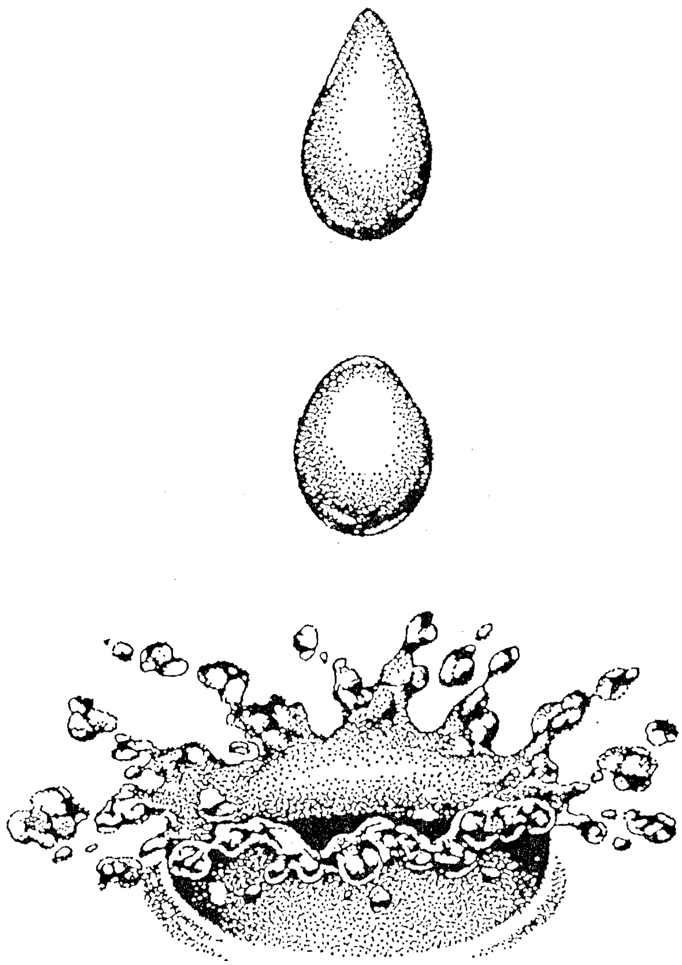
THE UNIVERSITY OF ARIZONA

ARIZONA COOPERATIVE EXTENSION

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

ARIZONA WATER QUALITY EDUCATION ACTIVITIES FOR GRADES 1-12



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The following activities are designed to make learning and demonstrating nonpoint source pollution concepts exciting and fun! These activities can be used alone or to enhance your own water resources education curricula. This material can also be found on the World Wide Web at http://ag.arizona.edu/waterquality/activitiesindex.html.

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Activity I-1: Water Tasting

Purpose: To provide an attention-getting introductory activity prior to discussing water quality education.

Background*: People prefer all types of drinking water. Most people like the taste of hard water because of the minerals in it. Softened water may taste salty depending on how hard the water was before treatment. Distilled water tastes "bland" or "flat" to most people, but some people prefer that taste.

Often people will be prejudiced about how water tastes based on its color or smell.

Materials:

small cups, less than 4 oz (could use nut cups)
4-5 1 gallon jugs
distilled water
food coloring
salt
evaluation form (optional)

Procedure:

1. Mark the small drinking cups with an identifiable color or number and mark one jug with the same color or number.

2. Make up enough of 3-5 different types of water so each student can taste each type. Suggestions: tap water from the school, distilled water, softened water, colored tap water, salty water (similar to ocean water or water from the Great Salt Lake), water containing iron or sulfides, etc.

3. Pour water into cups and group like water. Have students take one of each type of water, taste it, and rate it.

4. Discuss the different types and explain why some water tastes differently from other water.

* This information was taken from *GROUNDWATER: A VITAL RESOURCE Student Activities* by the Cedar Creek Learning Center in Cooperation with the Tennessee Valley Authority. 1986.

Extensions:

1. Discover how little (or how much) salt (sugar) needs to be added before students can taste it in the water.

2. Have the students make bar charts of the number of people who liked the various types of water and determine the percentage of the class who liked the water.

3. Make an observation table (see below) on the blackboard (and/or individually) and have the students use their senses to fill out the table based on their observations. Stress to the students to use measurable observations (e.g., tastes salty not yucky). Introduce and use concepts such as transparent, translucent, sediment, etc.

	Red	Black	Blue	Green
Visual				
Odor/Smell				
Taste				
Do you like it?				

Activity I-2: Acting Out the Water Cycle

Purpose: To dramatically teach students about the water (hydrologic) cycle.

Background*: Water doesn't disappear with our use of it in irrigation, manufacturing or consumption. The water we have now is the water we had at the beginning of time. Water forms, dissipates, and forms again in a cycle called the hydrologic or water cycle.

The water cycle is a gigantic circulation system operating over the earth's land and oceans in the atmosphere surrounding the earth. Being a cycle, there is no beginning or ending but for illustration, let's begin with the waters of the oceans, which cover about three-fourths of the earth.

Water from the surface of the ocean **EVAPORATES** into the atmosphere. That moisture in turn is lifted, eventually is **CONDENSED**, and falls back to the earth's surface as **PRECIPITATION**.

Precipitation that falls as rain, hail, dew, snow, or sleet is important to people and agriculture. After wetting the foliage and ground, some of the precipitation **RUNS OFF** into **STREAMS** and other waterways. This is the water that often causes erosion and is the main contributor to floods. Not all of the precipitation runs off. Some soaks into the ground and is available for evaporation. Some of it reaches the deeper zones and slowly **PERCOLATES** (**INFILTRATION**) through to springs and seeps to maintain and replenish them during dry periods. The streams eventually lead back to the oceans, where the water is again evaporated into the atmosphere.

Materials: note cards (I used 5 x 8 inch cards) - one for each student - **OR** - use master of "cards" at end of activity - one sheet per student

Procedure:

1(a). List one hydrologic cycle element per card (it doesn't matter that there may be an uneven amount of each element). **Suggested elements**: PRECIPITATION (or rain), EVAPORATION,

* Taken from *STOP, LOOK, and LEARN About Our Natural World, Volume 2* by the Nebraska Natural Resource Commission, Lincoln, Nebraska. November 1988.

RUNOFF, INFILTRATION, CONDENSATION (or clouds), STREAMS, SOLAR ENERGY (or sun), TRANSPIRATION.

- **OR** -

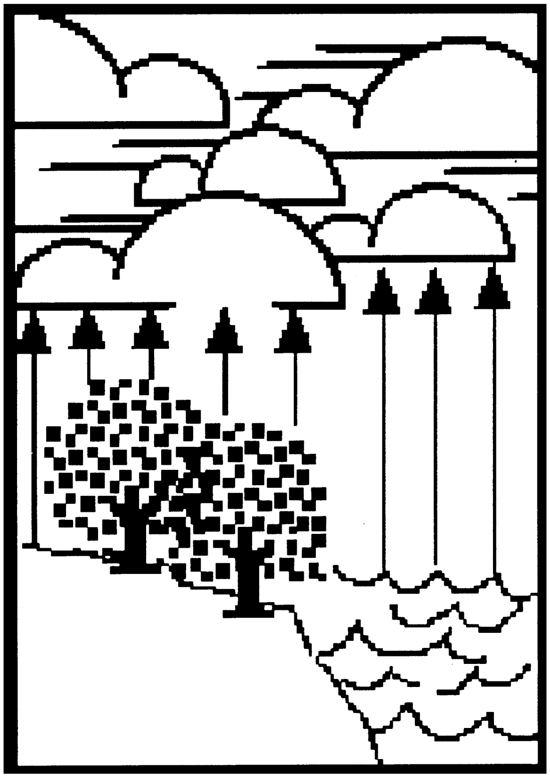
1(b). Have the students color the “cards” and cut them out. Put all the colored cards into a bag or box.

2. Allow each student to blindly pick a card.

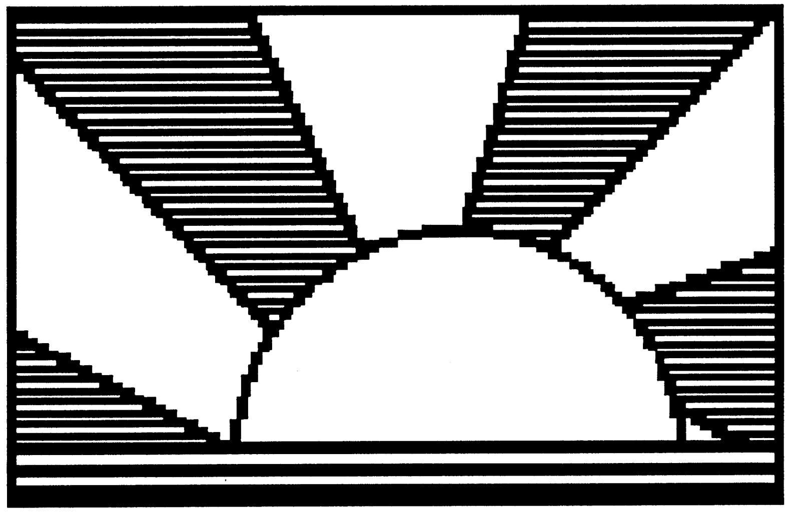
3. The students are to "act out" or pantomime the word on the card. Without talking to anyone, they are to group themselves with other like actions. Then, when everyone has found a group, they tell the teacher what they are or are doing.

4. Have the students choose a leader. The leaders from each group will then dramatize the entire hydrologic cycle. **Suggestions**: 1) the hydrologic cycle is not linear, so the students should not be standing in a line, 2) the hydrologic cycle in not 2 dimensional, encourage up and down variations, and 3) there is no proper beginning or ending - it is a cycle.

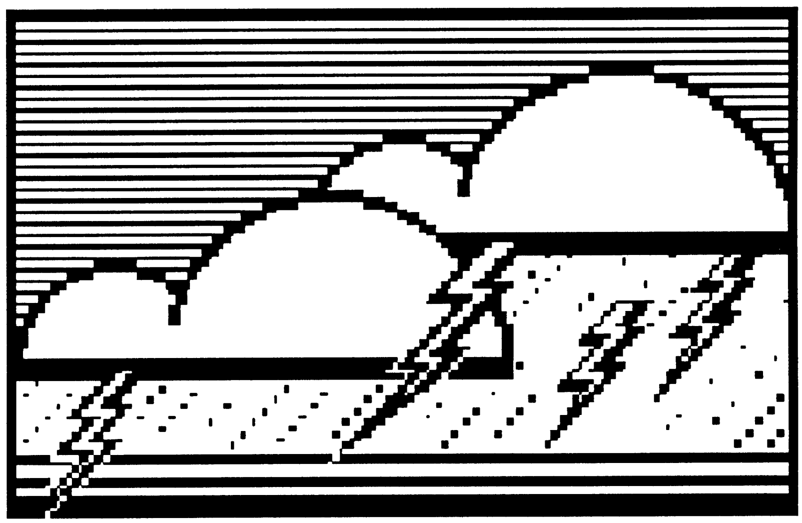
Extension: Have each group draw their hydrologic cycle element on a large sheet of butcher paper. Fill in with homes, school, mountains, highways, industries, construction sites, etc., and discuss how each area affects the hydrologic cycle.



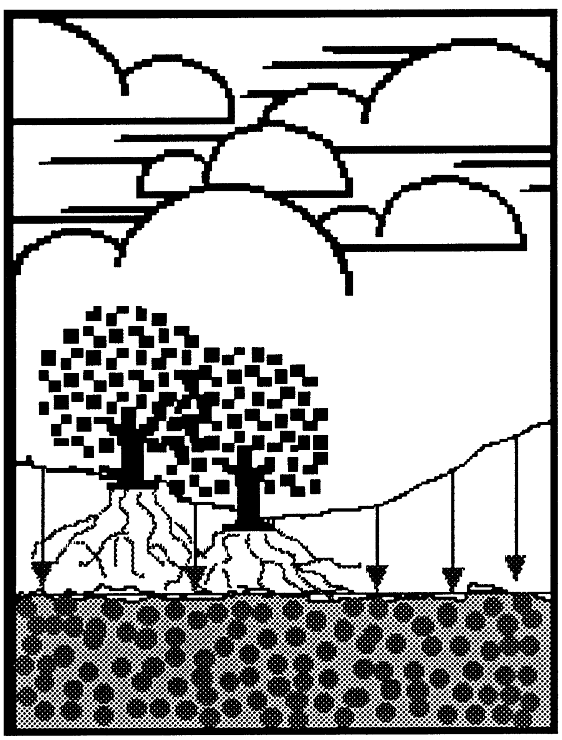
Evaporation



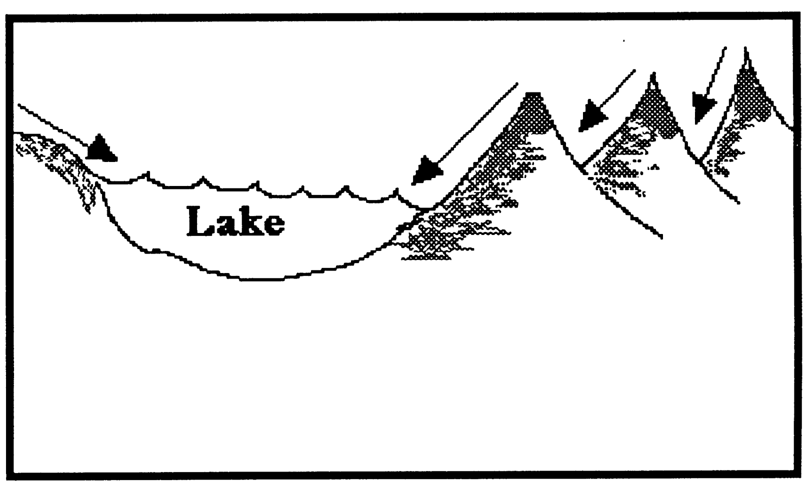
Sun



Rain



Infiltration



Runoff

Activity I-3: Water Cycle Relay Race

Purpose: To reinforce the concepts of the water (hydrologic) cycle.

Background*: Water doesn't disappear with our use of it in irrigation, manufacturing or consumption. The water we have now is the water we had at the beginning of time. Water forms, dissipates, and forms again in a cycle called the hydrologic or water cycle.

The water cycle is a gigantic circulation system operating over the earth's land and oceans in the atmosphere surrounding the earth. Being a cycle, there is no beginning or ending but for illustration, let's begin with the waters of the oceans, which cover about three-fourths of the earth.

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Materials:

1 tray of cubed ice per team	large poster of the water cycle with vocabulary words covered
1 set of vocabulary words per team	bucket
1 set of riddle cards	tape
1 spoon per team	

Procedure:

1. Review the water cycle paying particular attention to the following nine vocabulary words: **evaporation**, **condensation**, **cloud**, **precipitation**, **river**, **percolation**, **groundwater**, **evapotranspiration**, and **water**

* Taken from *STOP, LOOK, and LEARN About Our Natural World, Volume 2* by the Nebraska Natural Resource Commission, Lincoln, Nebraska. November 1988.

cycle.

2. Divide the class into teams of ~9 students. Show the class a water cycle poster, pointing out that the identifying words have been hidden. Explain that they will identify the blanks with the missing words in the course of the water cycle relay race.

3. Have the students line up in a single line. Pass out a spoon and a tray of ice cubes to each team and have each team place them at the end of the line. As part of the relay, each team will place an ice cube on the spoon and pass both from the back of the line to the front of the line.

4. Give each team a set of the nine vocabulary words written on slips of paper. Have the teams attach a piece of tape to each slip of paper. Ask the teams to discuss the words, review their meanings, and decide where they are located on the water cycle poster.

5. Read a water cycle riddle to the class. The students must quietly decide among their team which word best fits the riddle. The last person in line tapes the slip of paper with the matching word to the bottom of the spoon and places the ice cube in the spoon. He or she then passes the spoon and ice cube to the person in front of them, and so on down the line. The person at the head of the line walks quickly to the poster at the front of the room with the spoon and ice cube, places the ice cube in a bucket under the water cycle poster, tapes the word to the correct spot on the poster, and returns to the end of the line. The race continues with another riddle until all the riddles have been read.

6. Before beginning the race, review the rules for the relay: 1) No one may touch the ice cube after it has been placed on the spoon until it reaches the bucket. 2) If the ice cube falls off the spoon, the back person must put the ice cube back on the spoon, and the process starts again.

7. Invite the students to help decide how points should be awarded and keep track of the scores. Ask them to decide the number of points to be given to the team that finishes first, the team(s) that selects the correct vocabulary word, and the team(s) that correctly places the word on the poster.

8. The team with the most points wins.

Water Cycle Relay Race Riddles

Below the surface of the Earth
In between particles of dirt
That's where this water is found
Saturating everything deep underground.

Groundwater

In between and all around
Through the soil without a sound
Water seeping down, down, down
Slowly moving underground.

Percolation

Heat from the sun makes water rise
Up as vapor to the skies.

Evaporation

Cumulus, stratus, cirrus, too
Water vapor visible in skies of blue.

Cloud

Down is the direction this water falls
As crystal, drips, or even balls.

Precipitation

Once a gas but then it's changed
Into a liquid to be seen again.

Condensation

From the pores of plants
Water vapor escapes
Into the air without a trace.

Evapotranspiration

I start as a trickle and then I grow
Picking up speed as down I go
Over the surface of the land to the sea
Obeying the laws of gravity.

River

Water going round and round
Changing form but not the amount.

Water Cycle

Activity I-4: How Small is Small?

Purposes: To demonstrate the concept of parts per million (ppm) and parts per billion (ppb).

To explain how chemicals may be present in very small amounts in water such that they cannot often be detected by sight, taste, or smell even though they may still possibly pose a threat to human health.

Background: Concentrations of chemical pollutants in water are frequently expressed in units of "**PARTS PER MILLION**" (ppm) or "**PARTS PER BILLION**" (ppb). For example, chemical fertilizers contain nitrate, a chemical that can be dangerous to infants in quantities as small as 10 parts per million. Trichloroethylene (TCE), a common industrial solvent, is more dangerous than nitrate and when present in drinking water in quantities as small as 5 parts per million can cause a higher than normal incidence of cancer among people who drink the water regularly.

Materials for each group:

1 stirrer (solid coffee stirrers or tooth picks)
2 containers of clean water (one for diluting and one for rinsing)
2 dropping pipettes (medicine droppers)
food coloring (can have different colors for each group)
set of 10 white plastic spoons, clear containers, or Styrofoam egg carton
white paper (if clear containers are used)

Procedure:

1. If clear containers are used, line them up side-by-side, place a piece of white paper under each, and number 1 to 10 (left to right). If egg cartons are used, number each cup.

2. Place 10 drops of food coloring into container #1 (food dye is already diluted 1:10).

3. Either place one drop of food coloring into container #2 or take one drop from #1, transfer it to #2, and rinse dropper. Transferring the drop of food coloring requires more rinsing but is consistent with the procedure for the remaining containers. (You may double the drops to obtain more volume, just be certain that you also double the dilution water in step #4).

4. Add 9 drops of clean water to container #2 and stir the solution. Rinse the dropper.

5. Use the medicine dropper to transfer 1 drop of the solution from container #2 into container #3. Add 9 drops of clean water to container #3 and stir the solution. Rinse the dropper.

6. Transfer 1 drop of the solution from container #3 to container #4. Add 9 drops of clean water to container #4 and stir the solution. Rinse the dropper.

7. Continue the same process until no more color is visible in the last spoon, container, or egg carton cup.

Discussion:

1. The food coloring in container #1 is a food coloring solution which is one part pigment per 10 parts liquid. What is the concentration for each of the successive dilutions. Use table below (each dilution decreases by a factor of 10 - 1/10, 1/100, 1/1000, etc.)

2. What is the concentration of the solution when the diluted solution first appeared colorless?

3. Do you think there is any of the colored solution present in the diluted solution even though it is colorless? Explain. (Yes. The solution is still present but has been broken down into such small particles that it cannot be seen.)

4. What would remain in the containers if all the water were removed? (Residue from the food coloring, i.e., the pigment.)

Extensions:

1. Allow the water in the containers to evaporate and have students record their observations on what remains in the containers.

2. Discuss chemical contamination in drinking water. Use the attached list of maximum contaminant levels (MCLs) for some toxic or carcinogenic chemicals in drinking water (as regulated by the U.S. Environmental Protection Agency). These MCLs represent the maximum amount of a chemical that can occur in drinking water without the water being dangerous to human health. [Note: Some of the MCLs listed are subject to revision by the EPA shortly.]

3. Explain the relationship between ppm and ppb and the conversion of these units to milligrams and micrograms per liter. For example: 1 ppm = 1000 ppb; 1 ppm = 1 mg/L; and 1 ppb = 1 ug/L.

4. Try different colored food colorings. Does the eye perceive color differently? Do some colors "disappear" sooner than others?

Container No.	1	2	3	4	5	6	7	8	9	10
Concentration	1/10	1/100	1/	1/	1/	1/	1/	1/	1/	1/

Substance	**Concentration, ppb**	**Substance**	**Concentration, ppb**
Arsenic	50	Nitrate	10,000
Barium	1,000	Selenium	10
Cadmium	10	Endrin	0.2
Mercury	2	2,4-D (herbicide)	100

Note: The above substances do not represent a complete list of the regulated drinking water contaminants.

One part per Trillion . . .

Is A Very Finely-Split Hair

Worker exposure to certain chemicals is limited to a few parts per million. Regulations reduce an industrial waste discharge to one part per billion. Pesticide residues are found in drinking water in the low parts per trillion.

Extremely low measurements, and laws and regulations based on them, are growing more commonplace as science perfects increasingly sophisticated sensors.

Such infinitesimal figures probably don't register with most people. Only scientists and plant managers trying to get exposures and effluents down to levels as fine as frog hair comprehend and appreciate their meaning.

Shedding light on the subject, Dr. Warren B. Crumell of the Down chemical Company has made some comparisons that put the figures in perspective (see table below).

TRACE CONCENTRATION UNITS

UNIT	**1 Part Per Million**	**1 Part Per Billion**	**1 Part Per Trillion**
Length	1 inch/16 miles	1 inch/16,000 miles	1 inch/16,000,000 miles (a 6-inch leap on a journey to the sun)
Time	1 minute/2 years	1 second/32 years	1 second/320 centuries
Money	1 ¢/ $10,000,000	1 ¢/ $10,000,000,000	1 ¢/ $10,000,000,000,000
Weight	1 ounce salt/31 tons potato chips	1 pinch salt/10 tons potato chips	1 pinch salt/10,000 tons potato chips
Volume	1 drop vermouth/80 "fifths" gin	1 drop vermouth/500 barrels gin	1 drop vermouth/250,000 hogheads gin
Area	1 sq. ft./23 acres	1 sq. ft./36 sq. miles	1 sq. inch/250 sq. miles
Action	1 bogey/3,500 golf tournaments	1 bogey/3,500,000 golf tournaments	1 bogey/3,500,000,000 golf tournaments
	1 lob/1,200 tennis matches	1 lob/1,200,000 tennis matches	1 lob/1,200,000,000 tennis matches
Quantity	1 bad apple/2,00,000,000 barrels	1 bad apple/2,000 barrels	1 bad apple/2,000,000 barrels
Rate	1 dented fender/10 car lifetimes	1 dented fender/10,000 car lifetimes	1 dented fender/10,000,000 car lifetimes

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Activity D-1: Sources of Drinking Water

Purpose: To demonstrate the sources of freshwater and just how little drinking quality water we have on earth.

Background: About 72% of the earth is covered with water. The water on the earth can be divided into the following amounts:

Water Source	% of the Total Amount
Oceans	97.2
Icecaps/glaciers	2.0
Groundwater	0.62
Freshwater lakes	0.009
Inland seas/salt lakes	0.008
Atmosphere	0.001
All rivers	0.0001

The usable percentage of existing freshwater is reduced by pollution and contamination. The amount of water that is usable by humans is very small.

Materials:

display of world or globe
5 or 10 gallon aquarium (or other transparent container)
measuring cup
plastic quart containers (enough for one for every group of three students)
eye dropper
5 gallons of water
tablespoons (enough for one for every group of three students)

Procedure:

1. Show students the five gallons of water in the aquarium. Explain that the five gallons represent all the water on the earth and five gallons equals 1,280 tablespoons of water. Now obtain the values of water by calculating the percentages. For example: 97.2% = oceans, so take 0.972 X 1280 = 1244.16 tablespoons.

Water Source	Volume of Water (tablespoons)
Oceans	1,244.16
Icecaps/glaciers	26.24
Groundwater	7.93
Freshwater lakes	0.11
Inland seas/salt lakes	0.1
Atmosphere	0.0128
All rivers	0.0012

2. Once the values have been determined, ask the students to calculate the volume of water other than the amount contained in oceans (this total amount is about 34 tablespoons). Divide students into teams and place 34 tablespoons of water into each group's plastic quart jar. Then ask the students to remove the water represented by freshwater lakes and rivers (this amount is about 0.111 tablespoons or 1/10 tablespoon of water). Next ask the students to remove the amount of water represented by rivers using the eye dropper (this amount is one-thousandth of a tablespoon or less than one drop of water).

Extensions:

1. Have the students consider how fragile the freshwater supply is that's available to us through rivers and lakes.

2. Discuss with the students how dependent we are on our survival for this small percentage of water on the earth's surface (i.e., most humans can not exist for more than three days without water). Ask students to estimate the volume of freshwater they use on a daily and weekly basis.

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Activity D-2: How Drinking Water is Cleaned

Purpose: To demonstrate the procedures that municipal water plants use to make water safe for drinking.

Background: Water in lakes, rivers, and swamps often contain impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from surface sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes: 1) aeration; 2) coagulation; 3) sedimentation; 4) filtration; and 5) disinfection.

Aeration is the addition of air to water. It allows gases trapped in the water to escape and adds oxygen to the water. **Coagulation** is the process by which dirt and other suspended solid particles are chemically "stuck together" so that they can be removed from water. **Sedimentation** is the process that occurs when gravity pulls the particles of floc (clumps of alum and sediment) to the bottom of the cup. **Filtration** through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. Demonstration projects for the first four processes are included below.

Materials:

"swamp water" (or add dirt or mud to water)
20 oz. bottle with bottom fourth cut off
teaspoon of alum (potassium aluminum sulfate available at a pharmacy)
flexible nylon screen (approx. 5 cm x 5 cm)
20 oz. bottle with lid
plastic cups
fine washed sand
coarse washed sand
small washed pebbles
small washed pebbles
large beaker of jar
a teaspoon
a rubber band

Procedure:

1. Pour about 1 cup of "swamp water" into a 20 oz. bottle with lid. Have students describe the appearance and smell of the water.

2. To aerate the swamp water, place the cap on the bottle and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the plastic cups, then pouring the water back and forth between cups 10 times. Ask students to describe any changes they observe.

3. To demonstrate coagulation, add one teaspoon full of alum crystals to the swamp water used in step #2. Slowly stir the mixture for 5 minutes.
4. The process of sedimentation is accomplished by allowing the water in step #3 to stand undisturbed in the cup. Ask students to observe the water at 5 minute intervals for a total of 20 minutes and write their observations with respect to changes in the water's appearance.

5. Construct a filter from a bottle with its bottom cut off as follows (see illustration):
   A) Attach a nylon screen to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle, the screen will prevent the pebbles from falling out of the neck of the bottle.
   B) Pour coarse sand on top of the coarse pebbles.
   C) Pour fine sand on top of the coarse sand.
   D) Condition the filter by slowly and carefully pouring clean tap water through the filter until it drains clean from the bottom. Try not to disturb the top layer of sand as you pour the water. Conditioning the filter cleans out the fine particles and prepares it for filtration (step #5).

6. After a large amount of sediment has settled on the bottom of the cup of swamp water in step #4 carefully, without disturbing the sediment, pour the top two-thirds of the swamp water through the filter. Collect the filtered water in a cup. Pour the remaining (one-third bottle) of swamp water into the collection bucket. This completes the filtration process. Compare the treated and the untreated water. Ask students whether treatment has changed the appearance and smell of the water. [Inform students that a water treatment plant would, as a final step, disinfect the water to kill any remaining disease-causing organisms prior to distributing the water to homes. Therefore, the demonstration water is not safe to drink.]

Extensions: Add a few drops of food coloring to the top of the sand and have students pour water through the filter until all color has been filtered out. Discuss water pollution and its effects on human health.

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Activity G-1: Mini-Groundwater Models

Purposes: To demonstrate the concepts of groundwater, aquifer, infiltration, leaching, percolation, water table, and soil profile.

Background*: **GROUNDWATER** is defined as the water that seeps or percolates into the soil and is stored in an **AQUIFER** (water bearing material like gravel) where it can be pumped out for use.

Groundwater accumulates chiefly from rain that filters through the soil (also known as **PERCOLATION**, and **LEACHING**). It also forms from water that seeps into the ground from lakes and ponds. The water settles into the pores an cracks of underground rocks and into the spaces between grains of sand and pieces of gravel. A layer or bed of such porous materials that yields useful amounts of groundwater is called an **AQUIFER**. Wells are drilled down to an aquifer to draw groundwater to the surface.

The surface of groundwater, called the **WATER TABLE**, drops when more water is withdrawn than can be replaced naturally. In some areas that have large populations or little rainfall, the groundwater supply may have to recharged artificially. However, many regions of the world are using up the groundwater faster than aquifers are being recharged.

Groundwater pollution is a serious problem. Pollutants that seep into the ground can come from contaminated surface water, leaks from sewer pipes and septic tanks, and gasoline and chemical spills. Groundwater may also be polluted by chemical fertilizers and buried radioactive wastes.

See also pages 90-92 of *The Comprehensive Water Education Book Grades K-6* by the International Office of Water Education, 1994.

Materials:

clear plastic cups, about 10 oz in size
paper coffee filters, cut into 2 in. diameter rounds
1/4" clear tubing-cut to 6" lengths (vinyl tubing=$0.19/ft @ Fred Meyer)
10 cc capacity syringes ($0.19 ea @ USU Chemistry Stores)
duct tape (you need a very sticky and strong tape)
gravel, sand, topsoil
squirt bottles, misters, etc. filled with water
food coloring (optional)

* This information was taken from *GROUNDWATER: A VITAL RESOURCE Student Activities* by the Cedar Creek Learning Center in Cooperation with the Tennessee Valley Authority. 1986.

Procedure:

1. Take one length of clear tubing and tape to inside of cup so that the end of the tube rests on the bottom of the cup. The cup represents a "cut-out" of your backyard and the tubing is the "well".

2. Add a layer of gravel to the bottom of the cup. This represents the water holding material which makes up the aquifer.

3. Place a paper filter on top of the gravel. This is a "semi-permeable membrane" (i.e., water passes through but the soil and sand above it do not). Many soils act as semi-permeable membranes.

4. Add layers of sand and soil. This is the soil profile of your backyard!

5. Spray water on top of soil - this simulates rain.

6. Watch the water percolate through the soil and collect in the gravel (aquifer). This is a good way to demonstrate percolation.

7. Use a syringe as the pump and withdraw water from the "aquifer." (The syringe acts as a vacuum pump.)

8. Optional: add food coloring to the soil top near the well to act as pollution. See food coloring in withdrawn water.

Extensions:

1. Add all of one soil and compare infiltration rates (time it takes for the water on top of the soil to get to the gravel or cut holes in bottom of cup).

2. Add food coloring to top of soil and ask students how much water will need to be added to the system before all the coloring is gone. Is the food coloring still there? Let the water evaporate to see if pigment remains.

3. Find out what a typical soil profile is in your area and simulate that profile in the cup. Measure how long it takes water to reach the "aquifer." Draw conclusions of how long it would take for a pollutant to pollute your community's aquifer.

4. What pollutants from the activities in your community might the food coloring represent? Discuss nonpoint source pollution.

This activity was adapted from the Invitational Professional Development Workshop: *Water Activities Teaching Environmental Responsibility*. February 28-March 4, 1990. Camp Ocala, 4-H Center, Altoona, FL.

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Activity G-2: Contamination of an Aquifer

Purpose: To illustrate how water flows through an aquifer, how groundwater can become contaminated, and how difficult it is to clean up contamination.

Background: Many communities obtain their drinking water from underground sources called **AQUIFERS**. Water suppliers drill wells through soil and rock into aquifers for the groundwater contained in the aquifer. Unfortunately, the groundwater can become contaminated by harmful chemicals that percolate down through soil and rock into the aquifer - and eventually into the well. **GROUNDWATER CONTAMINATION** by chemicals is caused by industrial, agricultural, and urban runoff and/or the improper management of chemicals, including improper disposal of household chemicals, such as lawn care products and cleaners. Such contamination can pose a significant threat to human health. The measures that must be taken by utilities to either protect or clean up contaminated aquifers are quite costly.

Materials:

6" x 8" plastic boxes or disposable aluminum cake pans
2 lbs non-water soluble plasticine modeling clay or floral clay
3-4 lbs white aquarium gravel
pea gravel
small drinking straw
glue or caulking
food coloring
6 oz paper cups (no larger)
water
white paper

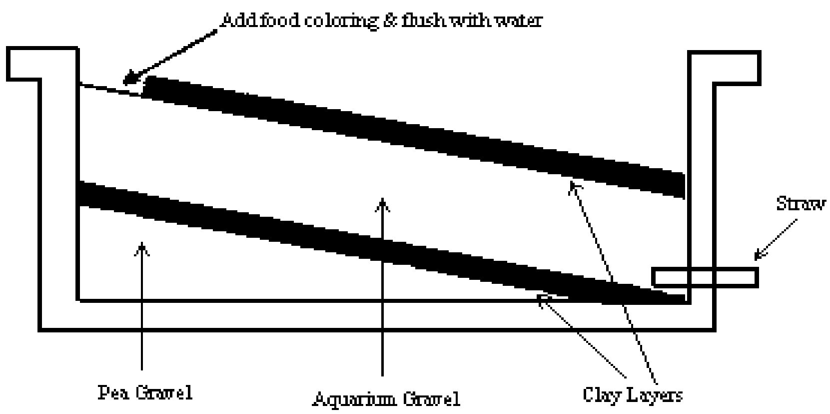
Procedure:

1. Set up a model aquifer as shown in the diagram on the back. Make a small hole in one end and insert a section of a drinking straw to serve as the drain spout. Seal the hole around the straw with glue, clay, or caulking. In addition, seal the clay layers of the model against the side of the container.

2. Place 10 drops of food coloring on the surface of the model near the highest end. This dye represents chemicals or other pollutants that have been spilled on the ground.

3. Slowly pour one 6-ounce cup of tap water on the aquarium gravel areas as shown in the diagram. Collect the water as it runs out of the straw and place the cup with water on the white paper. Repeat this process starting with 6 ounces of tap water and continue the flushing process until all the food coloring is washed out and the discharge water is clear. (Collecting the water in white cups or in test tubes held up against a white background will also enable students to detect faint coloration.)

4. Record the number of flushings required until a cup contains water with no visible color. [Note: 6 ounces of water in this model equals about 1 inch of rain.]



Discussion:

Before the Activity

1. Where does the water go that falls on the surface of the ground? How about any chemicals or other pollutants that fall on the ground? (Some chemicals/pollutants are washed away by rain, some become attached to rocks and soil, and some end up in the groundwater.)

2. What influences the time needed to flush an aquifer clean? (Depth and volume of the water table, type of underlying rock and soil, nature and concentration of the pollutant.)

After the Activity

1. After flushing, is the water in the model aquifer completely free of food coloring? (Probably not; trace amounts may remain.)

2. What keeps the chemical contamination in the demonstration from

reaching the lower levels of the model aquifer? (The clay layer.)

3. What are some of the problems that might result from a major chemical spill near a watershed area?

4. What steps could be taken to avoid damage to an aquifer?

Extensions:

1. Discuss the need for proper disposal of hazardous industrial wastes and harmful household chemicals, including used motor oil.

2. Simulate nitrate pollution due to fertilizer runoff. Pollute the aquifer with a small amount of soluble nitrate and perform a standard nitrate test after each successive flushing.

3. Knowing the annual rainfall in your area and that in this model 6 ounces equals 1 inch of rain, how long would it take for the aquifer to flush itself clean if 100% of the rain went to infiltration, 50% infiltration, 10% infiltration, 1% infiltration? [Note: The local Extension office may know about how much of the rain goes to infiltration.]

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Activity S-1: What is a Watershed?

Purpose: To demonstrate how watersheds are formed.

Background: The term **WATERSHED** refers to a geographic area in which water sediments and dissolved materials drain to a common outlet such as a larger stream, lake, underlying aquifer, estuary, or ocean. This area is also called the *drainage basin* of the receiving water body. A watershed can be large, like the Mississippi River drainage basin, or very small, such as the 40 acres that drain to a farm pond. Large watersheds are often called basins and contain many smaller watersheds.

No matter where you live, you're in a watershed. Your watershed may be made up of farmland, suburban development, industry, and/or urban areas. Changes in land management may affect the quality and quantity of water in a watershed. For instance, when more homes and roads are built, woodland is cleared, or parking lots are created, water runoff is intensified. Without natural protective barriers, greater quantities of water enter ditches, streams, and ponded areas faster. The result is often a higher and more rapid flow, during or after storm events, which can trigger flooding and the erosion of streambanks. The rapid flow carries more water away, leaving less for dry weather periods. The water may also carry pollutants, both dissolved and suspended, which will be deposited down stream.

Materials:
large plastic "blanket box" w/ lid, ~18"x24" (avail. at Walmart for ~$5.00)
10 lbs diatomaceous earth (coarse kind from pool supply store - 50 lbs ~$16.00)
blue food coloring
2 ft - 1/8" ID plastic tubing
adjustable drip valve to fit end of 1/8" tubing (adjustable for slow drips)
plastic jug to hold colored water (empty milk jug works well)
miniature trees (clippings from evergreens works well)
houses (monopoly pieces work well)
rocks, pea gravel
toothpicks
tin foil, pieces of felt
plastic spoon
3/8"-½" copper pipe fittings (angles, elbows, tees, straight pieces, etc.)
sponge
container for "props" (double sandwich box works well)

Procedure:

1. Place diatomaceous earth in large plastic box.
2. Puncture the bottom of the plastic jug with a pencil and insert the tubing. If leaks occur, caulk around tubing.
3. Fill plastic jug with water and add blue food coloring dropwise until desired color is obtained. (optional)
4. Connect the valve to one end of the tubing and secure to one end of the plastic box containing the diatomaceous earth. Clothespins or paper clips work.
5. Mound the diatomaceous earth up towards the valve. Allow the colored water to very slowly drip onto the diatomaceous earth to establish the meandering rivers; otherwise, gullies form and the river won't meander. Allow 2-4 minutes of dripping to establish the river(s).
6. Once the river(s) are established, you can increase the flow and manipulate the watershed using your "props." Use the toothpicks for bridges, the tin foil for concrete, the pieces of felt for cropland and lawns, the plastic spoon as a back hoe, the pipe fittings as water diversions, and the sponge as the sun to evaporate ponded water.
7. You can create flood events by allowing more flow through the valve but we recommend that you don't do this until the rivers are established.
8. Eventually, the diatomaceous earth will erode or "wash" away during the stream channel formation (forming an alluvial fan!). You can scoop-up the diatomaceous earth with your hands and reform the "earth."
9. Clean-up is easy. Dip the props in fresh water (use a bucket) -- diatomaceous earth washes off easily. If the diatomaceous earth gets on clothing, allow the clothing to dry and the diatomaceous earth will brush off like flour.
10. You can store this project with the water in it. Upon sitting, the diatomaceous earth will separate from the water. You will need to mix the water and diatomaceous earth together before using again.

Extensions: You can use mister bottles to allow for rain conditions while the rivers are forming. Observe how rain effects the formation of rivers.

This activity can be adapted for any age group. Younger audiences will be interested in manipulating the flow rate of the incoming water to see how rivers are formed, how they can meander, and the effects of a flood event. Older audiences will be interested in seeing how changes in the soil surface and stream manipulation affect the downstream characteristics of the river such as gully formations, channelization, streambank erosion, and impoundments.

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Activity S-2: Use Your Head, Protect Your Watershed!

Purpose: To describe and identify the land use activities within a watershed by analyzing its water quality.

Background*: A **WATERSHED** is an area of land from which all the water drains to the same location such as a stream, pond, lake, river, wetland, or estuary. A watershed can be large, like the Mississippi River drainage basin, or very small, such as the 40 acres that drain to a farm pond. Large watersheds are often called basins and contain many smaller watersheds.

NONPOINT SOURCE POLLUTION has many different sources, usually associated with rainfall and snowmelt runoff moving over and through the ground, carrying natural and human-made pollutants into lakes, rivers, streams, wetlands, estuaries, and underground water. Pollutants accumulate in watersheds as a result of various practices and natural events. These pollutants, while sometimes inevitable, drastically alter the state of the ecosystem. If we can determine the type of pollutant, then we can not only classify the source of the pollutant, but take preventative measures to alleviate any further contamination.

Materials:
Candy (i.e., Skittles ®,M+Ms ®)
Plastic baggies (1 baggie per student or per group of students)
Graph paper
Colored pencils

Procedure:

1. Divide the candy amongst the baggies. You may either have 1 baggie per student or 1 baggie per group of students. You should have about 30 pieces of candy per baggie. Each baggie represents a water sample from a watershed.

2. Use the table on the next page to initiate a discussion about the pollution that can come from different land use activities.

3. Have the class assign a pollutant (or group of pollutants) to each color of candy. For example, brown=sediment, red=pesticides, green=fertilizers or nitrogen. See chart on next page for one idea.

* This information was taken in part from *CLEAN WATER in YOUR WATERSHED: A Citizens Guide to Watershed Protection* by the Terrene Institute, Washington, D.C. 1993.

4. Distribute graph paper to each student (or group). Have the students draw a bar graph of the pollutants in their watershed. Label the x-axis with the names of the candy colors or pollutants and the y-axis with numbers.

5. Give each group a baggie with candy. Have the students separate and count the number of each color and graph them on the paper. You can use colored pencils to draw in the bars. Have the students try to determine what land use activities are occurring in their watershed.

Discussion: Discuss how each watershed is different and while some watersheds might contain an abundance of one certain type of pollutant, that almost all forms of pollutants can be found (even in small amounts). Can they classify their watershed, i.e., agricultural, industrial, urban, forest?

This activity is best suited for Grades 3-12. The younger audiences will enjoy exploring different classes of watersheds and pollution while integrating information about geography and economy. Older audiences will find interest in graphing and integrating math and chemistry into this project.

Land Use	Activities	Pollution Problems
Agriculture	tillage, cultivation, pest control, fertilization, animal waste management	sediment, nitrate, ammonia, phosphate, pesticides, bacteria
Construction	land clearing and grading	sediment
Forestry	timber harvesting, road construction, fire control, weed control	sediment, pesticides
Land Disposal	septic systems	bacteria, nitrate, phosphate
Surface Mining	dirt, gravel, mineral excavation	sediment, heavy metals, acid drainage, nutrients
Urban Storm Runoff	automobile maintenance, lawn and garden care, painting	oil, gas, antifreeze, nutrients, pesticides, paints

WATERSHED WATER ANALYSIS:

Color Contaminant

Red: ______________________________

Orange: ______________________________

Yel w: ______________________________

Gre : ______________________________

Dar Br wn: ______________________________

Light Brown: ______________________________

Purple: ______________________________

GLOSSARY

Aeration: The process of bubbling air through water or wastewater to remove impurities.

Aquifer: Areas underground where groundwater exists in sufficient quantities to supply wells or springs.

Coagulation: A clumping of particles in water and wastewater to settle out impurities; it is often induced by chemicals such as lime, alum, and iron salts.

Condensation: The process by which a vapor becomes a liquid.

Contamination (Water): The adding of any substance to water which makes it unfit for use.

Disinfection: A process whereby most microorganisms in or on a substance are killed; there is a high probability that pathogenic (disease causing) bacteria are killed in the process but depending on the process, destruction of viruses is not as certain.

Distillation: The separation of different substances in a solution by boiling off those of low boiling point first. For example, water can be distilled and the steam condensed back into a liquid that is almost pure water. The impurities (minerals) remain in the concentrated residue.

Diatomaceous Earth: An earthy deposit formed mainly of diatoms (one-celled marine life forms) that are pulverized and resemble sandy flour.

Erosion: The wearing away of the land surface by wind, water, ice, or other geologic agents. Erosion occurs naturally from weather or runoff but is often intensified by human land use practices.

Evaporation: The process by which water becomes a vapor usually through the application of heat energy.

Filtration: A mechanical process which involves moving water through a material, usually sand, designed to catch and remove particles.

Floc: The large particles formed in water and wastewater treatment processes when small particles begin to coalesce.

Flocculation: The formation of floc in the water and wastewater treatment process.

Groundwater: Water found under the ground, in aquifers and between soil particles.

Groundwater Recharge: Water that moves below the root zone as “deep percolation” and eventually joins the groundwater

Hard Water: Water containing excessive amounts of calcium and magnesium ions which prevents soap from lathering and produces scale and incrustation.

Hydrologic Cycle (Water Cycle): The cycle of water movement from the atmosphere to the earth and back to the atmosphere through condensation, precipitation, evaporation, and transpiration.

Infiltration: The gradual downward flow of water from the surface into the soil.

Irrigation: The controlled application of water for agricultural purposes through human-made systems to supply water requirements for crops not satisfied by rainfall.

Leaching: The process by which soluble materials in the soil, such as nutrients, pesticide chemicals, or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water.

Nonpoint Source (NPS) Pollution: Forms of pollution caused by sediment, organic and inorganic chemicals, and biological, radiological, and other toxic substances originating from land use activities, which are carried to lakes and streams by surface runoff. Nonpoint source pollution occurs when the rate of materials entering these waterbodies exceeds natural levels.

Percolation: The movement of water through the subsurface soil layers, usually continuing downward to groundwater.

Pollutant: Anything which alters the physical, chemical, or biological properties of water making it harmful or undesirable for use.

Precipitation: Water received on Earth directly from clouds as rain, hail, sleet, or snow.

Runoff: Precipitation that flows overland to surface streams, rivers, and lakes.

Sedimentation: The removal, transport, and deposition of detached soil particles by flowing water or wind. The process of solid particles settling out of water and wastewater treatment processes.

Soft Water: Any water that is not "hard," i.e., does not contain a significant amount of dissolved minerals such as salts containing calcium or magnesium.

Soil Profile: A vertical section of the Earth's highly weathered upper surface often showing several distinct layers or horizons.

Stream: A general term for a body of flowing water. In hydrology, the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally, it is applied to the water flowing in any channel, natural, or artificial.

Surface Water: All water on the surface of the Earth including lakes, ponds, rivers, oceans, streams, puddles, and runoff.

Transpiration: The process by which water vapor escapes from the living plant, principally the leaves, and enters the atmosphere.

Wastewater Treatment Plant: A facility that receives wastewater (and sometimes runoff) from domestic and/or industrial sources, and by a combination of physical, chemical, and biological processes reduces (treats) the wastewater to less harmful byproducts; also known by the acronyms WWTP, STP (sewage treatment plant), and POTW (publicly-owned treatment works).

Water Table: The upper surface of the zone of saturation; the upper surface of the groundwater.

Watershed: The land area from which surface water and runoff drains into a stream, channel, lake, reservoir, or other body of water; also called a drainage basin.