and are in charge of getting rid of some old cans of paint. Should you:
 - A. Put them in the garbage?
 - B. Bury them deep in the ground and cover them well?

- C. Share with a neighbor, donate to a community service group, or recycle in some way?
 - D. Burn them in your incinerator or burn barrel?
 - E. Dispose of them in a designated landfill?
6. Who should control the groundwater in an area?
- A. The county
 - B. The owner of the land above it
 - C. The people who use it
 - D. The state

GLOSSARY

Absorption - to suck up or take up, for example sponges taking up water, roots taking in water.

Adsorption - the adhesion of a thin layer of molecules to the surface of solids or liquids with which they come into contact.

Agricultural Drainage Wells - field drainage wells that farmers began putting down nearly a century ago to drain swampy areas which allow surface water and water from field tiles to fall 20 to 30 feet beneath the ground.

Aquifer - a permeable geologic formation that stores and transmits significant quantities of water.

Aquitard - soil and rock formation of low hydrologic activity.

Assimilative Capacity - natural ability of surface water to accept (utilize) potential pollutants without harmful effects (without impairing beneficial use).

Available Nitrogen - form of nitrogen which is immediately available for plant growth (NO_3^-) or (NO_4^-).

Available Nutrient - that portion of any element or compound in the soil that can be readily absorbed and assimilated by growing plants.

Bedrock - the continuous solid rock of the continental crust.

Best Management Practices - practices that have been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

Cohesion - attractive force which holds two particles together.

Coliform Bacteria - a group of bacteria predominantly inhabiting the intestines of humans and animals, but also found in soil. While harmless themselves, coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms.

Condensation - reduction to a denser form (as from steam to water).

Confined (Artesian) Aquifer - an aquifer which is overlain by impermeable strata (confining beds).

Contour Farming - farming sloping land in such a way that plowing, preparing land, planting, and cultivating are done on a nearly level path across the slope.

Conventional Tillage - those tillage operations which are considered standard for the specific location and crop and tend to bury the crop residues. It is usually used as a base for determining the cost effectiveness of control practices.

Cost Effectiveness - a term used to compare alternatives on the basis of cost (inputs) per unit of benefits (outputs), such as dollars per unit of pollutant load reduction.

Denitrification - the process by which nitrates or nitrites in the soil or organic deposits are converted to gaseous forms of nitrogen.

Desorption - the removal of sorbed ions or compounds from surface solids.

Dissolved Minerals - minerals (salts included) that are in solution in water.

Dissolved Oxygen - oxygen dissolved in water and readily available to aquatic organisms. It is usually expressed in milligrams per liter or as the percent of saturation.

Dolomite - a type of rock (calcium magnesium carbonate) or a common rock forming mineral. Often rocks referred to as limestone are actually dolomite.

Effluent - the discharge of a pollutant, or pollutants, in a liquid form from a containing space.

Eutrophication - natural or artificial process of nutrient enrichment whereby a body of water becomes filled with aquatic plants and low in oxygen content.

Evaporation - the process by which liquid passes off into vapor or invisible minute particles.

Evapotranspiration - combination of evaporation and transpiration of water into the atmosphere from living plants and soil. (A plastic bag tied over a plant will illustrate this.)

Fungicides - chemicals used to destroy fungi.

Groundwater - the subsurface water supply in the saturated zone below the water table.

Herbicides - chemicals used to kill undesirable vegetation.

Hydraulic Gradient - the ratio of the difference of water height to the horizontal distance traveled, i.e., the slope of the water table.

Hydraulic Head - the pressure exerted by a fluid at a given depth beneath its surface. It is proportional to the height of the fluid's surface above the area where the pressure is measured.

Hydrologic Cycle - the continuous process involving the circulation of water in oceans to the atmosphere to the land and back to the sea.

Impervious Rock - layer of rock generally considered under normal situations to be incapable of being penetrated.

Infiltration - downward flow or seepage of water through the pores or spaces in rock or soil.

Inorganic Chemicals - compounds that generally do not contain carbon and are derived from mineral sources.

Insecticides - chemicals used to kill insects.

Laminar Flow - a flow pattern in which particle paths are straight or gently curved and parallel (see turbulent flow).

Leachate - the soluble product obtained from the action of percolating liquid on the soil.

Leaching - the removal of salts and other materials from the soil by water movement through the soil profile.

Limestone - a sedimentary rock consisting chiefly of the mineral calcite (calcium carbonate).

Managerial Controls - control measures which involve changes in timing, chemical application rates, or tillage systems for the purpose of reducing the loss of pollutants.

Maximum Contaminant Level (MCL) - the upper limit allowable for pollutants in drinking water, above which the water is considered unsafe for consumption.

Mineralization - the microbial conversion of an element from an organic to an inorganic state.

Nitrification - the biochemical transformation of ammonium to nitrite and thence to nitrate.

Nitrogen Fixation - the biological or chemical process by which elemental nitrogen is converted to organic or available nitrogen.

No Till - a management practice of planting a crop without prior seedbed preparation, into an existing cover crop, sod or crop residue and eliminating subsequent tilling operations.

Nonpoint Source Pollution (NPS) - a contaminant that cannot be traced to one source, but rather comes from many different, nonspecific sources.

Organic Chemicals - chemical compound of carbon. Historically, organic compounds were those obtained from vegetable or animal sources. Today, many organic chemicals are synthesized by humans in laboratories.

Parts Per Million (PPM) - a common basis of reporting water analysis. One part per million equals one pound per million pounds of water.

Pathogens - disease-causing organisms.

Percolation - the downward movement of water through the soil.

Permeability - the ability of a formation to transmit groundwater or other fluids through pores or cracks.

Pesticides - chemical substances used to kill or control pests such as weeds, insects, algae, rodents, and other undesirable agents. As used in many references, it includes herbicides, insecticides, miticides, nematocides, rodenticides, fungicides, plant growth regulators, and desiccants.

Point Source Pollution - a contaminant that can be traced to an original source.

Porosity - the percentage of the total volume of a given body of rock that is pore space.

Potable - drinkable.

Precipitation - a deposit on the earth of rain, hail, mist, sleet or snow; also the quantity of deposit.

Primary Drinking Water Pollutants - the drinking water contaminants for which there are enforceable effluent discharge standards under the Clean Water Act.

Recharge - the replenishment of groundwater by infiltration of atmospheric water (precipitation) through the soil.

Rill - the process which forms small, well-defined incisions in the land surface less than thirty centimeters in depth.

Rodenticides - chemicals used to kill rodents.

Saturated Zone - the subsurface zone in which all openings or pore spaces are filled with water.

Seepage - the percolation of water through the soil from unlined canals, ditches, laterals, watercourses, or water storage facilities.

Silt - soil particles between 0.05 and 0.002 mm in equivalent diameter.

Sinkhole - a natural depression in a land surface, generally occurring in limestone regions and formed by solution or by the collapse of a cavern roof.

Spring - a flow of groundwater emerging naturally at the surface of the ground.

Surface Water - all water on the surface of the earth, including snow and ice.

Synergism - the simultaneous action of separate agents which, together, have a greater total effect than the sum of their individual effects.

Total Dissolved Solids - the total amount, in milligrams, of solid material dissolved in one liter of water.

Transpiration - direct transfer of water from leaves of living plants to the atmosphere.

Trickle Irrigation - an irrigation method in which water drips to the soil from perforated tubing or emitters.

Turbulent Flow - a high velocity flow in which streamlines are neither parallel nor straight but curled into small, tight eddies (the opposite of laminar flow).

Unconfined Aquifer - an aquifer that contains water under atmospheric pressure. Not overlain by impermeable stratum, the water level in the aquifer may rise or fall according to the volume of water stored, a variable dependent upon seasonal cycles of natural recharge.

Water Table - the level below which the soil or rock is saturated with water, sometimes referred to as the upper surface of the saturated zone.

Zone of Aeration - area between the ground surface and the water table.

