9-12

# BIOGRAPHY OF A RIVER

## OBJECTIVES

The student will do the following:

1. Compare and contrast facts about the development, history, and importance of several rivers in the state.

2. Throughly research the history and development of one particular river.

3. Describe deltas and their formation.

**SUBJECTS**:
Language Arts, Science (Physical Science, Earth Science), Social Studies (History, Economics, Geography)

**TIME**:
1-2 class periods plus research time

**MATERIALS**:
school or local library

## BACKGROUND INFORMATION

Rivers have played a vital role in the development of this country and others; this importance is reflected in the references to rivers in literature and history, both national and personal. Today rivers need protection, and one way to fuel an interest in preserving a river is to have students become familiar with their local rivers so that they feel an ownership to them. Writing a biography of a river is one way for students to combine research, interview skills, creative writing, history, and science into a single project. Keep this project fun and allow for creativity; however, set limits on what material is acceptable. If the writing is based on factual information, the project will be more realistic. If there are not enough rivers or waterways within the state, use neighboring rivers or famous rivers.

<u>Terms</u>

cinquain: a poem of five lines as follows:

| | |
|---|---|
| First line | One word, giving title |
| Second line | Two words, describing title |
| Third line | Three words, expressing an action |
| Fourth line | Four words, expressing a feeling |
| Fifth line | One word, a synonym for the title |

epitaph: a short composition in prose or verse, written as a tribute to a dead person

## ADVANCE PREPARATION

Obtain a list of state rivers and waterways. A student could complete this list for extra credit.

## PROCEDURE

I. Setting the stage

A. Begin a general discussion of familiar rivers. Ask:

1. What are the rivers in our state?

2. Who has ever seen/visited any of the rivers?

3. What did you do there?

4. Have any of your grandparents or parents told family stories about experiences on the rivers of this state?

5. Who has knowledge of other rivers in the U. S.?

6. How did rivers help in the development of this country?

7. In what ways are rivers important?

B. Explain that important people have biographies written about them. That is what students are going to do for the rivers of the state.

II. Activity

A. Assign each student (or pair, small group) a major river/waterway located within the state.

B. The river biography should include the following:

1. Birth information: This includes how the river was formed geologically, approximate time period, original course.

2. Location and description: Include a drawn or copied map of the river noting the major cities and describe the land uses along its route, its aquatic life, and

other characteristics.

3. Century report: Beginning with 1700 through the present, write a report to include:

    a. Historical events related to or occurring near the river.

    b. Important people related to the river or locations near the river.

    c. Contributions/uses of the river (industry, transportation, recreation, security, agriculture)

    d. Changes to the river and surrounding area.

4. Personal interviews: If possible, interview two people who have had personal experiences with the river. Write about their thoughts, remembrances, experiences, and other information about the river and its importance or role in their lives.

5. Death announcement: Research what could cause the "death" (no longer exists or no longer supports life) of the river. Write a fictional account of the events leading up to the death and the consequences of this death for the state.

6. Epitaph: Write an epitaph for the river in the form of a cinquain.

C. Place all the information in a folder or report and illustrate the cover.

III. Follow-up

A. Ask each student or small group to give a five-minute presentation about his/her river sharing the most significant facts and pointing out its location on a state map.

B. Have students be responsible for reading the biographies of at least two other rivers and write a comparison paper comparing their river with these two.

C. Research what makes a National Scenic River.

IV. Extensions

A. Research the role of rivers in cultural stories and myths.

B. Read descriptions of rivers in literature such as in Huckleberry Finn, the writings of J. Wesley Powell, the River Styx, and Cleopatra and the Nile. Compare these rivers with local rivers.

C. Have students research any songs written about their rivers or compose one themselves.

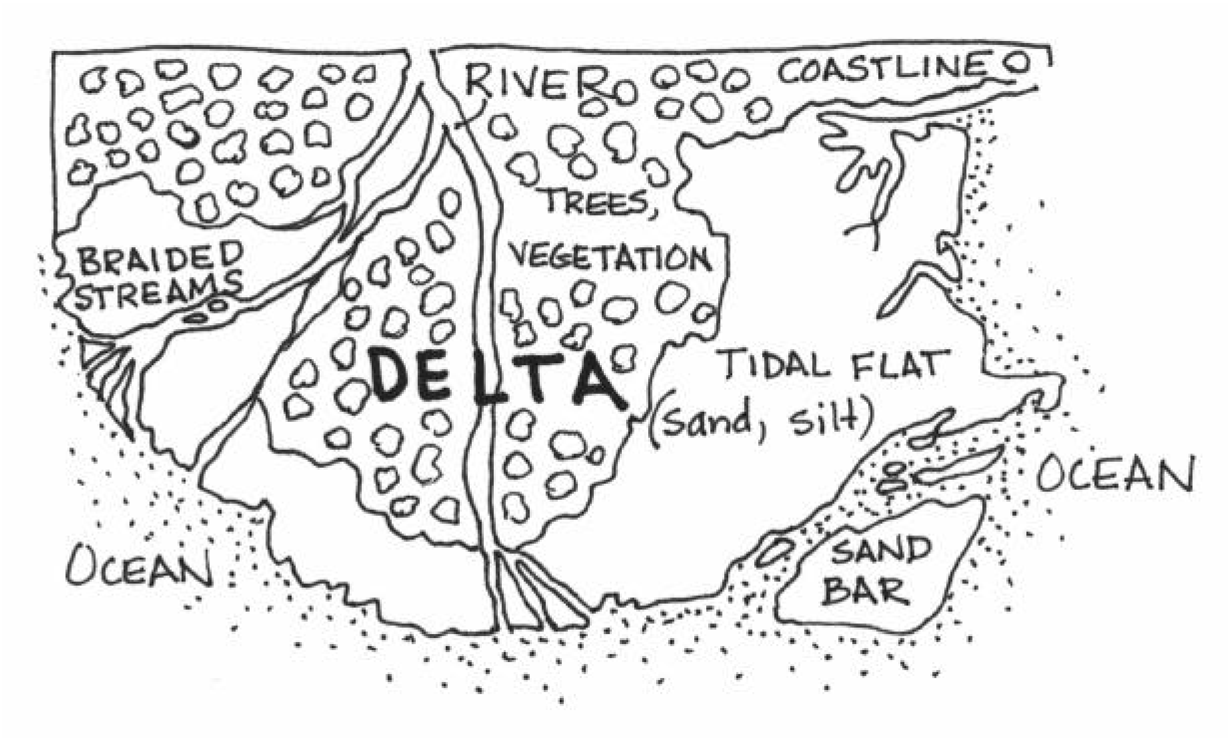
## RESOURCES


Carrier, Jim, "The Colorado - A River Drained Dry ," National Geographic, Washington, D. C., June, 1991.

Ellis, William, "The Mississippi: River Under Siege ," National Geographic, Washington, D. C., November, 1993.

Jackson III, Harvey H., "Rivers of History, Life on the Coosa, Tallapoosa, Cahaba, and Alabama," University of Alabama Press, 1995.

Yates, Steve, Adopting a Stream - A Northwest Handbook, The Adopt-A-Stream Foundation, 1988.

# THE DELTA

## BACKGROUND INFORMATION

The sketch below shows a view of a coastal feature that is seldom seen from this angle. This is an aerial "shot" of a delta. If you were to see it from ground level, you would not be able to describe the shape unless you walked around the edges as well as across it.

This delta is built up from sand and silt sediments. The plants on it started growing after the sediments began to accumulate. Some of the larger trees would probably be over a hundred years old. Notice that in the right side of the sketch, the delta appears to have been growing faster, and a sand bar has formed. Most of the sand and silt was carried down from the river.

The ocean tides, currents, and wave action help to shape a delta. Ocean currents and wave action coming from about the same direction, like those responsible for causing the lopsided appearance of this delta, are at work along all coasts. Sometimes the currents flow parallel to the shore, and at other times they curve in or out. Usually they go in one general direction for months and months. At other times, they may change speed or direction. On the other hand, waves usually approach the shore at an angle that changes with the wind.  Sometimes the wind blows out to sea.



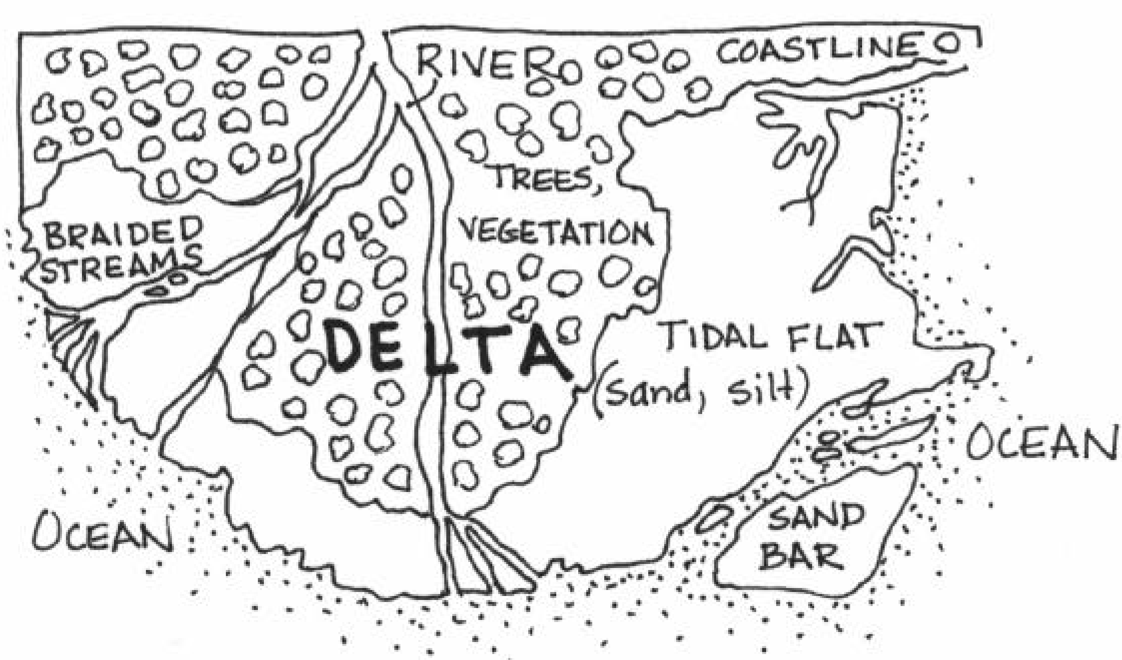
Ask students:

1. What is a delta?

2. What causes deltas to form?

3. What forms the shape of a delta?

Not all forms of pollution are bad.  Deltas are important.  Water, picking up dirt and moving it around, formed such important land masses as the Mississippi Delta and the Nile Delta.  Sediment also formed the fertile lands on either side of the Nile River.  Think of other agriculturally important places that depend on this process.



# CATCH ME IF YOU CAN --

9-12 (TWO WAYS TO MEASURE STREAM FLOW)

## OBJECTIVES

The student will do the following:

1. Compute the amount of water that flows through a stream.

2. Demonstrate an understanding of the data from USGS that are used to monitor stream flow.

3 Explain the influence a particular amount of rainfall may have on that stream.

**SUBJECTS:**
Math, Science (Physical), Social Studies (Geography)

**TIME:**
1-2 class periods
(field trip to stream)

**MATERIALS:**
topographical map of community (USGS)
dot grid/graph paper
floating device
(orange or lemon peel)
stopwatch or clock
measuring tape
graph paper
USGS data on stream flow
clothes OK to get wet

## BACKGROUND INFORMATION

Streams, rivers, and even small tributaries have large demands put upon them by having supply waters pulled from them and by the addition of discharge waters from various sources. The capacity of any tributary, no matter how large or small, must be taken into account before it can be used for a water supply source or a discharge receiving stream.

Storm water that moves across the surface of the land is called runoff. Factors that influence runoff to a stream include watershed size, slopes, soil types, land use, and vegetation. It is important to understand the correlation of these factors to actual water flow in a stream. A sound decision about water consumption or discharge for a given community should be based on this knowledge. (Other factors, such as the water needs of local wildlife and vegetation, also should be taken into account.)

Terms

AF: (acre foot) - volume of any substance required to cover one acre of a surface to the depth of 1 ft (43,560 $ft^3$) or (1232.75 $m^3$)

runoff: water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a waterbody; may pick up and carry a variety of pollutants stream gauging: the measurement of velocity of streams (stream velocity)

stream velocity: the volume of water in a stream flowing past a certain point per unit time, typically measured in cubic feet per second (cfs)

topographical map: a contour map designed to show elevation; commonly referred to as a "topo" map; scale 7.5' or 1:24,000

tributary: a stream that flows into a larger stream, river, or another waterbody

USGS: United States Geological Survey

velocity (linear): distance per unit time

watershed: land area from which water drains to a particular surface waterbody

## ADVANCE PREPARATION

This activity has a very comprehensive extension that could be used to demonstrate streamflow and to show how different variables in a watershed can affect flow rate. Refer to the Stream Flow Table extension.

A. Write terms and definitions on the board.

B. Discuss the graphing and simple math to be done.

C. Locate a site in the community to be measured for stream flow.

D. Contact the United States Geological Survey (USGS) office in the state to get streamflow data on the stream that will be measured. Note: Not all streams have been gauged and not all of those for a sufficient time period. Be sure to choose a stream for which sufficient data are available.

## PROCEDURE

I. Setting the stage

   A. Determine the boundaries of the watershed by looking at a topographical map of the area. The area above (upstream from) the point where the measurement will be taken is the most important. This information may also be available through the USGS office for the particular waterbody.

B. Discuss the impact of a given amount of runoff on the stream. (This cannot be determined by rainfall because a large and variable portion enters groundwater depending on soil types, slopes, and many other factors .)

C. Measure and mark a section of the stream.

II. Activity

A. Determine the linear velocity of a stream segment using a floating device.

1. Put a floating device (e.g., an orange peel or lemon peel) in the stream and clock the time it takes to get to a measured point downstream. Divide thedistance traveled by the floating device in the stream segment, by the time clocked.

2. If the measurement is done near the center of the stream where velocity is expected to be highest, multiply by 0.8 to get an average linear velocity.

3. Determine linear velocity ($v_l$) using the following equation:

$$v_l = \frac{\text{distance traveled}}{\text{time clocked}}$$

B. Calculate the cross sectional area of the stream segment.

1. At certain intervals across the stream section, measure the depth of the stream (from shore to shore). Calculate the average depth of the stream.

2. Also, measure the width of the stream section at various intervals along the channel and calculate the average stream width.

3. Calculate the cross-sectional area ($\text{Area}_{cross\text{-}sec}$) of the stream segment by multiplying the average depth ($d_{avg}$) x average width ($w_{avg}$).

$$\text{Area}_{cross\text{-}sec} = d_{avg} \times w_{avg}$$

C. Calculate stream velocity (*SV*) according to the following equation.

$$SV = \text{Area}_{cross\text{-}sec} \times v_l$$

Depending on the units used for measurement, *SV* units will be in terms of cubic feet per second (cfs) or cubic meters per second (CMS).

III. Follow-up

Compare the flow rate to data from USGS on the same stream.

IV. Extensions

A. Study USGS Streamflow Data to understand how the waterflow increases as tributaries flow into a stream.

B. Repeat measurements after a rain and during a drought at the same point on the stream.

C. See alternative activity on Stream Flow Table Teacher Sheet.

## RESOURCES

National USGS Office, Dept. of the Interior, Reston, VA 22092. 800-USA-MAPS

State Geological Contacts. (See Fact sheet pages J-1 to J-6.)

# STREAM FLOW TABLE

**TIME:**
1-2 class periods

**MATERIALS:**
flat trough
sand/silt mixture
supply hoses
3 buckets
2 screw clamps (or pinch clamps)
brick

## BACKGROUND INFORMATION

Many activities can be done with a stream table. All it takes is a little imagination and a few supplies. One of the challenges in interpreting the natural landscape is that many important variables act at the same time. The stream table will allow students to control some of these variables that are largely uncontrollable in nature. For example, an artificial river can be created, sped up or slowed down, or made to flow over various types of material. These variations can help greatly in understanding how natural rivers behave.

The stream table is modeled by a flat trough containing a sand-silt mixture that can be formed into various shapes. Water enters one end of the trough through a supply hose from an elevated bucket, flows across the sand, and leaves the other end through an exit hose into a second bucket. The flow of water into and out of the trough can be controlled by opening and closing the screw clamps (or pinch clamps). The slope of the trough can be changed by moving a support, such as a brick or a wooden block, back and forth.

<u>List of variables the stream table will let students control for study</u>

1. To calculate the rate of flow from the supply bucket:

Most of the stream table experiments call for students to adjust the rate of water flow into the reservoir to a certain number of milliliters per second. Doing this is easy. Simply time how long it takes (in seconds) for the supply hose to fill a 100 milliliter beaker. Then calculate the rate of flow like this (the example assumes that it takes five seconds to fill the beaker):

100 ml/5sec = 20ml/sec

2. To control the rate of flow from the hose:

To reduce the flow rate, simply tighten the screw clamp. Opening the clamp increases the flow. The rate of flow values given in the resources are approximate and can be varied up or down by

2ml/sec. Any rate between 8ml/sec and 12ml/sec will do for a resource calling for a rate of 10ml/sec. When students are sure that they have a flow of 10ml/sec, change the flow to 5ml/sec.



3. Keep water in the supply bucket at all times.

To help do this, an extra bucket is required. When the supply bucket is nearly empty, replace the full catch bucket with the extra bucket and transfer the water to the supply bucket. Students will have to do this every 5 minutes. Caution: Watch the catch bucket -don't let it overflow!

4. To control the flow of water leaving the stream table:

Students may want to form a lake at the lower end of the stream table. They can control the formation and depth of such a lake by adjusting the screw clamp on the exit hose. If students change the amount of water entering the stream table, the lake level will also change unless they read just the exit hose screw clamp. With the water flowing at 5ml/sec, adjust the exit hose to cause a lake to form.

5. To make a reservoir:

Students may want to make a reservoir at the end of the stream table. This is used to observe the effect of a wide, thin sheet of water. In general, a shallow reservoir molded near the top of the stream table will serve the purpose. However, students may wish to mold a larger dam when their study calls for a thick layer of sand and silt. Pile up the sand and silt with hands or use a small board.

6. To adjust the slope of the table:

If the students want to raise the upper end of the stream table a certain number of centimeters (above the table), simply slip a support under the stream table. Then, move it back and forth to get the desired height.

7. CAUTION:

a. Watch the catch bucket. Students must keep their eyes on the catch bucket to keep it from overflowing. Students can avoid the problem in some activities by pouring less than a full bucket of water into the supply system to start with. Anytime students use more than one full bucket of water, a third bucket will be needed to trade positions with the catch bucket before it is too late.

b. Be sure that the water supply pail is set on a box or other support about 30 cm above the table.



c. Keep the supply hose and clamp attached at all times to control the water flow.

d. Do not remove the sand-silt mixture from the stream table when students participate in these programs. The next class using the table will need the same sand-silt mixture.

e. The stream table is not a perfect model. Students will not get the same effects that a real river would produce. Remember that the particle sizes used are very much out of proportion to the volume of water flowing through the stream table.

8. QUESTIONS

a. When it rains, what percentage of water stays on the surface (later evaporating or soaking into the ground)?
(25%)

b. What happens to the rest of the water?
(It drains down to the nearest watershed.)

c. What influence do watersheds have on the lives of people, vegetation, topsoil, and agriculture? (discuss)

d. Are the runoffs controllable? How and with what effects?
(Construct dams.)

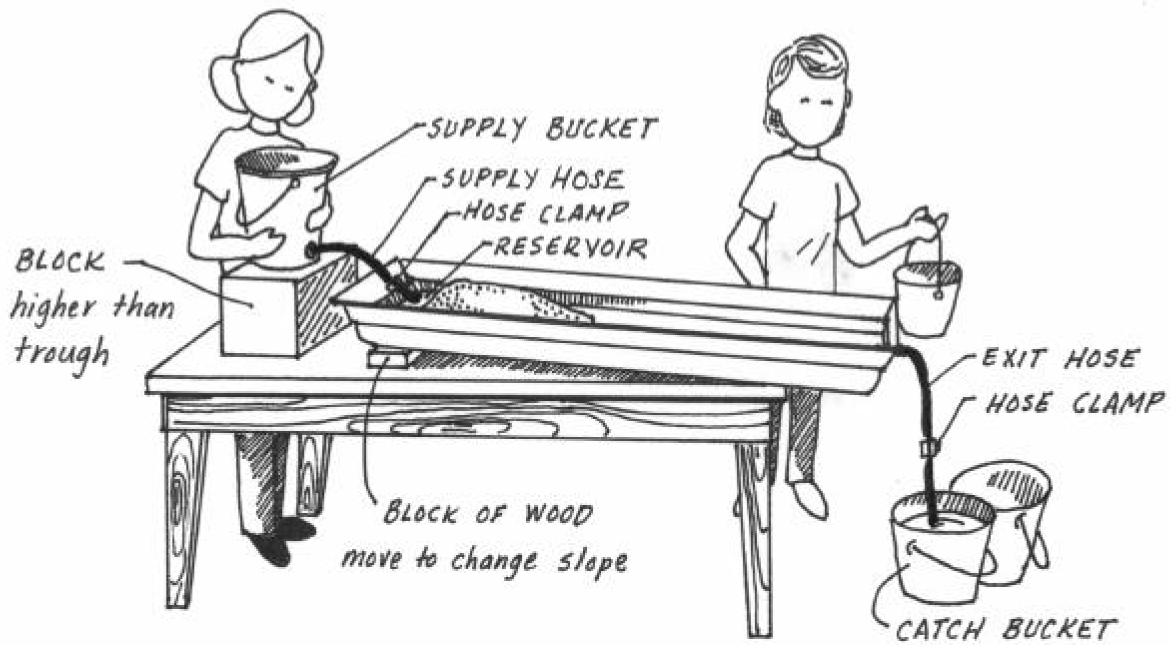
e. How does uncontrollable runoff lead to flooding in a particular area?

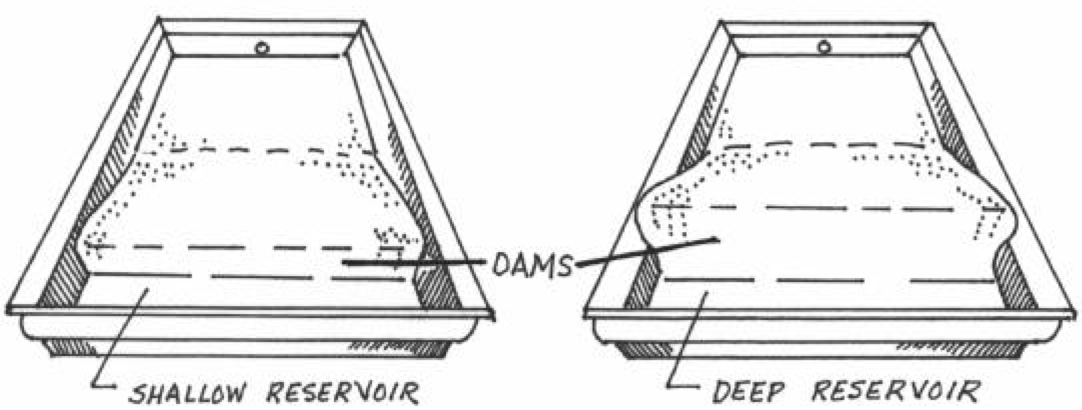
f. Mention the advantages and disadvantages of runoffs.
(They create watersheds, but wash off valuable topsoil and carry pollutants.)

g. What are common pollution sources that contaminate runoff?
(pesticides, fertilizers, oil, etc.)

h. What can people do to prevent pollution of storm water runoff?
(discuss)

i. Find out if your community has a storm water management, pollution prevention, or source water protection program. Learn what you can do to help.


SUPPLY BUCKET
SUPPLY HOSE
HOSE CLAMP
RESERVOIR
BLOCK
higher than
trough
EXIT HOSE
HOSE CLAMP
BLOCK OF WOOD
move to change slope
CATCH BUCKET


DAMS
SHALLOW RESERVOIR
DEEP RESERVOIR

9-12

# HELP!  LAKE OVERTURNING!

**SUBJECTS:**
Science (Biology, Earth Science, Environmental  Science)

**TIME:**
2 class periods

**MATERIALS:**
student handouts, one per student
4 large sheets of drawing paper and 4 boxes of crayons
hot plate
2 beakers
food coloring
table salt
2 large glass containers with open mouth
refrigerator or ice cubes
fan
ladle
funnel
tubing

## OBJECTIVES

The student will do the following:

1. Define the terms associated with this lesson.

2. Explain the process of overturning and its importance to aquatic life.

## BACKGROUND INFORMATION

Overturning refers to the phenomenon of a lake exchanging water from the bottom to the top and from the top to the bottom. This process is very important to the health of the lake's aquatic life.

Overturning is also an important factor in the recovery of a lake after it has been contaminated with a pollutant.  Lakes and ponds are lentic systems, which means that the surface water is standing as opposed to lotic or flowing systems, such as rivers.  It is much harder for a lake to recover from pollution than it is for a river, even a slow flowing one, because the time period for a total overturning of a lake may be as frequently as annually or as long as 10 to 100 years.  During this time, pollutants may build up and reach lethal levels, especially if the influx of contaminants is constant or in large volumes.

To understand the process of overturning, it is important to know two different categories of zones into which lakes may be divided.  One category is based on the depth of the water; the other is based on the temperature of the water.

The first set of zones is determined by the depth of the water that, in turn, determines the amount of sunlight that is able  to penetrate the water.  The amount of sunlight determines the amount and type of plant life and thus the amount and type of aquatic animal life.  The three zones in this classification are:

1. the littoral zone: shallow waters along a lakeshore where rooted vegetation grows; largest amount of sunlight penetration.

2. the limnetic zone: open water zone of a lake through which sunlight penetrates; located parallel the lake bottom and extending between the littoral zones; contains algae and other microscopic organisms.

3. the profundal zone: deepest area of a lake; located from the limnetic zone to the bottom of the lake; no sunlight penetrates; contains decomposing vegetation.

There is no set size for the zones because they change as other factors change. For example, if the lake fills with silt from construction runoff, the bottom will rise and the shoreline will expand causing a larger littoral zone. Also, the limnetic zone will thin because light penetration will decrease.

The second set of zones involved in the rate of lake overturn is based on temperature (thermal zones). The three zones within this classification are:

1. the epilimnion: the upper waters nearest the surface of a lake.

2. the thermocline or metalimnion: the transition zone between the top (epilimnion) and bottom (hypolimnion) zone.

3. the hypolimnion: the deepest waters in a lake.

The temperature zones of a lake change due to wind movement, solar intensity, and air temperature; thus, they are seasonal. During each season, the lake takes on different characteristics. The differences in water temperature among the zones lead to the movement of water and results in the process of overturning. A closer look at the seasonal changes shows how the process of overturning operates and brings changes to the lake. Note that this kind of overturning only occurs in temperate lakes that partially freeze in winter and thaw in spring. Some lakes in other climatic settings can also overturn, but the mechanisms are different.

Spring: As the ice from winter melts, the cold water sinks to the bottom. This is because ice is less dense than water, but water that is only slightly above the freezing temperature is denser than warmer water. Eventually the lake reaches a state in which all water is at the same temperature. There are no longer three distinct zones, only one zone. This unlayered water is easily mixed by brisk spring winds, and the oxygen and nutrients from the bottom are evenly distributed throughout the lake. This period is called the spring overturn.

Summer: The sun warms the surface of the lake, but the mild summer winds cannot mix this warmer water with the other zones. The lake again forms temperature zones, but this time the low-density surface layer is warm water. The thermocline has warm water above and cool water below. This reduces the amount of oxygen reaching the hypolimnion and makes it unsuitable for life requiring very much oxygen. This period is often referred to as the summer stagnation period.

Fall: Fall brings cooler air temperatures that gradually cool the epilimnion. This cooling process causes the epilimnion to become deeper and finally results in the lake being a uniform temperature again, eliminating the other zones. Again the water is easily mixed by wind, and the lake enters the fall overturn period.

Winter: As the winter air temperature turns cold, the epilmnion zone cools more than the other zones. This cold water is forced to the bottom until the epilimnion becomes so cold that it freezes and becomes a layer of ice. The hypolimnion now has water that is warmer than the epilimnion. The thermocline now has colder water on top and warmer water on bottom. Because the water is not able to mix freely; no additional oxygen will reach the hypolimnion until next spring. This period is called winter stagnation.

Terms

epilimnion: one of three temperature or thermal zones located at the top of a thermally stratified lake; varies in size and temperature characteristics based on a seasonal cycle

groundwater: water that infiltrates into the Earth and fills open spaces in the soil and rock below the Earth's surface; water within the zone of saturation

hypolimnion: one of three temperature or thermal zones located at the bottom of a thermally stratified lake; varies in size and other characteristics based on a seasonal cycle

lentic system: surface water that is standing such as a lake or pond

limnetic zone: a zone in a lake extending over open water from the edge of one littoral zone to the other and above the profundal zone; characterized by floating vegetation and moderate to high sunlight penetration

limnology: the science that deals with the physical, chemical, and biological properties and features of fresh waters, especially lakes and ponds

littoral zone: a zone along the shore of a lake that is characterized by very shallow water, rooted vegetation, high sunlight penetration

lotic system: surface water that is flowing such as a river or stream

overturning (turnover): process by which water and nutrients are circulated in a lake due to the thermal processes which can occur on a seasonal basis profundal zone: a zone in a lake extending from the bottom of the limnetic zone to the bottom of the lake; characterized by deep water, decomposing vegetation, and little to no sunlight penetration

seasonal: happening based on the yearly seasons of spring, summer, fall, and winter

stagnation: inactivity or without change

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration. It is stored in streams, lakes, rivers, ponds, wetlands, oceans, and reservoirs

.

temperature zones: regions characterized by different temperature characteristics

thermocline: one of the three temperature or thermal zones located between the upper and lower zones of a lake; also called the metalimnion. The thermocline is a thin boundary layer between two layers of distinctly different temperatures. The thermocline is a place characterized by dramatic vertical temperature change.

## ADVANCE PREPARATION

A. Students should be familiar with the differences between surface water and groundwater and the different types of surface water.

B. Copy Student Sheet (crossword puzzle) and Background Information for students.

C. Gather materials.

D. Copy or put vocabulary words and definitions on the board.

## PROCEDURE

I. Setting the stage

A. Introduce this activity by asking the students, “Can sunlight reach all levels of surface water?” Let students defend their responses. They should bring out that the correct answer depends on many factors such as the size and type of surface waterbody. Discuss the types and characteristics of surface water. What differences would the ability of light to reach various levels have on the characteristics of a lake?

B. This activity will introduce students to features of a lake that contribute to overturning (or layering) and familiarize them with the terminology.

II. Activity

A. Give the students a copy of the Background Information.

B. When all have completed reading, divide the class into 4 (or multiples of 4) groups giving each group a large sheet of paper with either Fall, Spring, Summer, or Winter written on the top and a box of crayons.

C. Instruct each group to draw a representative lake during the assigned season including both of the two categories (depth and temperature). Ask students to be prepared to explain to the class how or if the process of overturning takes place during their assigned season. (This could also be done on a chalkboard, white board, or drawn on a computer.)

D. For a temperature inversion experiment:

1. Put a volume of cold water in a glass jar followed by a smaller volume of hot water that has food coloring in it. Try adding the hot water to the jar containing the cold water without disturbing the cold water too much (use a small funnel with tubing attached and a soup ladle).

2. With the funnel and tubing, pour the water into the soup ladle first, letting it gradually fill up with hot water. Then gently overflow to the surface of the cold water. Do this for two jars, keeping the volumes consistent between the two.

3. Take a fan and direct airflow over the top of one of the jars. Observe how this wind affects the stratification of the water in the jar (similar to wind on a lake).

4. Repeat, but keep one jar at room temperature and the other jar hotter or colder and compare the changes in the two.

5. Alternative to this would be to:

    a. Put colored ice cubes on top of warm water and let them thaw.

    b. Put cold colored water in the bottom of a beaker with warm water on top and heat the bottom.

III. Follow-up

A. After each group has presented its drawings, made corrections, and answered questions, discuss the experiment.

B. Students should write a paragraph explaining overturning using all the terms correctly.

C. Have students fill out the Student Sheet as a quiz.

D. Have students study temperature change in a local lake throughout the rest of the school year.

IV. Extensions

A. Have the students make a model of each of the stages of overturn.

B. Have the students make a model of a lake and identify each of the physical zones.

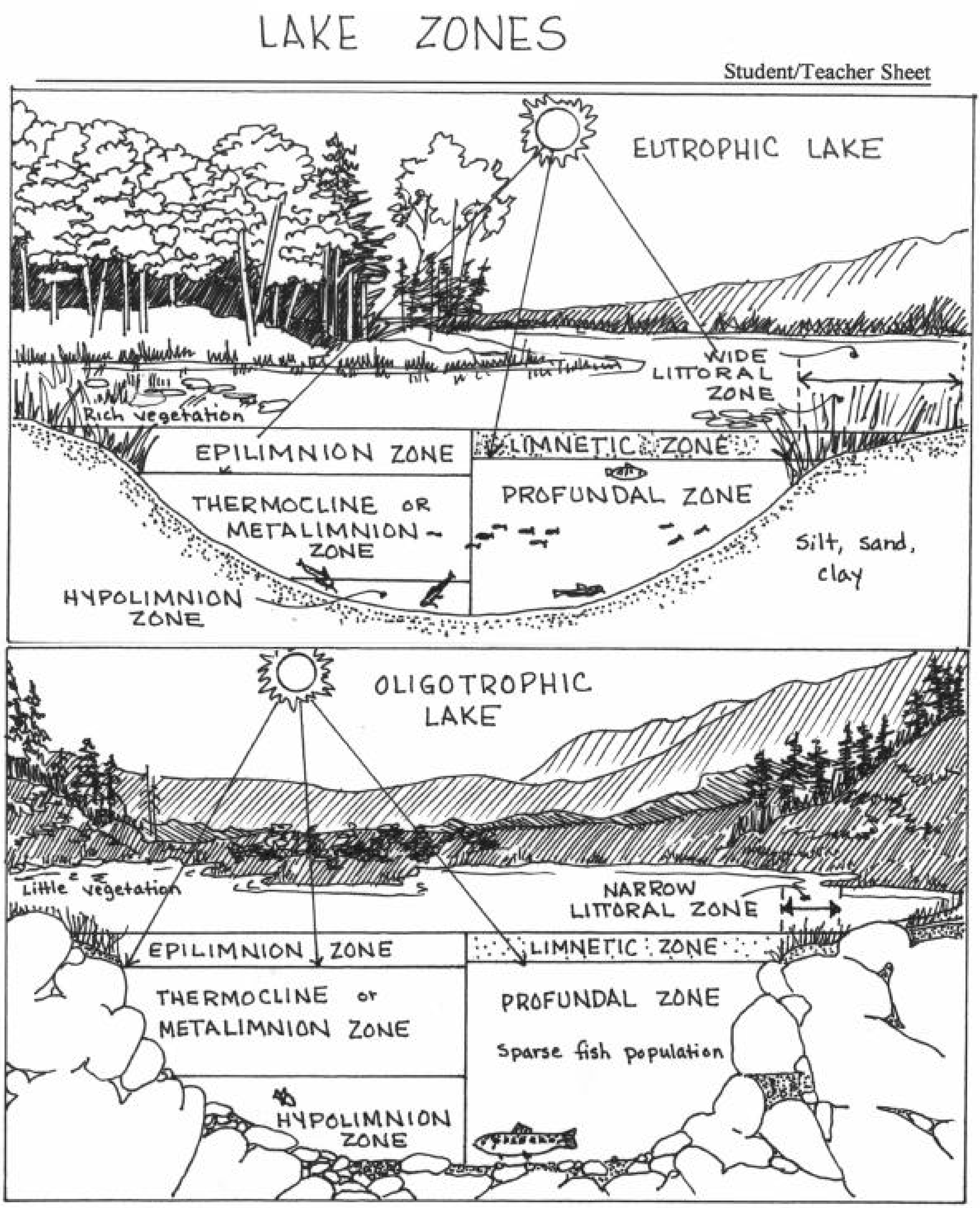
C. Have the students make a game based on this information.

## RESOURCES

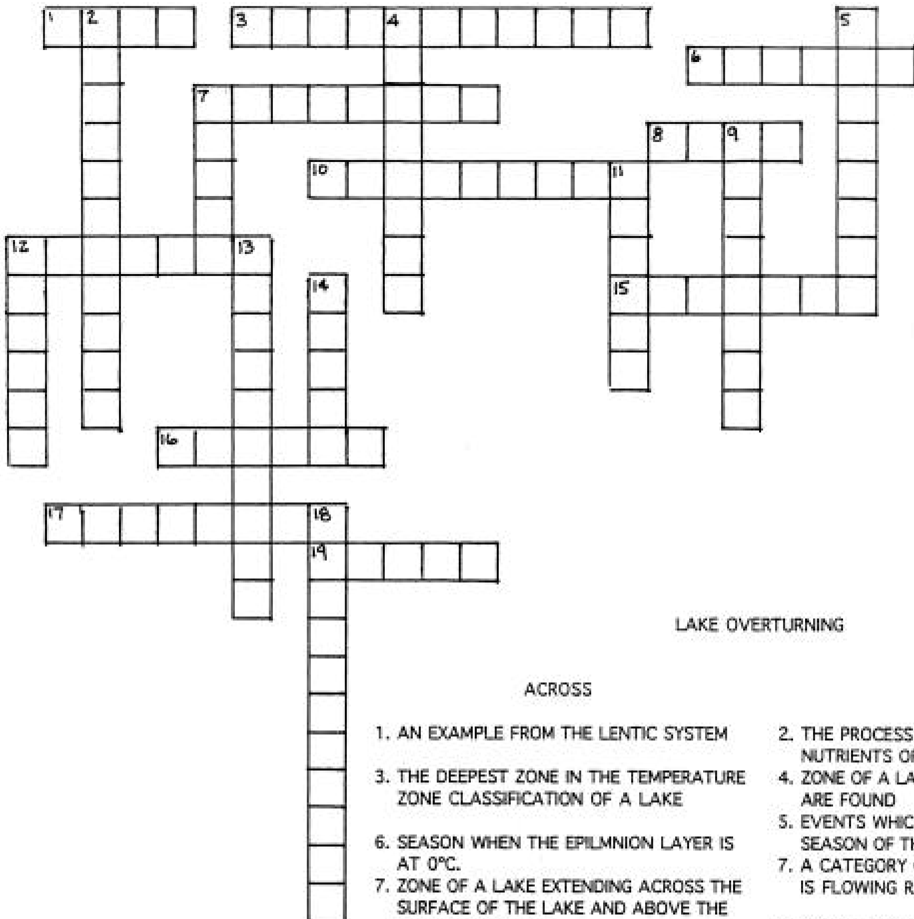
Andrews, William A., Investigating Aquatic Ecosystems, Prentice-Hall Canada, Inc., Scarborough, Ontario, 1987.

Chiras, Daniel, Environmental Science, High School Edition; Addison-Wesley Publishing Company, Menlo Park, CA, 1989.

Jones, Gareth, Alan Robertson, Jean Forbes, and Graham Hollier, The Harper Collins Dictionary of Environmental Science, Harper Collins Publishing, Ltd., New York, 1992.


LAKE ZONES
Student/Teacher Sheet
EUTROPHIC LAKE
WIDE LITTORAL ZONE
Rich vegetation
EPILIMNION ZONE
LIMNETIC ZONE
THERMOCLINE OR METALIMNION ZONE
PROFUNDAL ZONE
Silt, sand, clay
HYPOLIMNION ZONE
OLIGOTROPHIC LAKE
Little vegetation
NARROW LITTORAL ZONE
EPILIMNION ZONE
LIMNETIC ZONE
THERMOCLINE or METALIMNION ZONE
PROFUNDAL ZONE
Sparse fish population
HYPOLIMNION ZONE

NAME ______________________________



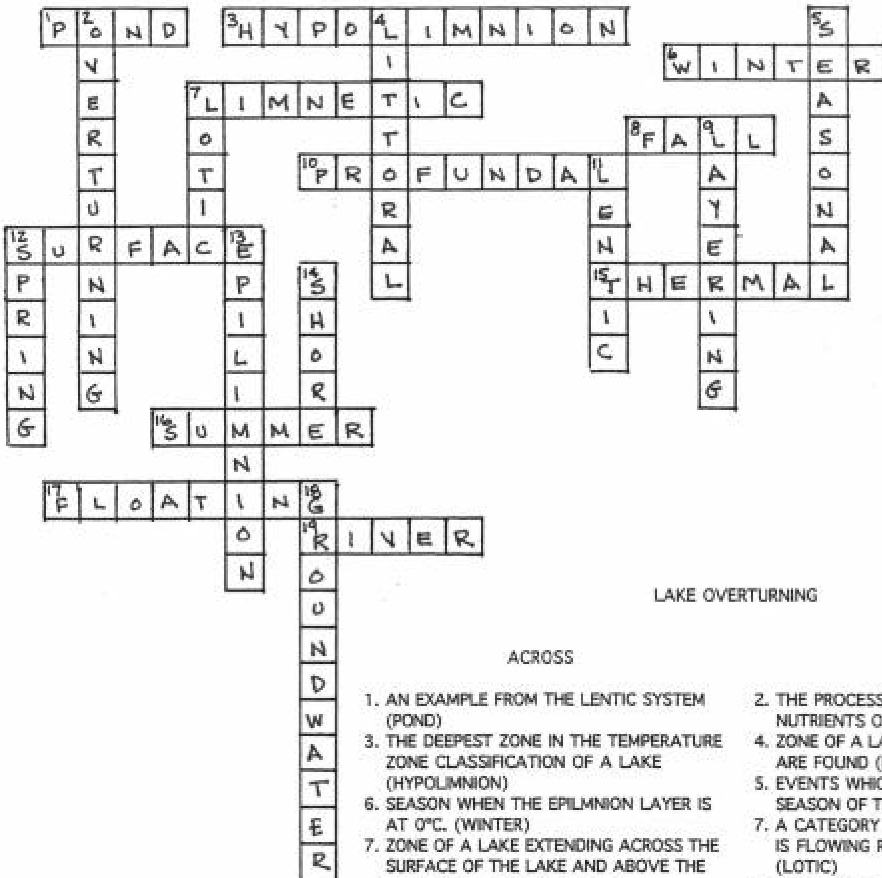
## LAKE OVERTURNING

### ACROSS

1. AN EXAMPLE FROM THE LENTIC SYSTEM
3. THE DEEPEST ZONE IN THE TEMPERATURE ZONE CLASSIFICATION OF A LAKE
6. SEASON WHEN THE EPILMNION LAYER IS AT 0°C.
7. ZONE OF A LAKE EXTENDING ACROSS THE SURFACE OF THE LAKE AND ABOVE THE PROFUNDAL ZONE
8. SEASON WHICH IS THE MOST SIMILAR TO SPRING IN THE OVERTURNING PROCESS
10. DEEPEST ZONE OF A LAKE; LITTLE IF ANY SUNLIGHT
12. WATER WHICH DOES NOT SOAK INTO THE GROUND BUT BECOMES LAKES, PONDS, ETC.
15. ANOTHER TERM USED TO INDICATE THE TEMPERATURE ZONES IN A LAKE
16. SEASON DURING WHICH THE SUN WARMS THE UPPER LEVEL FASTER THAN THE WINDS CAN MIX THE WATER
17. TYPE OF PLANTS FOUND IN THE LIMNETIC ZONE
19. A _____ IS AN EXAMPLE OF A LOTIC SYSTEM.

### DOWN

2. THE PROCESS OF MIXING THE WATER AND NUTRIENTS OF A LAKE
4. ZONE OF A LAKE WHERE ROOTED PLANTS ARE FOUND
5. EVENTS WHICH HAPPEN BASED ON THE SEASON OF THE YEAR
7. A CATEGORY OF SURFACE WATER WHICH IS FLOWING RATHER THAN STANDING.
9. ANOTHER TERM FOR OVERTURNING
11. A CATEGORY OF SURFACE WATER WHICH IS STANDING, NOT FLOWING
12. SEASON WHEN LAKE WATERS MIX FREELY DUE TO THE MOVEMENT OF WINDS AND THE DOWNWARD MOVEMENT OF COLD WATER FROM THE UPPER LEVELS
13. THE UPPERMOST LAYER IN THE TEMPERATURE CLASSIFICATION OF A LAKE
14. ONE BOUNDARY OF THE LITTORAL ZONE IS THE _____
18. ANOTHER TYPE OF FRESHWATER OTHER THAN SURFACE WATER




## LAKE OVERTURNING

### ACROSS

1. AN EXAMPLE FROM THE LENTIC SYSTEM (POND)
3. THE DEEPEST ZONE IN THE TEMPERATURE ZONE CLASSIFICATION OF A LAKE (HYPOLIMNION)
6. SEASON WHEN THE EPILMNION LAYER IS AT 0°C. (WINTER)
7. ZONE OF A LAKE EXTENDING ACROSS THE SURFACE OF THE LAKE AND ABOVE THE PROFUNDAL ZONE (LIMNETIC)
8. SEASON WHICH IS THE MOST SIMILAR TO SPRING IN THE OVERTURNING PROCESS (FALL)
10. DEEPEST ZONE OF A LAKE; LITTLE IF ANY SUNLIGHT (PROFUNDAL)
12. WATER WHICH DOES NOT SOAK INTO THE GROUND BUT BECOMES LAKES, PONDS, ETC. (SURFACE)
15. ANOTHER TERM USED TO INDICATE THE TEMPERATURE ZONES IN A LAKE (THERMAL)
16. SEASON DURING WHICH THE SUN WARMS THE UPPER LEVEL FASTER THAN THE WINDS CAN MIX THE WATER (SUMMER)
17. TYPE OF PLANTS FOUND IN THE LIMNETIC ZONE (FLOATING)
19. A ____ IS AN EXAMPLE OF A LOTIC SYSTEM. (RIVER)

### DOWN

2. THE PROCESS OF MIXING THE WATER AND NUTRIENTS OF A LAKE (OVERTURNING)
4. ZONE OF A LAKE WHERE ROOTED PLANTS ARE FOUND (LITTORAL)
5. EVENTS WHICH HAPPEN BASED ON THE SEASON OF THE YEAR (SEASONAL)
7. A CATEGORY OF SURFACE WATER WHICH IS FLOWING RATHER THAN STANDING. (LOTIC)
9. ANOTHER TERM FOR OVERTURNING (LAYERING)
11. A CATEGORY OF SURFACE WATER WHICH IS STANDING, NOT FLOWING (LENTIC)
12. SEASON WHEN LAKE WATERS MIX FREELY DUE TO THE MOVEMENT OF WINDS AND THE DOWNWARD MOVEMENT OF COLD WATER FROM THE UPPER LEVELS (SPRING)
13. THE UPPERMOST LAYER IN THE TEMPERATURE CLASSIFICATION OF A LAKE (EPILMNION)
14. ONE BOUNDARY OF THE LITTORAL ZONE IS THE ____ (SHORE)
18. ANOTHER TYPE OF FRESHWATER OTHER THAN SURFACE WATER (GROUNDWATER)

# THE AGING OF LAKES

## OBJECTIVES

The student will do the following:

1. Determine the trophic condition of a local body of water.

2. Demonstrate the use of a Secchi disc.

3. Test for pH, nitrogen, phosphorus, temperature, and dissolved oxygen in a body of water.

**SUBJECTS:**
Science (Chemistry, Biology, Ecology)

**TIME:**
several field trips

**MATERIALS:**
water analysis kit
Secchi disc
volunteer "lake watch" group
boat?
wader?

## BACKGROUND INFORMATION

Lake eutrophication is the increase over time of nitrogen, phosphorus, and other nutrients necessary for production of algae and other plants. It is an important part of the process by which lakes pass from their original nutrient-poor (<u>oligotrophic</u>) condition to a more productive (<u>eutrophic</u>) condition to become shallower with sedimentation and smaller with encroachment of marsh until, over geologic ages, lake basins are returned to land and terrestrial life. This "aging" process is called <u>succession</u>.

Humans speed up the lake aging process by discharging nutrients from sewage treatment plants, fertilized fields and pastures, and sediment from road, home, and commercial construction.

Nutrients can be bad for a lake if excessive enrichment causes an algal bloom. This abundance of algae eventually produces a large amount of decomposing organic matter, which depletes oxygen from the water. This can kill fish. The most productive fishing lakes have a moderate nutrient content that produces a balanced amount of algae and phytoplankton as fish food.

The study of lake conditions is called limnology and involves water testing to evaluate nutrient content, temperature, pH, dissolved oxygen (DO), profiles with depth, light penetration, and other tests that may be specific to a given location.

<u>Terms</u>

algal bloom: a sudden increase in the amount of algae, usually causing large, floating masses to form. Algal blooms can affect water quality by lowering DO content and decreasing sunlight penetration, are usually caused by excessive nutrient addition, and can be characteristic of a eutrophic lake.

eutrophic: refers to a body of water characterized by nutrient-rich water supporting abundant growth of algae and/or other aquatic plants at the surface

limnology: the science that deals with the physical, chemical, and biological properties and features of fresh waters, especially lakes and ponds

oligotrophic: refers to any ecosystem that has nutrient-poor water

succession (lake): gradual, orderly process of changes in a lake ecosystem brought about by changes in species types and populations; occurs over long periods of (geologic) time and ultimately results in the lake reverting back to land (a terrestrial ecosystem)

## ADVANCE PREPARATION

If possible, consult a local volunteer monitoring group for use of equipment and assistance in selecting and sampling a nearby lake. Equipment required includes: test kits equipped for N, P, pH, and temperature measurement; sampling equipment that will allow samples to be collected at specified depths; and a Secchi disc for measuring light penetration with depth.

## PROCEDURE

Students will go to a local lake monthly over a period of one school year and sample set locations. They will evaluate profiles and seasonal changes, determine the lake's health, trophic status, and annual trends, and predict changes to come.

I. Setting the stage

Coordinate with a volunteer monitoring group to schedule sampling visits to a lake. Make a record of specified measurements at fixed, preselected locations (usually just above a dam, an inland slough, the center of the lake, or others as appropriate).

II. Activity

A. At each sampling location, determine pH/temperature/DO profiles measured at every 5 feet of depth. (Where there is a marked change in a 5-foot interval, take more samples such as every 1 or 2 feet.) Record the data for a later plot of the results versus depth.

B. Collect water samples for N and P analysis (and pH and DO if needed). While analysis may be done later, proper sample preservation techniques should be observed. DO and pH may be run in the field using a pH/DO meter, test kit chemicals, or pH paper.

C. Measure/record Secchi disc readings for each location or each sampling visit.

D. Plot all parameters (pH, temperature, DO, N, P) versus depth for each location per visit.

III. Follow-up

A. Analyze changes/trends in data observed over the course of the year. Is the lake more oligotrophic or eutrophic? How can you tell?

B. If eutrophic, what are the sources of its nutrients?

C. How can these nutrient sources be controlled or managed?

IV. Extensions

A. Consult the state environmental agency about the trophic status of state lakes, how the sampled lake compares, and what specific management steps could be taken to protect the lake.

B. Read about some of the world's largest lakes and their trophic status such as Great Lakes, Lake Baikal, Lake Zurich, Lake Chad.

## RESOURCES

Contact state environmental agency (see lists in the appendix) to find out about local volunteer monitoring groups.

Water Analysis Kit, page F-69, Water Testing Fact Sheet

## WATER PROFILE DATA SHEET

STUDENT(S) - ______________________________

LAKE - ______________________________

LOCATION - ______________________________

| | | | | | | | DO PROFILES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | pH | TEMP | N | P | DISC | | 1FT | 2FT | 4FT | 6FT | 8FT | 10FT | 12FT |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
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# 9-12 BIODIVERSITY = WATER QUALITY

## OBJECTIVES

The student will do the following:

1. Learn to collect surface water samples.

2. Determine the degree of pollution in a stream by using indicator organisms and a pollution tolerance index.

**SUBJECTS:**
Science (Biology, Environmental Science)

**TIME:**
2 hours
field trip + travel time

**MATERIALS:**
each team will need:
measuring tape
a white enamel pan
calculator (optional)
notebook and pencil
kick seine, screen, or net
student sheets
If samples are to be preserved, containers with 70% alcohol (ethyl or isopropyl) solution are needed.

## BACKGROUND INFORMATION

Diverse natural ecosystems provide important ecological services including maintaining hydrological cycles, regulating climate, contributing to the processes of soil formation and maturation, storing, and recycling essential nutrients, absorbing, and breaking down pollutants. They also provide sites for inspiration, tourism, recreation, and research.

For those concerned with the effects of chemicals on wildlife, species have been used as indicators of ambient environmental conditions for many years; the canary in the coal mine is one of the most famous examples. In some cases, species can be used to indicate the biological effects of pollutants more accurately than predictions from chemical analyses. For example, the larvae of mayflies, caddisflies, stone flies, and true flies have been used to identify point sources of environmental hazards in streams and other wetlands. Earthworms, which pass large amounts of soil through their digestive tracts, are excellent indicators of ground pollution. Bees, whose body hairs electrostatically attract dust particles and collect pollutants linked with their food, water, and even air, have become an early warning system at nuclear power plants, weapons factories, testing laboratories, and solid waste dumps. Mussels, oysters, and fish are collected regularly as part of a National Status and Trends Program established by the National Oceanographic and Atmospheric Administration (NOAA) along the USA coastline.

Rivers are among the oldest and most used and abused natural features on Earth. The bedrock over which a stream flows will add different chemicals to the water as the water wears it down. Storm water runoff brings a variety of chemicals with it as it enters a river. Land use within the drainage area also impacts upon rivers. As people alter the landscape, they degrade river water. Further demands, such as water use for manufacturing and for removing the waste of municipalities and industry, have led to the degradation of water quality. To judge the health of a river, both the diversity of organisms and physical and chemical quality of the water should be measured. It is necessary that students be aware of biodiversity and the importance of biodiversity as an indicator. By sampling streams, we can understand the concept of indicator organisms and tolerance levels. The procedures are designed so that they can be done quickly and easily, and they provide a rapid means of sampling shallow areas in order to detect moderate to severe stream pollution. The organisms are classified into three groups based on their pollution tolerance. Each of the three groups is given an index value, with the least tolerant group having the highest value. The water quality value is the total of the resulting numbers. The higher the sum, the higher the water quality. The general abundance of each kind of organism is also noted, though it is not figured into the index.

<u>Terms</u>

biodiversity: the number of different varieties of life forms in a given area, or an index derived from this number

indicator organism: an organism whose presence or absence typically indicates or provides information on the certain conditions within its environment

nonpoint source pollution (NPS): pollution that cannot be traced to a single point (e.g., outlet or pipe) because it comes from many individual sources or a widespread area (typically, urban, rural, and agricultural runoff)

point source: known source of contamination

riffle: fast moving area in a stream. Usually the surface is broken by small waves or rocks; the slope of a stream bed is steeper in riffles than it is in open pools, where the water surface tends to be smoother.

## PROCEDURE

I. Setting the stage

   A. Before the field trip, review safety procedures for water activities.

   B. Hand out Student Sheets and have students study the taxonomic (taxa) groups.

   C. Divide students into teams.

II. Activity

Each team will:

A. Choose a one-meter square area representative of the riffle or shallow area being sampled.

1. Use a kick seine, screen, or net to collect samples to be placed in white basins or bowls.

2. Approach the sample sites from downstream to avoid disturbing the organisms at the sampling location.

B. Three samples will be taken to be sure representative samples are collected. Samples may also be taken from some other microhabitats at the site, such asrocks in slow moving water near banks, because different organisms may befound there.

C. Samples should be placed in pans for identification. If they are preserved, they should be put in alcohol containers.

D. Record on Student Sheet the presence of each TYPE of organism collected and classify it by its tolerance. (Use the Student Sheet: Macroinvertebrate Picture Key.) Estimate the number of each organism type and record on Student Sheet.

E. Calculate the stream index by multiplying the NUMBER of TYPES of organisms in each tolerance level by the index value for that level and add the resulting three numbers. DO NOT use the number of individuals.

1. Group 1- Pollution Intolerant (Index Value =3)

| | | | |
|---|---|---|---|
| 1. | Stonefly | 4. | Riffle Beetle |
| 2. | Caddisfly | 5. | Mayfly |
| 3 | Water Penny | 6. | Gilled Snail |
| | | 7. | Dobsonfly |

2. Group 2- Wide Range of Tolerance (Index Value =2)

| | | | |
|---|---|---|---|
| 8. | Crayfish | 13. | Damselfly |
| 9. | Sowbug | 14. | Watersnipe Fly larva |
| 10. | Scud | 15. | Crane Fly |
| 11. | Alderfly larva | 16. | Beetle larva |
| 12. | Fishfly larva | 17. | Dragonfly |
| | | 18. | Clam |

3. Group 3- Very Tolerant (Index Value =1)

| | | | |
|---|---|---|---|
| 19. | Aquatic worm | 22. | Leech |
| 20. | Midge Fly larva | 23. | Pouch Snail |
| 21. | Blackfly larva | 24. | Other Snails |

4. Cumulative Index Values:

| | |
|---|---|
| 23 and above | = Excellent Water Quality |
| 17 -22 | = Good Water Quality |
| 11 -16 | = Fair Water Quality |
| 10 or less | = Poor Water Quality |

III. Follow-up

A. Have each group graph the results of this activity with a bar graph using the total index number for each group.

B. When this is completed, the groups will meet together to compare graphs.

1. Make generalizations about their results.

2. Record results for the class and produce a composite graph.

C. Answer these questions.

1. What is the quality of this stream?

2. What are some possible reasons for the quality of this stream?

3. When examples of organisms that are sensitive to pollution are present, what might this indicate to you?

IV. Extensions

A. Test the stream for physical and chemical water quality parameters.

B. Have a professional consultant in the environmental field address the class.

C. Perform a literature search to find articles about biodiversity and water quality.

D. Go to a site that is known to be polluted by runoff and compare to the study site done for this activity.

## RESOURCES


"Citizen Stream Quality Monitoring Program," Ohio Department of Natural Resources.

Enger, Eldon D. and Bradley F. Smith, Environmental Science: A Study of Interrelationships, 5th Edition, Wm. C. Brown Publishers, Dubuque, IA, 1983.

"Save Our Streams" (The Izaak Walton League of America) - Pollution Tolerance Index.

TEAM MEMBERS ______________________________________________

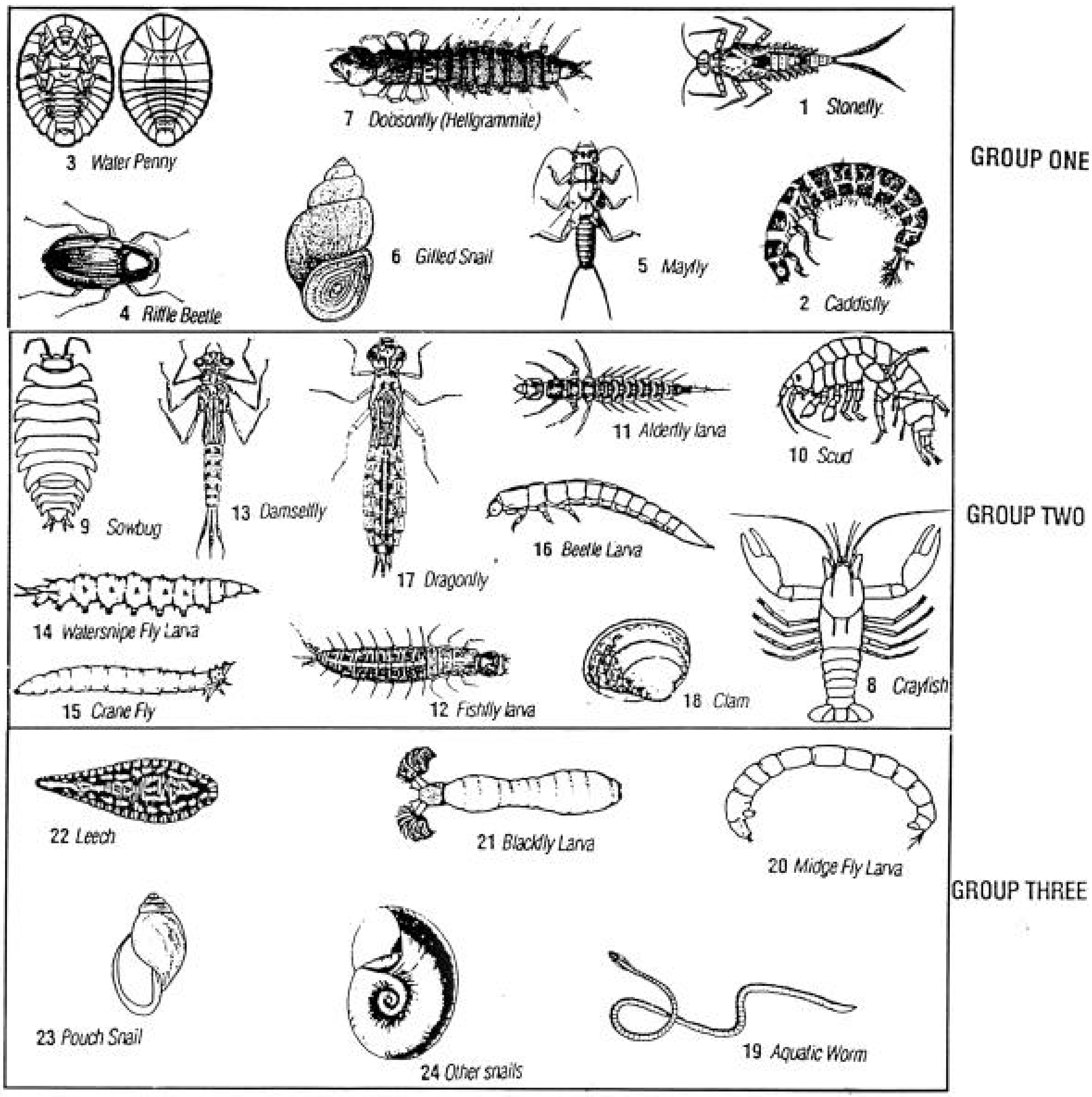
Data Record
# _____
Test Site (riffle)

1. Quantity and types of organisms present in Group 1 on key.

2. Quantity and types of organisms present in Group 2 on key.

3. Quantity and types of organisms present in Group 3 on key.

# MACROINVERTEBRATE PICTURE KEY



# FLOODS

## OBJECTIVES

The student will do the following:

1. Explain some causes of flooding.
2. Describe methods of flood control.
3. List some disadvantages of flood control methods.
4. Locate areas in danger of flooding.
5. Demonstrate use of topography maps.

**SUBJECTS:**
Science (Physical Science, Earth Science), Social Studies (History, Geography)

**TIME:**
2 class periods

**MATERIALS:**
large sheets of plastic (tarp or poly)
garden hose and water
sweater boxes (6)
PVC pipe, rain gutter, or ½" or ¾" poly tubing
dirt, clay, or sod
bricks
Legos ®, clay, or plaster

## BACKGROUND INFORMATION

Flooding is a natural phenomenon that occurs when a watershed receives so much water that the stream channel cannot contain the water, and the water overflows the stream banks. Causes may include excess rain, melting snow, human-made channels and diversions, overloaded storm sewers, or failures of dams or levees. Because many cities are located on or near rivers and streams to take advantage of transportation, fresh water, good soil, hydroelectric power, recreation, and aesthetic factors, floods can be expensive in terms of property damage and loss of life.

We can minimize flooding damages by not developing floodplains. Lakes, levees, and dams, have been constructed for the purpose of controlling floodwaters; however, often these "solutions" help one city and cause problems for another city downstream. They also usually cause changes in ecosystems.

Episodic flooding, such as the Johnstown floods in Pennsylvania (3 times), the Midwest Flood of 1993, and the Southeast Floods of 1994, are known to most Americans. Elsewhere in the world, seasonal flooding is a way of life. These annual floods carry in huge amounts of silt and topsoil that provide fertile ground for next year's crops. Rainfall and river monitoring systems can now alert forecasters to warn people in danger zones to take emergency action.

Terms

dam: man-made or animal-made barrier across a stream that holds and regulates flow of water

delta: a deposit of sand and soil, usually triangular, formed at the mouth of some rivers

dike: elevated structure alongside of stream that acts as a barrier to flood waters

diversions/channeling: altering the course of a river or stream causing the stream to change its direction

floodplain: relatively flat area on either side of a river that may be under water during a flood

levee: an embankment, natural or artificial, built alongside a river to limit high water events from flooding bordering land

man-made: made by humans; artificial or synthetic

natural: produced or existing in nature; not artificial or manufactured

watershed: land area from which water drains to a particular surface waterbody

## ADVANCE PREPARATION

A. Collect the following, if possible, and show to students.

   1. National Geographic Video - The Power of Water

   2. Pictures from the '93 Midwest flooding, Bangladesh Flood, and/or other recent major floods

B. Start keeping a current events file on flooding.

## PROCEDURE

I. Setting the stage

   A. Discuss flooding and the problems that cause it. Also discuss the benefits of flooding.

B. Ask students why there currently seems to be an increase in flooding and damage from flooding.

II. Activity

A. Have students work in groups to research and report on Johnstown floods, Midwest Flood, Bangladesh Flood, flooding of the Nile, and U.S. or other nation's flood insurance. Each group could take one topic and report to the class. Students should look into the problems as well as any benefits from these floods.

B. Ask students to look for and bring in articles about flooding.

C. Use a topographic map to locate areas in the community, state, and region in potential danger of flooding. A local meteorologist or geologist may be able to help answer these questions.

1. Have floods occurred?

2. When and how often have they occurred?

3. How damaging were they?

D. Use an atlas to locate areas subject to flooding worldwide; look for large cities on a river, coast, or delta.

E. Find out local, state, and federal regulations in the area applicable to building on a floodplain.

F. After one group has reported on federal flood insurance, discuss pros and cons of this insurance. Compare to the insurance practices of other nations, if desired.

G. In pairs or groups (preferably six), construct river models. Compare the capacity of a natural meandering stream to hold floodwaters versus the lack of flood-contaminant capacity of a straight channel. Use PVC pipe or rain gutter for the river; use dirt, clay, sod for the land; use bricks or plastic for nonporous surfaces; use Legos ®, clay, and/or plaster for levees. One end should be higher so the river will flow. Each box needs drainage at the low end.

With six groups:

1. Groups 1 and 2: same structure except one with dikes and levees along river's edge and the other without.

2. Groups 3 and 4: same structure except one with underdeveloped floodplain (dirt and grass or other vegetation); the other urbanized with asphalt and concrete (nonporous surfaces).

3. Groups 5 and 6: same structure except one with fairly even terrain; one with sloping terrain.

H. Pour an equal amount of water in high end of each one. Compare within pairs or groups and vary the amount and rate of inflow. Record observations.

I. One person from each group should demonstrate its river to members of the other groups. Each student should record observation and variables.

J. Discuss the different ways the water responded. Students may want to repeat some of the experiments.

K. Have students play the role of city or county planners and ask them how they would deal with development on floodplains. Ask them if and from where relief money to pay for flood damage during flooding will come.

III. Follow-up

A. Discuss what kind of measures are taken to prevent flooding.

B. How might some of these measures affect other urban and rural areas?

IV. Extensions

A. Contrast and compare being a flood victim in the USA and being one in Bangladesh. Write of personal losses, present (flooded) situation, and future.

B. Have students pretend they are buying a house on a floodplain. Compare the costs of buying and owning the house (include insurance costs) to the costs of buying and owning a house not located in a floodplain. A local real estate agent and/or insurance agent could help with estimates.

C. Have students discuss pros and cons of farming in a floodplain.

## RESOURCES

Cobb, Charles E. Jr., “Bangladesh: When the Water Comes,” National Geographic, June 1993, Vol. 183, No. 6, pp. 118-134.

Mairson, Alan, “The Great Flood of 93, " National Geographic, January 1994, Vol. 185, No.1, pp. 42-81.

National Geographic videotape “The Power of Water .”

Newton’s Apple, “Floods,” Public Broadcasting System, Television Show.

# BEST MANAGEMENT PRACTICES FOR FORESTRY

9-12

## OBJECTIVES

The student will do the following:

1. Identify which BMPs should be employed on a logging area.

2. Evaluate whether those BMPs are properly employed.

3. Measure in-stream water quality parameters to determine whether the logged area is affecting quality.

**SUBJECTS:**
Science (Physical Science, Ecology, Earth Science), Math, Social Studies (Geography), Language Arts

**TIME:**
2-3 class periods (possible field trip)

**MATERIALS:**
topographic maps (USGS) - use community
water test kit capable of analyzing for total suspended solids, pH, dissolved oxygen, and temperature
BMPs for forestry guidebook
forestry fact book if available

## BACKGROUND INFORMATION

Until early in the 20th century, the forests in the eastern U.S. were considered inexhaustible, and were typically logged and abandoned for conversion to other uses or allowed to reforest on their own. Timber was needed for railroads, mines, and housing construction that accompanied the population expansion south and west. Much of the deforested land was farmed or grazed.

Logging practices employed during this "cut and get out" period were often abusive to the soil and surface waters. Little was known about erosion, its efforts or its control. Today, however, forest land managers are sensitive to the need to protect the land during and after harvesting, and best management practices (BMPs) have been developed by each state to guide logging, road construction and other forestry activities so that the forests can continue to produce wood products while providing wildlife habitat and protecting stream water quality. The forest activities that are primary sources of pollution are logging roads, stream crossings, skid trails and log loading areas, as well as near-stream logging. Conducted improperly, these activities can cause sedimentation (from erosion) and other adverse impacts. Forestry BMPs are designed to prevent pollution from these activities, and are very effective if properly employed.

Two methods are most commonly used to evaluate whether water quality is being protected during a forestry operation. The first is an evaluation of whether BMPs are being or have been employed. The second is to measure in-stream indicators of pollution likely to be caused by forest practices. This activity includes both approaches.

Terms

best management practices (BMPs): techniques that are determined to be currently effective, practical means of preventing or reducing pollutants from point and nonpoint sources, in order to protect water quality. BMPs include, but are not limited to: structural and nonstructural controls, operation and maintenance procedures, and other practices. Usually, BMPs are applied as a system of practices rather than as a single practice.

contour: (1) imaginary line on the surface of the Earth connecting points of the same elevation; (2) a way of shaping the surface of the land in a particular form, commonly used to prevent erosion and control water flow.

erosion: the process of detachment, transport, and deposition of soil material

filter strip: area of land that infiltrates surface runoff and traps sediment and associated pollutants

log landing: site where logs are sorted and loaded onto trucks for hauling

reforestation: restocking of a forest stand through natural regeneration or artificially planted seed or seedlings

sediment: eroded soil material, containing primarily inorganic constituents

silviculture: care and cultivation of forest trees; forestry

site preparation: the use of machines, herbicides, fire, or combinations thereof to dispose of slash (unmerchantable debris), improve planting conditions, and provide initial control of competing vegetation

skid: to drag logs with specialized equipment to a landing slope: degree of deviation of a surface from the horizontal, measured in degrees

streamside management zone (SMZ): area left along streams to protect streams from sediment and other pollutants, protect streambeds, and provide shade and woody debris for aquatic organisms

suspended solids: small particles of solid materials in water that cause cloudiness or turbidity

USGS: United States Geological Survey

water bar: a long mound of dirt constructed across the slope to prevent soil erosion and water pollution by diverting drainage from a road or skid trail into a filter strip

waters of the state: includes every natural or artificial watercourse, stream, river, wetland, pond, lake, coastal, and ground or surface water wholly or partially in the state, that is not entirely confined and retained on the property of a single landowner

## ADVANCE PREPARATION

The objective of this activity is to introduce the student to forestry BMPs, how they should be prescribed and evaluated, and how some water quality indicators may be affected by logging practices.

Locate several logging sites in the local area, preferably adjacent to streams. Sites can be in the process of being harvested prior to construction activities (land clearing), but a "true" forestry activity is preferable. A site above and below the logging area along the stream should be identified. If there is no stream below the logging area, parts of this activity can still be done. Students should be made aware of good conservation practices.

## PROCEDURE

I. Setting the stage

A. Put terms on the board and define. Discuss.

B. Discuss problems that can be caused by erosion and sedimentation from an improperly logged area or poorly designed or constructed roads.

C. Using the state silviculture BMP manual, identify the BMPs that should be followed on the logged area.

II. Activity

A. Determine whether the BMPs that should have been followed were in fact followed.

B. Observe the stream channel above and below the logged area.

1. Evaluate whether eroding soil is reaching the stream channel.

2. If the stream is flowing, and preferably after a storm, test for suspended solids and temperature.

3. Additional parameters such as pH and DO may be tested. However, these are less likely to change as a result of logging.

4. Testing water on-site for various parameters is preferred, but students may collect samples to test for suspended solids. Temperature should always be taken in the field, not in the laboratory.

C. Data sheets created by students should include information about the logging operations/roads, approximate acreage, BMPs, stream conditions, watershed information, SMZs, forest roads, and other BMPs observed.

D. Students should use data collected to compare operations. Comparisons can be made by group discussion, essay, graphic display, or a combination of these. (A forestry professional can be invited to the class to answer questions about the silvicultural practices.)

E. Have students document any obvious situation that may need attention and use the information to speak to that state forestry agency representative.

III. Follow-up

A. Ask students to think of other ways that erosion from silvicultural practices could be controlled.

B. Have students determine if any of these BMPs could help prevent soil erosion from other practices (construction, farming, ranching, and other unpaved roads).

C. Illustrate two hypothetical forestry operations, one with good sediment control and one with poor control, and have students identify the specific good and bad practices.

IV. Extensions

Invite a forestry professional to talk to the class about local or state forestry practices and to discuss forestry issues.

## RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison- Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Englewood Cliffs, NJ, Prentice-Hall, Menlo Park, CA, 1993.

See pages L-1 to L-6 for State Forestry Offices

# SIMPLE TEST-MICROBIAL CONTAMINATION

9-12

## OBJECTIVE

The student will do the following:

1. Explain the existence, growth, and possible effects of bacteria in drinking water.

**SUBJECTS:**
Science (Ecology, Biology), Health

**TIME:**
2 class periods

**MATERIALS:**
(for each group)
10 ml of three water samples
gelatin (light color, like lemon)
cotton swabs
petri dish with lid for each student group, sterile
tripo magnifier, AGFA lenses, or hand lenses
permanent marker

## BACKGROUND INFORMATION

The water we drink is not always as clean as it appears to be. Water in streams, rivers, lakes, and ponds has pollutants dissolved or suspended in it. Also, there are many naturally occurring microorganisms living in waterbodies. Some of these microorganisms (e.g., some of the bacteria and viruses), are disease-causing. Some of the waterborne diseases they cause are dysentery, typhoid fever, and infectious hepatitis. Therefore, it is most often not safe to drink water from streams or rivers without testing and/or purification. There are simple tests that check for certain types of bacteria in water.

Terms

bacteria: typically one-celled, non-photosynthetic microorganisms that multiply by simple division. They occur in three main forms: spherical (cocci), rod-shaped (bacilli), andspiral (spirilla).

contaminant: an impurity that causes air, soil, or water to be harmful to human health or the environment; something that makes a substance impure, infected, corrupted, or polluted

microorganisms: microscopic or ultramicroscopic organisms (e.g., bacteria, protozoa, viruses) protozoa: mostly microscopic animals made up of a single cell or a group of more or less identical cells. Protozoa live chiefly in water, but many are parasitic.

virus: any of a group of ultramicroscopic or submicroscopic infectious agents that cause various diseases in animals, such as measles and mumps, or in plants, such as mosaic disease. Viruses are capable of multiplying only in connection with living cells.

## ADVANCE PREPARATION

A. Prepare gelatin according to directions and pour approximately two tablespoons into each petri dish. Cover with the lids. Let cool overnight.

B. Collect water samples from three sources. (One may be tap water. Others may be from local ponds, rivers, streams, drainage ditches.)

## PROCEDURE

I. Setting the stage

A. Discuss Background Information with students.

B. Define terms and discuss what students know about these organisms.

II. Activity

A. Have students divide petri dish into four equal sections using a marker on the outside bottom part of the dish. (Be sure they keep the lids on.) Then dip a cotton swab in a sample of water, rub the cotton swab over gelatin in one marked section of the petri dish, and cover it with the lid. Repeat with the other two samples using a clean cotton swab each time and making sure that a new section is used each time. Do not allow water to run from one section to another. Incubate upside down at room temperature.

B. At the next class period, ask students to observe the three areas for colony growth. These will appear as circular spots on the gelatin. (The fourth section is a control.)

C. Have students discuss the rate of growth of the colonies. Explain that the dish was incubated naturally at atmospheric temperature during which time each single bacterium on the gelatin multiplied to form a colony visible to the naked eye. Was there any growth in the control section? Why or why not?

D. Ask students where they think each bacterial colony originated (from water, air, cotton swab). Have them support their answers.

III. Follow-up

Ask students:

A. Are all water pollutants visible?

B. What are some possible sources of bacterial pollutants?

C. How can bacteria be removed by a water treatment plant?

D. Did this experiment test for all types of water pollutants? (No; not chemicals, viruses, protozoa.)

E. Are all bacteria harmful? What kinds of tests would need to be done to determine the harmful from the harmless bacteria?

IV. Extensions

A. Conduct a similar type of experiment to monitor for sewage contamination. Collect samples upstream and downstream from a wastewater effluent site or near an area where livestock is raised. (Caution - Use latex gloves for collection.)

B. Have students conduct research to find other types of laboratory methods to monitor bacterial contamination of water.

C. Have students research different diseases caused by waterborne microorganisms and discuss why many of these diseases are not as prevalent today as they once were.

D. Have students research various waterborne pathogens which are difficult to measure, control, or regulate, and which still pose serious threats to water quality. (Some examples are *Cryptosporidium parvum, Giardia lamblia*, *Schistosoma*, etc.) Learn about current regulations (state or federal) designed to test for and protect against such contaminants.

E.. Have students examine various microbes with a microscope for possible identification of type.

## RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D. , Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

# POLLUTANTS: HOW MUCH TOTAL OR HOW MUCH PER UNIT OF WATER?

9-12

## OBJECTIVES

The student will do the following:

1. Define the concept of concentration as different from an expression of total amount.

2. Explain that chemicals may be present in water or wastewater in concentrations so low that they are undetected.

3. Demonstrate changing concentrations through a serial dilution.

4. Distinguish between loading and concentration as these terms apply to wastewater effluents discharged into a receiving stream.

5. Calculate concentration and loading.

**SUBJECTS:**
Math, Science (Chemistry)

**TIME:**
1 class period

**MATERIALS:**
red food coloring
toothpicks
2 medicine droppers, 1 for color, 1 for water
beaker or jar of water
1 bottle that will hold 10 ml
one 2-liter soda bottle
10 ml pipette
1 liter graduated cylinder
white foam egg cartons
spectrophotometer if available (to measure dilution)

## BACKGROUND INFORMATION

Often, consumers must think not only in terms of the total amounts, but also in terms of "unit per unit" measurements. An example of this is unit pricing, where product costs for groceries are expressed in terms of total cost and cost per unit weight (e.g., cost per ounce or cost per gram). This same "unit per unit" i.e., units of pollutant per unit of water, concept is applied to water and wastewater quality measurements.

Water is called the "universal solvent," since many common substances are easily dissolved in water. Other substances, such as suspended solids do not dissolve in water, but are often present in water or wastewater discharges (effluent). Pollutants which are either dissolved or suspended in water are often measured or expressed in terms of "concentration," typically milligrams per liter (mg/l) or micrograms per liter (µg/l). However, pollutants in wastewater effluents are often required, through permit conditions, to be measured in terms of "loadings" as well as concentration. Loadings are simply the total amounts (mass) of a pollutant as measured on a daily (or some other time interval) basis, such as pounds per day (lb/day) or kilograms per day (kg/day). Wastewater pollutant concentrations are also typically expressed in mg/l (parts per million, ppm) or µg/l (parts per billion, ppb).

The flow of rivers or streams can play a major role in determining the effects of a pollutant on them. This is because stream flow (also called stream velocity) is defined as the volume of water flowing over a point per time interval, which can be expressed as $m^3$/s or cubic feet per second (cfs). Therefore, if the average flow of a river is 14 $m^3$/s, the volume of water flowing at any one "point" of the river in one second is 14 $m^3$. And if a different river had twice the average flow, 28 $m^3$/s, the volume of water flowing at any one "point" of this river in one second is 28 $m^3$. Now, if two pollutant samples of an equal amount (mass) are discharged in the two rivers described above, what would happen to the concentration of the pollutant in the two rivers? In simple terms, the river with the higher flow would have a lower concentration of pollutant, but by how much? Since concentration is a unit of mass per unit of volume, if the amount of pollutant stays the same and the flow doubles, then the concentration will be reduced by one-half. The following equations demonstrate this numerically:

| *River I* | *or* | *River II* |
|---|---|---|
| $\frac{500mg}{14m^3}$ | | $\frac{500mg}{28m^3}$ |
| $35.71\ \frac{mg}{m^3}$ | | $17.86\ \frac{mg}{m^3}$ |
| $0.03571\ \frac{mg}{l}$ | | $0.01786\ \frac{mg}{l}$ |

## ADVANCE PREPARATION

Set up lab stations with the listed materials for students to work in groups.

## PROCEDURE

I. Setting the stage

A. Explain to students that they will be modeling a very common lab procedure called a serial dilution in Activity 1 that is widely used in medical and bacteria- logical labs as well as water quality labs. In water quality labs, it is most commonly used to dilute water samples for coliform bacteria determinations. If students are familiar with growing bacteria in petri dishes, ask them what happens when there are too many bacteria added to the dish. (They grow all over the place, and it becomes difficult to count each colony.) The ideal is to have separate colonies such that each represents a single original cell.

B. Explain to students the material in the background and be sure that they understand about discharges into a receiving stream in high and low flow conditions.

C. Warn students about keeping droppers separate for food coloring and water.

II. Activity

A. Serial dilution:

1. Place 10 drops of red food coloring into the first egg carton well. Food coloring as it comes from the bottle is already a 1:10 dilution.

2. Use a clean dropper to add 9 drops of clean water to well #2, then take 1 drop of well #1 and add to well #2. Mix with toothpick before taking from Well #1 and adding to Well #2. Caution: Be sure that the medicine dropper that is used for the color is cleaned between each use. If not, the dilutions will be incorrect.

3. Again add 9 drops of water to well #3, then 1 drop of well #2 to well #3. Mix.

4. Repeat until there are 10 wells with liquid.

5. The food coloring in well #1 is 1 part color per 10 parts liquid. What is the concentration in well #2? Make a chart that shows each dilution all the way to well #10.

Example

| Well # | Calculation | Expression of dilution |
|---|---|---|
| 1 | 1/10 | 1 part per 10 |
| 2 | 1/10 x 1/10 | 1 part per 100 |
| 3 | 1/100 x 1/10 | 1 part per 1000 |
| 4 | 1/1000 x 1/10 | 1 part per 10,000 |
| 5 | 1/10,000 x 1/10 | 1 part per 100,000 |
| 6 | 1/100,000 x 1/10 | 1 part per 1,000,000 |
| 7 | 1/1,000,000 x 1/10 | 1 part per 10,000,000 |
| 8 | | |
| 9 | | |
| 10 | | |

6. At which concentration did the color disappear? Do you think there were any parts of the red coloring in well #10? Explain.

7. What would remain in the wells if all the water were removed? Allow the water to evaporate and observe.

B. Difference between loading and concentration:

1. Fill the small bottle with 10 ml of water and add 1 drop of red food coloring. If one drop were to equal 0.01 mg of pollutant, express the resulting concentration in mg/liter. How much total pollutant in mg do you have?

2. Now add the whole 10 ml bottle to the 2-liter bottle. How many total mg of pollutant do you have? Express the concentration in mg/liter.

III. Follow-up

A. To explain further how small 1 ppm or 1 ppb is, give students the following examples.

1. Distance to the sun = 93 million miles. If you drive 93 miles, that is 1 ppm.

2. Distance to the moon = 239,000 miles = 1.26 billion ft. If you move 1.26 ft., that is 1 ppb.

B. Ask students to write other examples.

C. Give students the pollutant concentration amounts in Extension A. Ask students if they feel these regulations are strict enough and if they think that keeping pollutants at such a low level is cost effective. Discuss. (The instructor may want to have students complete Extension A before the discussion.)

IV. Extensions

A. The maximum contaminant levels of some pollutants in drinking water (as of 1996) are given below. Ask students to do reports on these substances and explain why they are considered to be so toxic. Students should research health effects of each substance.

| | |
|---|---|
| arsenic | 50 ppb |
| cadmium | 5 ppb |
| mercury | 2 ppb |
| endrin | 2 ppb |
| lindane | 0.2 ppb |
| 2,4-D herbicide | 70 ppb |

B. Ask students to discuss the differences between release of the toxic pollutants listed above and discharge of wastewater from treatment plants that contain ammonia, nitrates, phosphate, or BOD. (The former are either not able to be broken down or have a long life in nature; the latter, except BOD, are very biodegradable in a short period of time and typically break down into simple non-toxic compounds.)

## RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works,4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Seuss, Dr., The Lorax, Random House, New York, 1971. (Also available on video)

# ETHICAL DILEMMAS WHAT'S A BODY TO DO?

9-12

**SUBJECTS:**
Social Studies (Economics), Science (Environmental Science), Language Arts

**TIME:**
1 class period

**MATERIALS:**
pen/marker
index cards
teacher sheet

## OBJECTIVE

The student will do the following:

1. Distinguish between decisions based on ambitions and dreams versus environmental ethics surrounding water.

## BACKGROUND INFORMATION

In the course of daily living, one makes many decisions. Some of those decisions will alter a life's course, and others may provide temporary comfort or discomfort. The school environment gives students the opportunity to experience and practice the decision-making process, make mistakes, and learn from the decisions and the consequences. Such is the aim of this activity. The problems deal with the conservation and protection of a valuable resource - water.

Terms

con: against; in opposition; negative consideration

ethics: the study of the general nature of values and of the specific moral choices to be made by the individual in relationships with others and his/her environment

pro: for; in support of; affirmative consideration

## ADVANCE PREPARATION

Because of the nature of this activity, advance preparation is not necessary. However, if the teacher wishes, the questions may be written on index cards. This activity can be used at the end of a class or just after an assembly when there is not time for a planned lesson. It is also feasible to spend many hours of research for fact-based decisions.

## PROCEDURE

I. Setting the stage

A. Students should be made aware that the decisions they make affect all aspects of their environment.

B. The responsibility of stewardship of the Earth is great and needs to be taken seriously.

C. Students, as adults, should approach problems with open minds and willingness to accept responsibility for their actions.

II. Activity

A. Have students form groups for a discussion-type setting.

B. Distribute paper, pens, and index cards with scenarios. (See Teacher Sheet.)

C. Instruct the students to make two lists entitled "pros" and "cons" before they make their decision.

D. Have students read or watch The Lorax by Dr. Seuss.

III. Follow-up

After a predetermined amount of time, have the groups share their decisions.

IV. Extensions

A. Require this activity as a research paper.

B. Treat the problems as debate issues.

C. Have students go to their school library and develop a bibliography of environmental writings.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Seuss, Dr., The Lorax, Random House, New York, 1971. (also available on video)

Suggested Scenarios:

1. A paper company builds a new mill in your area. You take a job at the plant. Later, you learn that the plant is responsible for the destruction of the woods where you hunt. The plant's water effluent is polluting the local river with dioxin and other toxic chemicals. How would you react to this?

2. Would you raise cows near the stream from which your drinking water is pumped? It is the best grazing land, and you can get the fastest growth (that means the most money).

3. There are plans for a water park near your neighborhood. It is predicted that 500,000 people would visit this park during the summer. Your town is very small and depends on the river for water and electricity. The water park will use a tremendous amount of water from the river and it will allow people to camp overnight along the river. Your town needs more jobs and income. How would you vote on this issue in an election?

4. Make up additional scenarios or write up a few actual cases.

# WHAT ARE FECAL COLIFORMS AND HOW ARE THEY RELATED TO WATER QUALITY?

9-12

## OBJECTIVES

The student will do the following:

1. Describe indicator organism.

2. Describe fecal coliforms.

3. Explain how fecal coliforms are indicative of water quality.

4. Demonstrate a test conducted to measure coliforms.

5. Describe sources of water contamination.

**SUBJECTS:**
Science (Biology, Environmental Science), Health

**TIME:**
2 class periods

**MATERIALS:**
Hach m-Coli Blue 24 broth or Coliform testing kit
membrane filtration equipment
filters
petri dishes (15mm)
gloves
tweezers
water samples in bottles
incubator

## BACKGROUND INFORMATION

Many concerns regarding water quality have been related to the transmission of disease. Throughout history many diseases have been waterborne. Cholera, typhoid fever, and dysentery are examples of waterborne diseases that have plagued humans until the advent of modern technology for the effective treatment of wastewater and drinking water. The following are examples of diseases that could be contracted from contaminated water, the organisms that cause them, and the association related to drinking water or other sources.

| *Diseases* | *Organisms* | *Associated With* |
|---|---|---|
| Microencephalitis | *Naegleria fowleri* | Fecal coliform bacteria (Fecals) |
| Typhoid fever | *Salmonella typhi* | Contaminated water |
| Cholera | *Vibrio cholerae* | Contaminated water |
| Dysentery (gastroenteritis) | *Staphylococcus aureus* | Fecals in drinking water |
| Amoebic dysentery | *Entamoeba histolytica* | Fecals in drinking water |
| Bacillary dysentery | *Shigella* | Fecals in drinking water |
| Lung fluke | *Paragonimus westermanni* | Contaminated fish |
| Schistosomiasis | *Schistosoma* | Contaminated water |

Historically, tests have been developed to measure the quality of our water and foods. By testing ambient conditions of waters for specific organisms, *indicator organisms*, water quality managers monitor the safety of the waters for their specific uses such as drinking water supply, swimming, or fish and wildlife uses. The primary characteristic for indicator organisms is that they are consistently present in human wastes in substantial numbers. The detection of these organisms in the water is a good indicator that fecal wastes are entering the water. The indicator organisms should also survive in water at least as well as other pathogenic organisms would survive. Testing for these organisms is fairly simple. People with technical training, such as operators of water treatment plants in small communities, do much of the testing.

In the U.S., the commonly used indicator organisms are the coliform bacteria. Coliforms are defined as aerobic or facultative anaerobic, gram-negative, non-endospore-forming, rod-shaped bacteria that ferment lactose to form gas within 48 hours of being placed in a growth medium at 35ºC. Coliform bacteria are commensal and are common in the intestines of warm- and cold-blooded animals. They aid in food digestion. When animals defecate, the coliform and pathogenic microbes, if present, pass out of their bodies with the wastes. If these wastes find their way into a water supply, they bring bacteria and other microbes with them. Large numbers of coliform organisms indicate the possible presence of pathogens.

The fecal coliform bacteria test is easy to do but requires a precise incubation temperature of 44.5ºC, not varying more than 0.2ºC either way.

Fecal coliform population standards for drinking water are the same for all states and are required by the EPA. Standards for swimmers and other recreational uses are set by the states and approximate the water quality criteria given below, with some variability by state.

| | | |
|---|---|---|
| Swimming Pools | | 1 fecal coliform/100ml |
| Non-coastal Swimming Beaches | | 200 fecal coliforms/100ml |
| Incidental/Recreational (not swimming) | | 2000 fecal coliforms/100 ml |
| Coastal Swimming Beaches | | standards same as Incidental/Recreational |
| Fish and Wildlife | -June-September | 1,000 fecal coliforms/100ml |
| | -October-May | 2,000 fecal coliforms/100ml |

For water that is to be used as a drinking water source, the Safe Drinking Water Act does not specify a maximum fecal or total coliform level prior to treatment. However, water that is to be used for drinking purposes must be sampled for total coliform bacteria, on a schedule based on the water system's user population. No more than five percent of these samples may contain any type of coliform.

<u>Terms</u>

aerobic: with oxygen; needing oxygen for cellular respiration

anaerobic: in the absence of oxygen; able to live and grow where there is no air or free oxygen, as certain bacteria

aseptic: free or protected from disease-producing or putrefying microorganisms

commensal relationship: a relationship between two organisms in which one is benefited by the relationship and the other is neither benefited nor harmed

facultative anaerobic: describes an organism that can use another electron accepting moecules other than oxygen for cellular respiration, if oxygen is not present

ferment: to break down sugars only partially, producing a gas (usually $CO_2$) and alcohol

gram negative: the result of a certain laboratory test done on microorganisms to divide them into two groups (either gram negative or gram positive). Gram negative bacteria have a cell membrane composed of lipopolysaccharide and protein.

incubation: the phase of development of a disease between the infection and the first appearance of symptoms

indicator organism: an organism whose presence or absence typically indicates or provides information on the certain conditions within its environment lactose: a type of simple sugar that can be digested by fecal coliform bacteria

nonendospore-forming: does not form an encapsulated nucleus resistant to most harsh environmental conditions

nonpoint source pollution (NPS): pollution that cannot be traced to a single point (e.g., outlet or pipe because it comes from many individual sources or a widespread area (typically, rural, urban, and agricultural runoff)

pathogens: disease causing agents, especially disease-causing microorganisms

pathogenic: producing disease

point source pollution: pollution that can be traced to a single point source such as a pipe or culvert (e.g., industrial, wastewater treatment plant, and certain storm water discharges)

rod-shaped bacteria: a physical form of bacteria. These are longer than they are wide; cylindrical

## ADVANCE PREPARATION

A. Order Hach m-ColiBlue 24 broth or a Coliform testing kit.

B. Set up membrane filtration equipment. Instructions will come with the supplies.

C. Run off Student Sheet.

D. Collect or have students collect water samples from the tap, bottled water, or surface water (local river, stream, wetland, lake, pond, reservoir, or ocean). Use clean bottles with lids to collect.

## PROCEDURE

I. Setting the stage

A. List and define terms on the board.

B. Discuss Background Information.

C. Review aseptic technique with students.

II. Activity

A. Have students write a hypothesis about what they think the results of the fecal coliform testing will be and write a brief paragraph about why they made specific predictions.

(If using a coliform testing kit, follow the directions for procedure. Otherwise follow the directions below.)

B. Filter 100ml of each sample using a small filter. Clean all equipment before starting and between each sample.

C. Use tweezers to remove the filter paper and place in a sterile petri dish.

D. Break open an ampule of the m-ColiBlue 24 broth and pour over the filter paper. Label each dish.

E. Incubate at 44.5ºC for 24 hours.

F. Examine for growth at the end of 24 hours. Total coliform counts can be attained by counting both the red colonies and the blue colonies. For E. Coli counts, count only the blue colonies.

G. Record data on Student Sheet.

III. Follow-up

A. Have students write a statement accepting or rejecting their hypotheses. Explain why the test turned out like it did.

B. Have students list some possible sources of coliform contamination in the samples that were positive.

C. Discuss how these contaminants affect the cost of purifying drinking water. Ask students for ideas on how to prevent contamination.

IV. Extensions

A. Students could research the different pathogenic microorganisms found in water. Each student could report on one disease.

B. Discuss nonpoint source pollution and problems this can cause.

## RESOURCES

High school biology book or high school environmental science book.

Jacobson, Cliff, Water, Water Everywhere, (Student Reading Unit About Water Quality), Hach Company, Loveland, CO, Catalog Number 21975-00. 1-800-227-HACH.

Water Analysis Kit, page F-69, Water Testing Fact Sheet

## Data Sheet

List each water sample source below and record number of colonies beside each one.

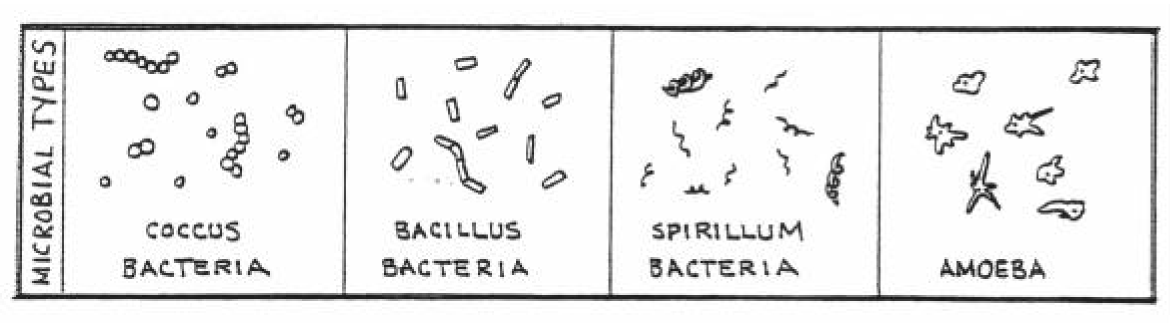
1.

2.

3.

4.

5.


MICROBIAL TYPES
COCCUS BACTERIA
BACILLUS BACTERIA
SPIRILLUM BACTERIA
AMOEBA

9-12

# TURBIDITY

## OBJECTIVES

The student will do the following:

1. Define turbidity.
2. Describe the effects of turbidity on aquatic ecosystems.
3. Measure turbidity levels.
4. Compute average turbidity.

**SUBJECTS:**
Science (Environmental Science, Ecology, Earth Science, Chemistry)

**TIME:**
1 class period

**MATERIALS:**
white gallon milk containers
black markers
rulers
scissors
large petri dishes
Secchi disc
meter sticks
stapler
ball of string marked in 1cm units
4-5 light-colored small buckets
dirt
water
100 mL beakers

## BACKGROUND INFORMATION

Turbidity is defined by the American Public Health Association as the "optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample." In other words, "How cloudy is the water?"

The amount of suspended material present determines the ability of light to pass through water. Turbidity may be caused by large amounts of silt, microorganisms, plant fibers, sawdust, wood ashes, chemicals, coal dust, and plankton. Soil erosion from agriculture, mining, logging, dirt roads, construction, and dredging operations contribute to the silt problem.

The most accurate way to determine water's turbidity is with an electronic turbidimeter. The turbidimeter is a photoelectric cell that accurately measures the light scattered by suspended particles in a water sample. The results are reported in units called Nephelometric Turbidity Units or NTUs.

Turbidity can also be measured by filtering a water sample and comparing the filter's color to a standard turbidity color chart or by a device called a Secchi disc that determines turbidity from a sample's clarity.

Turbidity affects fish and aquatic life by:

1. Interfering with sunlight penetration that, in turn, results in lower oxygen concentrations and large carbon dioxide concentrations.

2. Clogging the gills of fish and shellfish and killing them directly.

3. Providing a place for harmful microorganisms to grow.

4. Reducing the visibility for certain fish to find food but, on the other hand, helping protect some from predators.

The table below shows the amount of fish and plankton per acre that may be expected in ponds of different turbidities.

| FACTOR MEASURED | CLEAR PONDS | INTERMEDIATE PONDS | MUDDY PONDS |
|---|---|---|---|
| Average turbidity units: | Less than 25 | 25-100 | over 100 |
| Amount of fish in ponds per acre: | 162 | 94 | 29 |
| Comparative amount of plankton: | 12.8 | 1.6 | 1 |

Terms

plankton: microscopic plants and animals in water which are influenced in mobility by the movement of water (i.e., as opposed to nekton (fish) which can swim)

Secchi disc: a black and white circular plate that is used to determine water clarity

turbidity: the cloudy or muddy appearance of a naturally clear liquid caused by the suspension of particulate matter

## ADVANCE PREPARATION

A. Discuss the use of Secchi disc with students. These discs are lowered into a pond or lake with a rope that has measurement markings on it. The disc is lowered to a point where it is no longer visible and then raised up through the water until it becomes visible. The depth ofvisibility is measured and compared to a chart. The depth of visibility is determined by the degree of turbidity in the body of water.

B. Prepare 4-5 buckets of turbid water using tap water and local soil in various ratios. Mark the ratios on the buckets. Try the Secchi disc experiment on each bucket to make sure that some have no visibility.

C. Prepare a chart on the board for data from each group.

## PROCEDURE

I. Setting the stage

A. Use the atmosphere and its particulate matter as an example to initiate discussion of turbidity.

B. Have students name/list particles in the air; then list particles in the water. Discuss similarities.

C. Discuss Background Information with students and review vocabulary.

II. Activity

A. Have the students work in 4-5 groups. Number the groups for chalkboard recording purposes.

B. Each group needs 1 white gallon milk container, black permanent marker, ruler, large petri dish, scissors.

C. Cut out one complete side of the milk jug and place it under the lid of the petri dish and draw a circle. Cut it out. Use the ruler to divide and mark the circle in quarters. Color 2 opposite quarters black. This will resemble a small Secchi disc that is used to measure the clarity of water. Attach a string ½ meter in length to the middle of the disc with a stapler and mark the string every centimeter.

D. Have students stir each turbidity bucket and then immediately lower the Secchi disc into the bucket.

E. The disc should be lowered until it is no longer visible.

F. Have one student record the distance from disc to water surface using the meter stick or by the centimeter marks on the string. Record data on Data Sheet.

G. Each group should repeat steps for each bucket and record data on Data Sheets and on the board.

H. Obtain measurements from the other groups that were recorded on the board and calculate an average for each sample. Record the values on the Data Sheet. The smaller the measurement, the greater the turbidity.

I. Have students compare the turbidity of a local river or stream during fair weather conditions and immediately after a storm. Ask how could one help prevent increase of turbidity resulting from farming or logging.

III. Follow-up

Have students bring in various water samples and align them by a visual observation in order of turbidity. Place each on the sheet of white paper and label the source of each. Discuss what caused turbidity in each sample by discussing the factors surrounding the body of water from which it was taken.

IV. Extensions

A. Try Secchi disc measurements on a field trip to various bodies of water.

B. Have a field biologist, hydrologist, or water quality expert discuss problems and sources of water turbidity. They may demonstrate various ways of measuring turbidity.

C. Demonstrate the removal of sediment by mixing in alum. This is done by water treatment plants.

## RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Cunningham, William P. and Barbara Woodworth Saigo, Environmental Science: A Global Concern, Wm. C. Brown Publishers, Dubuque, IA, 1997.

Enger, Eldon D. and Bradley F. Smith, Environmental Science: A Study of Interrelationships, 5th Edition, Wm. C. Brown Publishers, Dubuque, IA, 1983.

Jacobson, Cliff, "Water, Water Everywhere," (Student Reading Unit About Water Quality), Hach Company, Loveland, CO, Catalog Number 21975-00. 1-800-227-HACH.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

# TURBIDITY DATA SHEET

| GROUP: | SAMPLES: #1 | #2 | #3 | #4 | #5 |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| AVERAGE: | | | | | |

# CLEAN CLOTHES - CLEAN ENVIRONMENT? 9-12 PHOSPHATES

## OBJECTIVES

The student will do the following:

1. Develop a survey form.

2. Collect data on consumer use and knowledge.

3. Design graphs using collected data.

**SUBJECTS:**
Science (Chemistry, Biology), Math, Social Studies (Economics)

**TIME:**
2 class periods

**MATERIALS:**
paper
pencil/pen
computer (optional to organize data)
labels from detergent products
examples of various detergents
dish and laundry survey form for consumers (student developed)
data collection table (student developed)
water or phosphate analysis kit (if water survey is desired)

## BACKGROUND INFORMATION

Phosphate is a nutrient necessary for plant and animal growth. Almost all fertilizers contain phosphates. When it rains, varying amounts of phosphates wash from golf courses, sod farms, and farm soils into nearby waterways. Phosphates stimulate the growth of plankton and water plants that provide food for fish. This may increase the fish population and improve the waterway's quality of life. When too much phosphate is present, algae and water weeds grow wildly and choke the waterway, using up the large amounts of oxygen and causing many aquatic organisms to die.

The phosphate cycle is said to be "imperfect" because not all phosphates are recycled. Some simply drain into lakes and oceans and become lost in sediments. Phosphate loss is not serious because new phosphates continually enter the environment from other sources.

Phosphates are used in fertilizers, pesticides, industry, and cleaning compounds. Natural sources of phosphates are phosphate-containing rocks and solid or liquid wastes. Phosphates enter waterways through human and animal wastes (the human body releases about a pound of phosphates per year - or billions of pounds per year from the world's population), phosphate-rich rocks, wastes from laundries, cleaning and industrial processes, and use of farm fertilizers and pesticides. Phosphates also are used widely in power plant boilers to prevent corrosion and the formation of scale.

Phosphates will not hurt people or animals directly unless they are present in very high concentrations. Even then, they will probably do little more than interfere with digestion. It is doubtful that humans or animals will encounter enough phosphate in natural waters to cause any health problem.

Total phosphate consists of organic and inorganic phosphates. The organic phosphate is formed in living or dead plant and animal tissue. Organic phosphates are important in nature and also may result from the breakdown of organic pesticides containing phosphates. Inorganic phosphate is found in soil, water, and human-produced materials (detergents). Other forms of phosphate are produced by natural processes and are found in wastewater. Poly forms are used for treating boiler water and in detergents and can break down into simpler forms in water.

A certain amount of phosphate released into a stream or river is immediately taken up by algae and plants. Too much phosphate results in excessive growth of plants and causes algal blooms. When plants die, bacteria and other microbes increase in order to break down the organic material. These microorganisms consume available oxygen that, in turn, results in the death of larger aerobic organisms such as fish. This process is called eutrophication. If eutrophication continues, the aquatic system becomes anaerobic, which gives off the rotten egg odor produced by hydrogen sulfide gases. Eutrophication occurs naturally at a very slow pace. Human interference can speed the process by introducing improperly treated sewage, industrial waste, or runoff from feed lots and farmland into receiving waters..

This activity concentrates on the phosphates in detergents. In recent years, some detergents have added to their advertising claims comments such as, "Contains no phosphates" or "Low in phosphates." What are these phosphates, and what is all the fuss about? If they are so bad, then why have they been used in detergents? If they are or were in detergents, then how can they lead to water pollution? Compounds containing phosphate ions are usually associated with the need for high energy substances such as detergents and fertilizers. Phosphates have been used to improve the cleaning power and sudsing ability of detergents. We have culturally associated "lots of suds" with ability to clean, but this is not necessarily true. Now the makers of detergents are trying to sell their product based on their low or lack of phosphate content.

This activity will allow students to research the sources of these phosphates, survey consumer knowledge, and evaluate the impact on our waterways.

Terms

algal bloom: a sudden increase in the amount of algae, usually causing large, floating masses to form. Algal blooms can affect water quality by lowering DO content and decreasing sunlight penetration, are usually caused by excessive nutrient addition, and can be characteristic of a eutrophic lake.

eutrophication: the process in which a body of water becomes oxygen deficient, nutrient-rich, and supports an abundant growth of surface aquatic plants and algae; natural aging cycle of lakes, normally taking centuries, but it can be rapidly accelerated when outside sources of nutrients are added, such as wastewater, fertilizer, or feed lot runoff.

phosphate: an ion composed of a phosphorus atom with 4 oxygen atoms attached ($PO_4^{-3}$). It is an important plant nutrient.

## ADVANCE PREPARATION

A. List terms and definitions on the board.

B. Copy and discuss Background Information with students.

C. Have students bring in labels from detergent products.

## PROCEDURE

I. Setting the stage

A. Assign students to work in groups. Have them compile data on different detergents, including cost, phosphate content, and phosphate-related advertising claims (e.g.,"free of phosphates" and/or ability to create suds).

B. Students should collect data from all types of cleaning products, such as laundry detergents and dishwasher detergents. Predetermine the minimal number they must examine.

C. Students should then compile data in table form and, if possible, graph form. (A bar graph would work well .)

D. Have students determine if there are any local or regional phosphate-detergent bans in place. What do they prohibit? Get state/local environmental officials to discuss the ban's effectiveness. Wastewater treatment plant data should show the effect of the ban if phosphate (or total phosphorus) concentrations before and after the ban are evaluated.

E. Have students design a survey form or questionnaire asking 25 people (different families):

1. Their choice of laundry detergent and dishwasher detergent.

2. Why they use that detergent. (List top three reasons.)

3. If they are aware of the effect of excessive use of phosphates.

4. Would they change detergents if their current choice were high in phosphates? Students can survey their own family and one neighbor. Do they consider cost, phosphate content and/or other factors when choosing a detergent?

F. Students will share survey results with the group and then with the class. Have groups or the entire class analyze the compiled data and draw conclusions.

G. Compare the consumer data and determine if any relationship exists among choice and cost, phosphate content, and/or other factors.

III. Follow-up

Students can analyze local rivers or lakes within the watershed for phosphate content and algal growth using a water testing kit from a supply company. This data can be compared with choice of detergents and conclusions should be drawn. Be sure to ask students if the phosphates could be coming from anywhere else.

A. Each group will turn in a report of data and conclusions.

B. Students may bring in samples of surface waters and add different detergents to each and see if there is an algal growth difference between the different detergents.

IV. Extensions

Students might want to analyze the wastewater treatment systems of upstream and downstream communities to see if there are specific processes used to reduce phosphorus. If so, they should see small phosphorus increase downstream of effluent discharge. If no phosphorus removal, they may see significant increase in stream phosphorus concentration (depending on flow of plant and flow of stream).

## RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Water Analysis Kit, page F-69, Water Testing Fact Sheet

# WHAT TURNED THE CREEK ORANGE?

9-12

## OBJECTIVES

The student will do the following:

1. Describe how land disturbed by surface mining becomes more porous, permeable, and vulnerable to leaching--properties not necessarily fixed by reclamation.

2. Demonstrate how water leaches elements from soils and rocks, dissolves minerals, and carries them elsewhere through groundwater.

3. Explain how large concentrations of elements naturally present in small amounts can adversely affect plant growth. (Extension)

**SUBJECTS:**
Science (Earth and Physical)

**TIME:**
1 class period

**MATERIALS:**
sample of iron ore (limonite, hematite, or magnetite)
weak acid (vinegar will do)
bag of soft cookies with chocolate chips or raisins
toothpicks
newspaper sheets
PVC pipe, 6-8 inches diameter, 12-18 inches long, with 4-6 holes about 0.25 inch diameter) holes about 4 inches from end
sand
plastic dishpan or shallow pan about 15" x 15"
jug of water
package of Koolaid ® - cherry or orange
optional: gravel-sized crushed sandstone

## BACKGROUND INFORMATION

When land has been mined in a way that removes coal or other resources from a shallow depth, the surface of the ground is disturbed over many acres. It may be disturbed down to a depth of 30-50 feet. All the soil is removed, and ground that might have more or less solid rock beneath the soil is broken up to excavate the seam of coal.

To prevent large-scale erosion at closed surface mining sites, mining companies are now required by law to reclaim the site by replacing soil and planting cover vegetation and trees. After mining, an attempt is made to contour the surface and direct runoff toward a settling pond. If this is correctly engineered, erosion and damaging runoff are controlled while plants establish themselves and a natural reclamation occurs. After reclamation, if the land looks the same on the surface, with grass, weeds, and trees becoming established, is it really the same in all of its characteristics? Before mining activities, rainfall seeped slowly down through soil and rock until it reached a relatively impervious rock layer. Mining of groundwater above and below the water table was slow through many small channels that had probably been established over hundreds or thousands of years. After reclamation, rainwater that does not run off over land will penetrate the soil and a layer of disrupted rocks. It will flow more readily due to increased amounts of open spaces between blocks of rock and cracks within the rock. In some areas, remaining seams of coal or organic-rich shale associated with coal may contain sulfide minerals that are chemically converted to sulfate minerals on exposure to air or oxygen-rich groundwater. Sulfate minerals readily dissolve in the water making the water more acidic (actually, like very diluted sulfuric acid). The size of the rock chunks creates a much greater surface area for the rainwater to contact coal. In addition to the sulfate minerals already dissolved, this acidic water causes additional leaching of minerals and natural elements from the rock. Some elements, therefore, get into groundwater in much greater concentrations than normally found. When that groundwater reappears in a spring or stream, it will be carrying those increased chemical concentrations to other areas far away from the originally mined land. The acidic waters that are formed in this way are called acid mine drainage.

Terms

acid mine drainage: acidic waters that are formed in mine areas from water coming into increased contact with sulfate and sulfide minerals. This forms sulfuric acid.

contour: (1) imaginary line on the surface of the Earth connecting points of the same eleva(2) a way of shaping the surface of the land in a particular form, commonly used to prevent erosion and control water flow

leaching: the removal of chemical constituents from rocks and soil by water (Leach = to leak)

permeability: the capacity of a porous material to transmit fluids. Permeability is a function of the sizes, shapes, and degree of connection among pore spaces, the viscosity of the fluid, and the pressure driving the fluid.

reclamation: bringing land that has been disturbed by some process back to its original condition

settling pond: usually a human-made pond that is designed to remove many of the particularly from runoff water

## ADVANCE PREPARATION

A. Go over Background Information with students.

B. Present terms and define.

## PROCEDURE

I. Setting the stage

A. Ask students to imagine that they are walking a trail in a wilderness area. The wilderness area is bordered, over the hill from the river, by many acres where mining was done 10 years ago. Grass and trees now cover that land. They have taken a trail that leads up a ravine where a stream is running down toward the river below. An old growth forest with very large trees borders the stream; it is shaded and cool in the ravine. As they walk upstream, they begin to notice a change in the color of the stream water. At first it is barely noticeable but gets progressively more intense. There is a definite red-orange color in the water. The farther they go upstream, the more intense the color becomes; and they begin to notice red-orange particles that have been deposited on the stream bottom where the water is slower. Finally they reach the source of the stream, which is a spring coming out of a hillside. The red-orange color is very bright here, and red-orange particles and deposits can be clearly seen where water is slowly seeping and bubbling out.

B. Ask students to suggest possible causes for the red-orange color. Remind them of the mining activity and try to picture the topography of the land with the old mines on the surface at the top of the hill from this ravine. Lead their thoughts in the direction of possible minerals that might cause that color. Show the iron ore sample and ask how iron might be dissolved.

II. Activity

A. Put the iron ore sample into the weak acid. Agitate to increase dissolution. A crushed sample with more surface area will work best. If only a single chunk is available, you might put that in the acid a week ahead of this presentation. A bright red-orange color should appear on the rock surface where oxidation occurs, and some should dissolve in the acid solution.

B. To demonstrate earth disturbance from mining, give teams of two students a cookie and a toothpick on a sheet of newspaper. Tell each team that one person is to "mine" the chocolate chips or raisins out of the cookie using only the toothpick as a mining tool. The student must mine the cookie with as little disturbance as possible but attempt to get maximum yield of "resource." The other team member may help by holding the cookie still. That team member's job is to use his/her fingers to put the cookie back to original condition. Have teams display their success; judge how much resource they mined and how well they reclaimed the land.

C. To demonstrate permeability of disturbed land, set the PVC pipe on its end in the shallow pan, holes nearer the bottom. Fill loosely with sand to a depth about 6-8inches above the holes. Pour enough water in the top to make a depth of about 4-6 inches. Ask students what they think will happen. Let them observe until water comes draining out of the holes. Then pour dry Koolaid ® drink mix on top of the sand and repeat with more water, again asking students to predict what will happen. After they have observed the colored Koolaid ® draining out of the holes, have a student pack the sand very tightly down in the pipe, using a plastic drink bottle bottom or other tool. Ask students what difference they think packing will make. Repeat with the water and discuss.

D. (Optional): use gravel-sized crushed sandstone as a substrate to compare with the sand. Students may also want to compare the time it took for the liquid to drain with both substrates.

III. Follow-up

A. Ask students what they know about the presence of iron in water, rocks, and soil. Many soils and groundwaters have a fairly high concentration of iron, which may be seen as a rusty red or yellowish color. Ask them whether this is natural, harmful, a nuisance, etc.

B. Ask students:
What is formed when iron is leached out of rock by acidic water that causes the rusty red color? (iron oxide or rust) What is the chemical formula for this? (Hint: The iron reacts with the oxygen in the acid.)

C. Have students come up with a chemical formula for the formation of sulfuric acid from pyrite ($FeS_2$) and water.

D. Have students describe and explain what happened in the PVC pipe demonstration. How does this demonstrate land disturbed by mining?

IV. Extension

Have students research the effects of high concentrations of iron on plant growth, and explain or tell what might be done to correct soils with too much iron. An experiment could be done to observe effects of iron on plants. The typical problem is too little iron the proper form, causing yellowing of leaves!

## RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Camp McDowell Environmental Center, Route 1, Box 330, Nauvoo, Alabama 35578, 205-387-1806 (phone), 205-221-3454 (fax).

9-12

# THERMAL POLLUTION

## OBJECTIVES

The student will do the following:

1. Explain why raising the temperature of a body of water is considered pollution.

2. Demonstrate the effects of temperature on the dissolved oxygen content of water.

**SUBJECTS:**
Science (Physical Science, Biology)

**TIME:**
1 class period

**MATERIALS:**
dissolved oxygen test kit
4 bottles that can hold 100-300ml
ice water & warm water

## BACKGROUND INFORMATION

Water plays a role in absorbing and transferring heat from sun to Earth and back to the atmosphere. Water has a higher specific heat than most other substances, which means it can absorb more heat per gram than many other substances. Water can absorb about four times more heat energy than an equal mass of air for a given change in temperature. Temperature is a measure of the rate at which the substance's molecules are moving, and water molecules have the ability to absorb more heat energy before increasing molecular motion. When water molecules evaporate, breaking away from other molecules to form steam or vapor, the heat energy of the dispersed molecules is converted into kinetic energy. This reduces the heat energy of the remaining water and thus cools the water. Living things utilize this process to dissipate heat, and the Earth dissipates heat this way as well.

Thermal pollution may be a problem where industrial sources use water as a coolant. These industrial environments include conventional industry and coal-fired, oil-fired, or nuclear-powered electricity plants. Thermal pollution occurs when the temperature of the coolant water reaches the point where it can kill or harm fish or other wildlife. Thermal pollution results when water is used for absorbing heat and returned to a receiving stream before cooling back to normal stream temperature. This type of polluting discharge is regulated just as chemical pollutants are. Some other things that can cause thermal pollution are: loss of tree coverage over a body of water due to logging or construction, damming of water that slows water movement down and causes temperature to increase, and increased turbidity, which adds more color to water, causing more heat absorption. The major effect of thermal pollution is a reduction in the dissolved oxygen (DO) of a stream, which affects plant and animal life. Many species of fish cannot live in low oxygen streams. Most of the popular game fish, such as salmon or trout, that "run" streams need high oxygen levels (7-10 ppm). Fish, such as catfish and carp, can tolerate lower oxygen levels (3-4.5 ppm). High temperatures and the resulting low oxygen also interfere with breeding activities and egg and larval development of many organisms including amphibians and insects.

Terms

concentration: strength or density, as of a solution, as in amount of solute per volume of solution

dissolved oxygen (DO): oxygen gas ($O_2$) dissolved in water

kinetic energy: the energy of a body resulting from its motion

parts per million (ppm): a measurement of concentration of 1 unit of material dispersed in 1 million units of another (for water, same as mg/l)

specific heat: the number of calories needed to raise the temperature of one gram of a given substance 1$^o$C, relative to the number of calories (one calorie) needed to raise the temperature of 1 gram of water 1$^o$C

## ADVANCE PREPARATION

Read carefully and practice the procedure for the DO kit ahead of time. Two can do it more easily than one. The manipulations take some practice.

## PROCEDURE

I. Setting the stage

A. The procedure can be done first without explanation, asking students to infer the problems with thermal pollution. The teacher may wish to give the explanations first.

B. The method used for determining oxygen in water is one widely used in water laboratories. The greatest problem for accuracy is introduction of air bubbles in bottles during the procedure by agitation.

C. In this experiment, agitation will be done deliberately as a way of demonstrating the differences in oxygen holding capacities of water at different temperatures.

D. The teacher should do the agitation and then have the students work in pairs on each DO determination.

II. Activity

A. Fill the four bottles with water: 2 with water that has been cooled with ice, 2 with hot water out of the tap or that has been warmed (boiling is optional). Try to fill slowly and carefully, with little force or agitation. Leave an air pocket at the top of each bottle.

B. Cap and agitate by shaking one of the cold bottles and one of the warm bottles. Then uncap and allow all four bottles to sit uncapped while the tests are done.

C. Follow the instructions to get a DO value for each of the four bottles.

III. Follow-up

Ask students to discuss the following:

A. Based on the results of the activity, what effect does increased temperature have on dissolved oxygen? Try to explain why.

B. What is the normal percentage of oxygen in air and in water? (21% in air, and 0.0007% in water, by volume)

C. Is there a limit to how much oxygen may be good for organisms? (People can die from too high of a percentage of oxygen.)

D. What happens to the heat in cooling towers? Is that a form of air pollution? Heat is greatly increased in the air over cities. Should clean air regulations regulate the release of heat from air conditioners?

E. What compounds are more efficient absorbers of heat than water? (Freon, alcohol)

F. When fast-running streams are dammed or naturally slow down, what happens to the oxygen content? Why? Does that affect the species of fish living in that area? Explain.

G. Why are trout usually found only in mountain streams?

H. Discuss how warm water animals, such as manatees, tend to congregate around power plant discharges. Also discuss how this affects them. (They get stuck in pipes and are cut up or killed by blades.)

IV. Extensions

Ask students to research the following:

A. Optimum water temperatures and oxygen levels needed by different species of game and non-game fish.

B. How the temperatures and oxygen levels determined in A. affect thermal pollution regulations for different stream classifications.

## RESOURCES


Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.