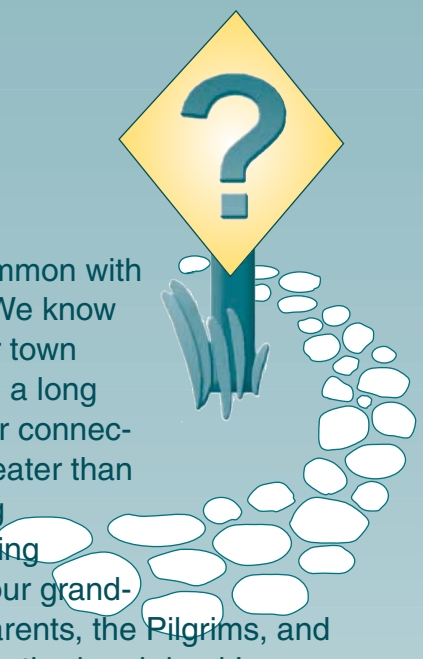
1 What is Pollution?



OVERVIEW

Think about all the things you used or touched today: water, clothes, carpeting, the plastic wrapper of a loaf of bread, newspaper, television set, a car or school bus, and many others that make our lives safer, easier, and more comfortable. Although all these things have benefits, there are consequences of producing, using, distributing, and disposing of these items.

When human activities release harmful substances into the environment, in quantities or concentrations that can cause harm to humans or other living things, the result is called **pollution**. Pollution is created, and can be found in, almost any setting (residential, industrial, commercial, institutional, and agricultural) and any type of community (urban, rural or suburban). These types of pollution are not separate and distinct but affect each other. For example, pesticide or herbicide applied to farm fields may eventually find their way into groundwater, while components of automotive exhaust can combine with moisture in the air and come back to the earth as acid precipitation.

Although there are many kinds of pollution (noise, light, radiation to name a few), this packet will primarily look at air, land and water pollution. The following background will provide more information about the movement of harmful substances in the environment and the three main types of pollution that impact the Earth's closed system.

BACKGROUND

Earth's Closed System

It may seem to us that things that happened a long time ago are very foreign to us, or that we have nothing in common with people from the past. We know that people lived in our town before us, maybe even a long time before us. But our connection with the past is greater than that. You are breathing the same air and drinking the same water that your grandparents, great-grandparents, the Pilgrims, and even the dinosaurs breathed and drank!

This is because the Earth is a **closed system**. The air that the dinosaurs breathed did not disappear after they breathed it—the particles of air came back together and re-entered the atmosphere to be breathed by other animals. The water they drank has gone through the **water cycle** countless times before coming to your local well or water supply.

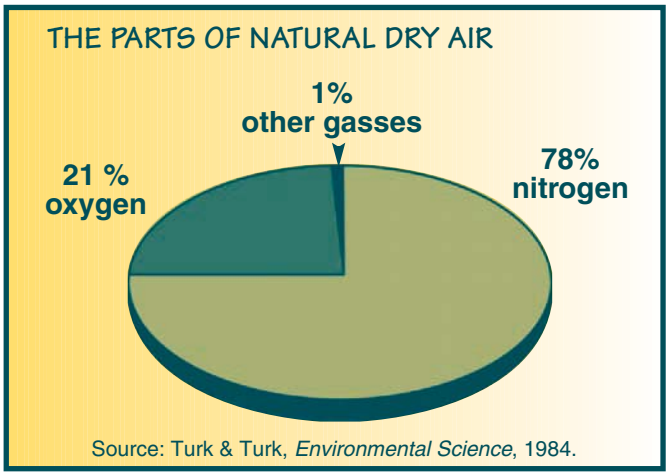
Earth is sometimes compared to a spaceship. Aside from the occasional meteorite and receiving energy from the sun, it does not get new supplies of water, air or any other substances. It must rely on and recycle the matter and energy it has. The basic elements that the Earth had millions of years ago will still be here millions of years from now, although perhaps in a different form.

Cycles, Cycles, & Recycles

Nature uses air, water and land over and over again. This is nature's form of recycling. Energy in the form of sunlight provides the power for these processes to occur.

The Air (Oxygen) Cycle

No new air is added to the earth. When we breathe we exhale carbon dioxide. Green



plants grow by using sunlight, water, and the carbon dioxide gas that people and other animals breathe out, and in turn they produce the oxygen we need to breathe in. This process is known as **photosynthesis**. Without green plants all the oxygen in the air would eventually be used up and the earth would no longer be able to support life.

The Air We Breathe

No matter where you go or what you do, there is something that you have in common with every other living person. When you are walking to school or eating lunch, whether you are awake or asleep, you are doing it. You are breathing.

Whether outside playing or in the classroom learning, everyone has to breathe. In your lifetime you will breathe about 625,000,000 times. What will you be breathing? Air. Take away your supply of air and you could live for only a few minutes.

Air is one of our most valuable resources. Clean air is a mixture of different gases, such as nitrogen and oxygen, with small amounts of water vapor, argon, carbon dioxide, neon, helium and hydrogen. Unfortunately, there can be pollution in the air we breathe. Air pollution occurs when harmful things are present or released into the air. These harmful things are called pollutants and they come from many sources.

School buses and your family's car produce emissions that can pollute the air. The factories that make things such as desks, books and bicycles can also produce emissions that go into the air. In fact, all over the world, millions of vehicles and factories release air pollutants. Still more of these pollutants come from things that ordinary people do every day. Here is a partial list of common things which contribute directly to pollution in the air:

- Burning paper, plastic, leaves and trash
- Heating homes with wood, coal and oil
- Using air conditioners
- Smoking cigarettes, pipes and cigars
- Driving cars, trucks, motorcycles, air planes and motor boats
- Using lighter fluid to start outdoor grills

All of these activities can pollute the air. Sometimes you can smell the pollution, and sometimes, when the air looks hazy or smoky, you can see it. However, even air that looks and smells clean can be polluted.

The Cycling of Materials (Decomposition)

Wood, cotton and other materials produced by living things are broken down into atoms (simpler particles that are too small to be seen) by microscopic plants and animals such as bacteria and fungi. We call this process **decomposition**. The atoms will combine to become new substances or new living things. This is nature's way of recycling matter and turning it from one form to another. Decomposition is particularly important in maintaining our soil.

The Land We Depend On

Soil, dirt, land—no matter what you call it, it's the material that makes up the top layer of the Earth. We build our homes on it, we raise food in it, we mine resources such as coal beneath it, we bury our garbage in it.

Soil is a mixture of minerals (clay, silt, sand, gravel), water, air and living and dead organic matter. As you dig down into the ground, topsoil will generally make up the first foot or so of depth. If you were to dig beneath the topsoil you would find layers of subsoil, bedrock, clay, or sand, depending on local geography.

Soil appears to be unchanging and lifeless, but soils are really full of life and are always changing. A teaspoon of healthy soil can contain billions of organisms ranging from simple bacteria and fungi to more advanced forms of life such as earthworms, insects and spiders. The decomposition of organic matter is what makes the soil rich and fertile.

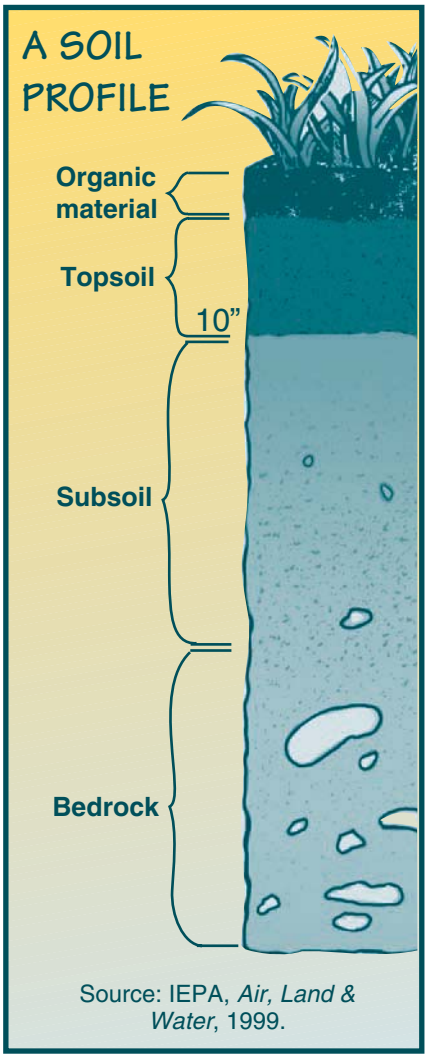
The quality of the land can be damaged or polluted by human actions. This usually occurs because people do not understand soils and make poor decisions about how to use the land. Land pollution can occur in both rural and urban areas. Here are some examples of land pollution:

- Litter or trash on the land.
- Pesticides or other chemicals building up in the soil.
- Oil dumped or spilled onto land.
- Residue from mines or industry piled up.
- High concentrations of animal waste from farms.
- Chemicals leaking from underground tanks or landfills.

These can either make the land itself toxic, and so harm the animals or nutrients in the soil so that it cannot support life. Land can also be damaged by **erosion**, which occurs when the topsoil is blown away by wind or washed away by water.

The Water Cycle

Did you ever wonder where water comes from, where it goes, and how it gets there? In nature, water circulates endlessly through a system called the water cycle (**hydrologic cycle**). The cycle begins when heat from the sun causes water to evaporate. This water comes from the land, lakes, rivers and especially the oceans. The sun-warmed water vapor rises into the atmosphere where it cools and condenses into water drops that form clouds and rain or snow.



Source: IEPA, *Air, Land & Water*, 1999.

Plants are also part of the water cycle. The water that plants take up from the ground through their roots is passed through their leaves by a system called **transpiration**.

Eventually moisture returns to earth as precipitation. The water changes its form from liquid, to gas, to liquid or solid (ice), and its location from the lake or ocean to the air, to the land, and back again.

Some of the moisture that falls onto the land in the form of rain or snow evaporates back into the air. Some runs off into lakes, streams, and rivers (**surface water**). The rest soaks into the soil and becomes **groundwater**.

Water in the soil that is not used by plants is collected in the spaces between soil particles and fills in the cracks and fractures in under-

ground rocks. The special rock formations that hold and transmit water are called aquifers. The water in aquifers is referred to as groundwater; the top of the groundwater level is known as the **water table**.

Water, the Liquid of Life

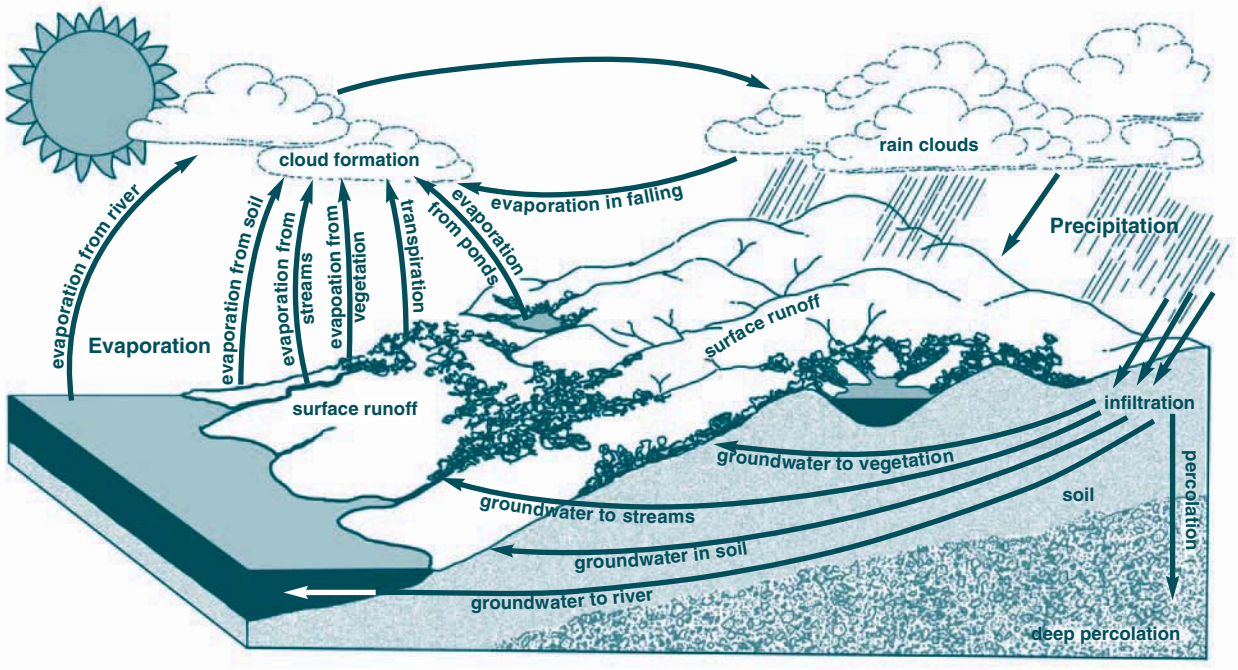
Although it is the most common substance found on earth, water should never be taken for granted. You cannot live without it. Your own body is two-thirds water, and you need about eight cups every day to stay healthy. Take away your supply of water and you could survive for only a few days.

Water is also needed to produce the food you eat. Farmers need water to grow crops and to raise animals. It takes about 15 gallons of water to grow the wheat for one loaf of bread, and about 4,000 gallons to produce a pound of beef. You also need water for bathing, washing dishes and clothes, and brushing your teeth. Industry must have water to make all kinds of things that people use, such as the clothes you wear, the paper in this packet, the steel, plastic and glass to make a car and the items used to build your home.

There is a lot of water on Earth. Eighty percent of Earth's surface is covered with water, but only a tiny portion of it is usable as drinking water. Ninety-seven percent of the earth's water is salt water; another 2 percent is frozen. All of our drinking water comes from the remaining 1 percent. Much of that is hard to reach and exists in aquifers and underground wells. Some of this water is already polluted.

Water is considered polluted when it contains substances that are harmful to people or other life forms, or if its temperature or oxygen content renders it dangerous to living things.

The Hydrologic Cycle



Source: Miller, *Environmental Science: Introduction*, 1986.

Here are just a few examples of water pollution:

- Oil or fertilizer runoff from streets or fields
- Laboratory chemicals dumped down drains
- Soil runoff into rivers, lakes and streams
- Release of heated water into waterways
- Raw sewage or animal waste entering waterways during floods or heavy rains

CONCLUSION

These three types of pollution may seem to be separate, but in reality they are not. Air, land and water constantly come into contact with each other. Water molecules spend time suspended in air, traveling through and joining with other water molecules in rivers, lakes and streams. In the same way, pollutants can move from one medium to another. For example, toxic chemicals in the soil can leach into aquifers and pollute drinking water.

Furthermore, when we try to clean up pollution after it has been generated, we sometimes end up just moving it from one location or medium to another. For example, the air filters used in cars help keep air clean, but must eventually be disposed of themselves in landfills. Types of pollution are connected just as air, land and water are connected.

General EE Resources

- *Association of Illinois Soil and Water Conservation Districts (AISWCD)*
Lists resources and programs available through the AISWCD which includes contests, projects, education tools and a Local Outreach/Education Directory. www.ilconservation.com/

- *Environmental Literacy Council*
Offers a number of teacher resources as well as a wealth of information on the environment. www.enviroliteracy.org/index.php

- *Illinois Department of Agriculture*
www.agr.state.il.us

- *Illinois Department of Commerce and Economic Opportunity* www.istep.org

- *Illinois Department of Natural Resources*
www.dnr.state.il.us/lands/education/index.htm

- *Illinois Department of Public Health*
www.idph.state.il.us

- *Illinois Environmental Protection Agency*
www.epa.state.il.us

- *Illinios Recycling Association*
www.illinoisrecycles.org

- *Illinois State Geological Survey*
Provides information on Illinois geology and online publications and maps such as the Illinois Surface Topography map.
www.isgs.uiuc.edu

- *National Resources Conservation Service (NRCS) - Soil Education*
Provides information regarding soil facts, state soils, tools for educators and much more. http://soils.usda.gov/education/

- *University of Illinois Extension - Schools Online*
An interactive web site, targeted towards third through fifth grades, can be used by parents and students to learn about the world around them, as well as a useful tool for teachers.
www.urbanext.uiuc.edu/schoolsonline/

- *U.S. EPA*
www.epa.gov

- *Office of Solid Waste Educational Resources*
www.epa.gov/epaoswer/education/index.htm
- *Teacher Center www.epa.gov/teachers/*

- *U.S. Geological Survey*
http://education.usgs.gov/

"Drawing Out" Pollution

Subject: Art
Science

Skills:
- Observing
- Comparing/ Contrasting
- Organizing
- Researching

Concepts: 1. A-E

Objectives: Students will:
1) identify forms of pollution and describe the effects that various pollutants can have on people, wildlife and plants.

2) describe relationships between various forms of pollution and human actions.

State Standards:
Science: 11.A.2 b, c, d, e
Social Science: 17.C.2 c
Physical Dev. & Health: 22.C.3 a

Vocabulary:
- pollutant
- pollution

Setting: Indoor and Outdoor

Materials:
- blackboard and chalk
- clipboards
- poster board or butcher paper
- crayons, markers, pencils
- tape

Time: One or two class periods

Activity Overview

In this activity students share what they know about pollution, identify pollution in their community and expand their understanding of different types of pollution.

Background

Although not all pollution is visible, most of us are not far from an example of a possible **pollutant** or the effects of **pollution**. It can be as obvious as a billowing smokestack, or as subtle as a plot of ground where no plants have grown for a long time.

Below are some ideas of what you might have students look for if they were searching for sources of pollutants:
- Evidence of fossil fuels being burned (dark smoke from vehicle exhaust or smokestacks)
- Solid waste that is not properly disposed of (litter, oil, tires, appliances)
- Signs that toxins or dangerous chemicals are being used (signs saying a lawn has been treated with weed killer or fertilizer, crop dusters)
- Discharge through pipes in watersheds into streams, lakes, ponds, rivers

If actual sources of pollution are difficult to identify, consider having students look for animals or things that may have been affected by pollution and work backward to determine the cause, such as:
- Unusual number of dead plants or animals
- Statues or buildings that appear excessively dirty or corroded
- Signs that toxins or chemicals have been released in the area (odd smells)
- Oil slicks on the surface of a body of water

Preparation

1. Review vocabulary and background information on "What is Pollution," pages 13-17.

2. Scout the proposed path for the student walk either on school grounds or within the community. Try to plan a route that will allow students to find examples of pollution. It might

be helpful to arrange for the assistance of other adults who are aware of objectives of this activity.

Procedure

1. Ask students to imagine what life would be like without clean air, land or water.

2. Have students brainstorm a list of as many things as they can that might contaminate, or make unsafe, the air we breathe, the land we live on, or the water we drink. Have students share their ideas and write their suggestions on the board. Ask students if they know what word people use to describe the types of things they have listed.
Answer: Pollution or Pollutants.

3. Discuss what the term pollution means and explain the three basic types.

4. Take students on a walk outdoors to look for pollution or pollutants. Have the students bring paper, clipboards and a pencil. During the walk have students find examples of pollution on land, in the air and in water. As students spot different examples, have them explain how each one could pollute, and what kinds of plants or animals could be affected by each one. For example, oil in the parking lot could wash into a storm drain which empties into a creek or river; aquatic insects, fish, frogs, turtles, and plants could be affected. Also, ask students what might have caused each form of pollution. For example, how did the oil get on the parking lot in the first place?

5. Have students record what they find and have them indicate how many times they see certain types of pollution.

6. Back inside, have students draw pictures of pollutants they spotted on the walk. They can continue to research examples of pollution by looking through magazines, newspapers, and the Internet. Students should try to find at least one example for each type of pollution: air, land and water.

7. Create a large chart on posterboard or butcher paper with columns for each of the three categories of pollution. Have students take turns placing their pictures into the different categories.

Ways to Classify Pollution

Air Pollution	Land Pollution	Water Pollution

8. As a group, review and discuss the finished chart. Ask students the following questions:
- Do any items appear in more than one category?
- Can something pollute two different things, such as air and water, or land and water? If so, how?
- Can people always see, hear and smell pollution?
- Which examples might affect people's health?
- Which examples might affect plants or animals?

9. Return to the answers given in step one. Do students feel they are living in a clean environment? Why or why not?

Wrap Up

Assessment

• Distribute copies of the Urban, Suburban and Rural Assessment of Drawing Out Pollution, pages 21, 22 and 23. Students should circle items in the pictures that are

potential sources of pollution. They should explain how each item circled might cause pollution and what or whom it might affect. Possible answers can be found on page 24.

Extensions

Interdisciplinary

• Read aloud the story "The Cat in the Hat Comes Back" by Dr. Suess (available through most public libraries). Although generally considered appropriate for younger audiences, this is an excellent example of a book with deeper meanings for students to explore. Ask students what represents pollution in the story (the pink stuff). Have students discuss the various ways that the cat tries to get rid of the pollution (moving it from one place to another, breaking it into little pieces). Ask them if people sometimes think about pollution this way. Have them consider how the cat finally got rid of the pollution (a voom, a mysterious machine that gets rid of anything). Ask students if they understand how it works. Do they think such a machine exists to get rid of pollution, why or why not? (Answer: No, once pollution is generated, it generally takes time, energy and effort to remove it. Also, some trash is reused or recycled, not simply disposed of.)

Community

• As a part of step 8, have students list pollution prevention solutions for each of the pollutants or pollutions identified. For example, if oil is found in the parking lot, students could suggest checking vehicles for oil leaks and providing routine maintenance. Then have students determine if the solution will cause more harm than good.

Technology

• Have students research information on types of pollution and local pollution sources on the Internet. One resource for information on local pollution sources is Enviromapper at http://www.epa.gov/enviro/html/em/index.html

Resources

• *Lake Notes - Septic Systems Fact Sheet*
Information on how a septic system works, signs of problems, suggestions for avoiding pollution. IEPA (see order form in appendix)

• *Lake Notes - Fertilizers and Pesticides: Options for Lawn and Garden Use Fact Sheet*
Information on safe fertilizer application, integrated pest management, and safe use of pesticides. IEPA (see order form in appendix)

• *Lake Notes - Home and Yard Fact Sheet*
Information on what you can do in your home and yard to prevent pollutants from getting into lakes and streams. IEPA (see order form in appendix)

• *World of Fresh Water* (PDF Version)
Use these activities to help your students understand the effects of pollutants on lakes, rivers, and streams. Grades 4-6 (66 pages)
http://www.epa.gov/ORD/WebPubs/fresh/fresh.pdf

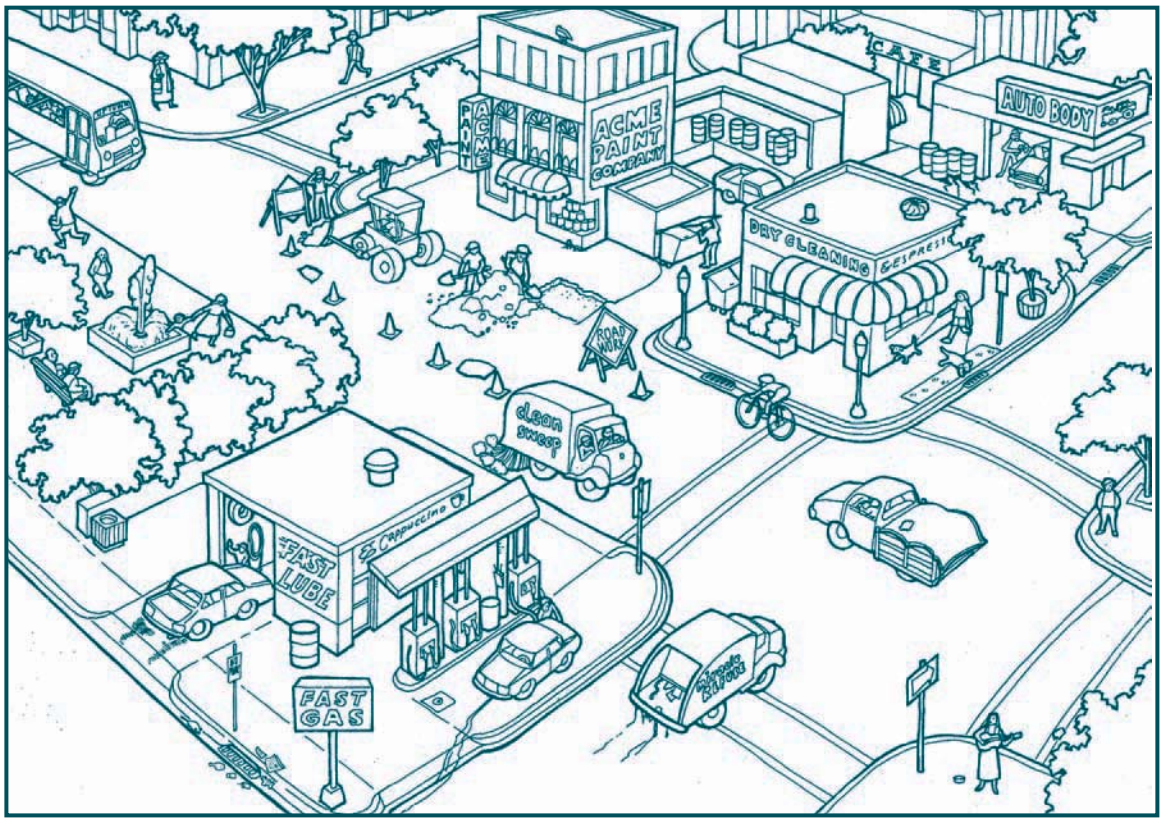
• *Project A.I.R.E - Air Pollution Background Information* (PDF Version) Fact sheet on air pollution and ways to detect and prevent it.
http://www.epa.gov/region01/students/pdfs/rd_airpol.pdf

• *Desdemona's Splash!* (CD-ROM)
Interactive game on water quality and the environment, specifically how activities in a watershed affect water quality.
CTIC, 1220 Potter Drive, #170, West Lafayette, Indiana 47906, 765/494-9555

• *Environmental Education Holdings*
The EPA Region 5 library contains a variety of environmental education materials to assist teachers in the classroom. For a listing of EPA's Region 5 environmental education holdings, please visit the following web site:
http://www.epa.gov/region5/library/collection/enved.htm.

Urban Assessment of "Drawing Out" Pollution

Directions: Circle the items which are potential sources of pollution. Explain how each item you circled might cause pollution and whom or what it might affect.



Source: *Desdemona's Splash!* 1997 (Adapted)

Item Circled	How it Might Cause Pollution	Whom or What it Might Affect
Example: *motor oil stains at Fast Lube*	*rain can wash oil into storm drain that empties to lake or stream.*	*humans, animals*

Suburban Assessment of "Drawing Out" Pollution

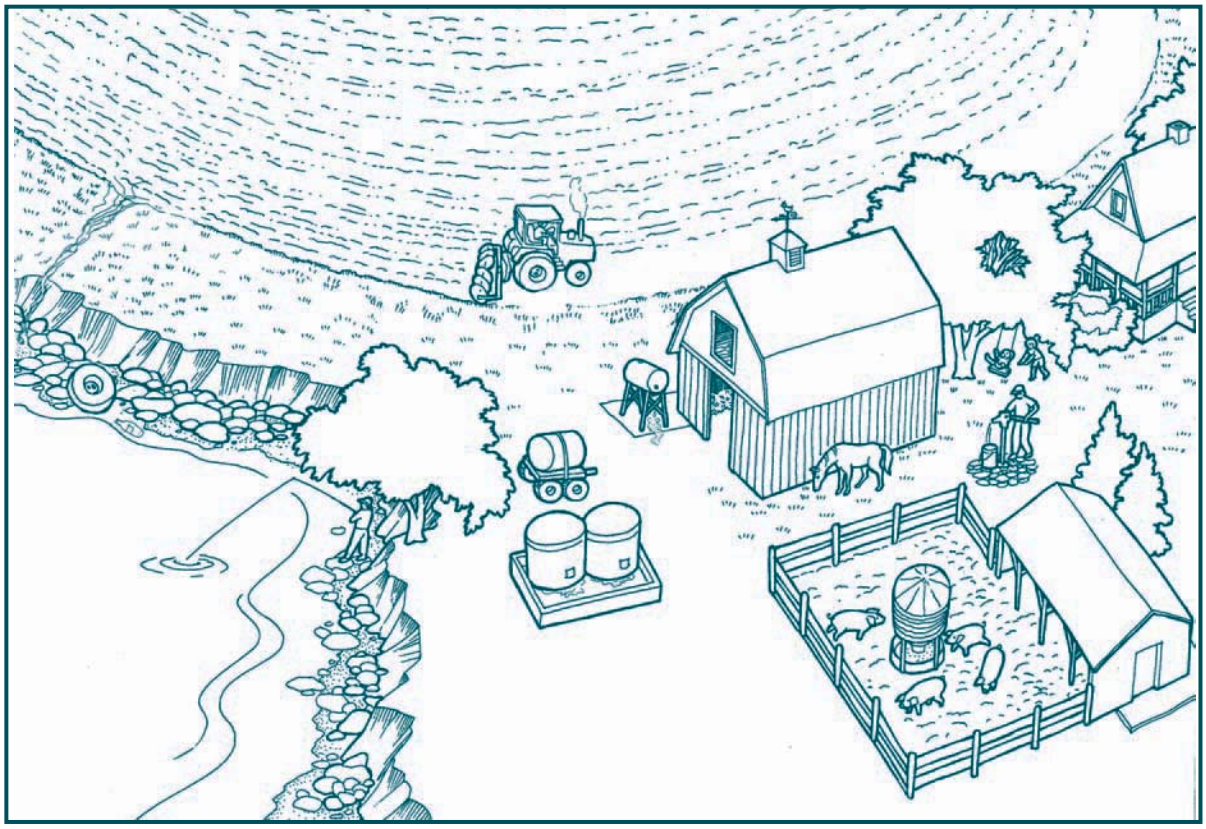
Directions: Circle the items which are potential sources of pollution. Explain how each item you circled might cause pollution and whom or what it might affect.

Source: *Desdemona's Splash!* 1997 (Adapted)

Item Circled	How it Might Cause Pollution	Whom or What it Might Affect
example: *person spraying garden pesticides*	*toxic chemicals may get into water supply.*	*humans, good insects, animals*

Rural Assessment of "Drawing Out" Pollution

Directions: Circle the items which are potential sources of pollution. Explain how each item you circled might cause pollution and whom or what it might affect.



Source: *Desdemona's Splash!* 1997 (Adapted)

Item Circled	How it Might Cause Pollution	Whom or What it Might Affect
example: *trash dumped along river bank*	*can pollute lakes or streams, toxic chemicals may get into water supplies.*	*humans, animals*

Possible Answers for (this is not meant to be an inclusive list):

Urban Assessment of "Drawing Out" Pollution

Item Circled	How It Might Cause Pollution	Whom or What It Might Affect
example: motor oil stains at Fast Lube	rain can wash oil into storm drain that empties to lake or stream.	humans, animals
gasoline pump	nozzle may release toxic fumes, underground storage tanks may leak.	humans, plants, animals
truck or car exhaust	releases pollutants into the air.	fish, animals
litter	may get into storm drain, ugly.	fish, aquatic insects
exposed soil at construction site	rain can wash soil into storm drain that empties to lake or stream.	humans, fish
pet waste	rain can wash nutrients and bacteria into storm drain that empties to lake or stream.	humans, fish, aquatic insects
leaking cans from autobody and paint shops	rain can wash chemicals into storm drain that empties to lake or stream.	humans, good insects, animals

Suburban Assessment of "Drawing Out" Pollution

Item Circled	How It Might Cause Pollution	Whom or What It Might Affect
example: person spraying garden pesticides	toxic chemicals may get into water supply.	humans, good insects and animals
person applying lawn chemicals	toxic chemicals may get into water supply.	humans, animals
person cleaning paint rollers	toxic chemicals can wash into storm drain that empties to lake or stream.	humans, plants, animals
car exhaust	releases pollutants into the air.	humans, fish, aquatic insects
motor oil on driveway	rain may wash oil into storm drain that empties to lake, or stream.	fish, animals
litter	may carry chemicals that can get into storm drain, ugly.	humans, fish
dogs	rain can wash nutrients and bacteria into storm drain that empties to lake or stream.	humans, birds, fish, animals

Rural Assessment of "Drawing Out" Pollution

Item Circled	How It Might Cause Pollution	Whom or What It Might Affect
example: trash dumped along river bank	can pollute lakes or streams, toxic chemicals may get into water supplies.	humans, animals
farm chemicals leaking on ground	rain may wash into lakes or steams.	humans, aquatic insects, animals
exposed soil on stream bank	rain may wash into lakes or streams.	aquatic insects, fish
motor oil on the ground	oil may get into the groundwater, can wash into lakes or streams.	humans, fish, aquatic insects
animal waste	rain may wash waste into lake or stream.	humans, fish, aquatic insects
tractor	releases pollutants into the air.	humans, plants, animals
farming area (exposed soil)	rain may wash eroded soil into lake or stream.	animals, plants, aquatic life

"Sock It" to Air Pollution

Subject: Science

Skills:
- Predicting
- Interpreting

Concepts: 1. A, C, N, R
3. A, F, G

Objectives: Students will:
1) be able to describe different sources of air pollution and some of the effects of air pollution.

2) recognize that some types of air pollution are invisible or visible only under certain circumstances.

State Standards:
Science: 11.A.2 b, c, d
13.B.2 b

Vocabulary:
- air pollution
- particulates

Setting: Indoor and Outdoor

Materials:
- three to five new white tube socks
- access, keys, and permission to run three to five different vehicles
- an adult assistant
- copies of the "Sock It" to Air Pollution Automotive Prediction Grid (p.26)
- clip boards

Time: One class period

Activity Overview

In this demonstration students will observe that **air pollution** is not always visible and that not all vehicles produce the same amount of pollutants.

Background

Motor vehicles—cars, trucks, buses—are a major source of air pollutants in North America today.

The United States Environmental Protection Agency has established national air quality standards for six specific air pollutants: sulfur dioxide, carbon monoxide, oxides of nitrogen, ozone, particulate matter and lead.

These pollutants can cause health problems if they are breathed at high enough concentrations. The national air quality standards are meant to ensure that levels in the free air never get high enough to cause any such problems. Standards at levels low enough to protect both human health and welfare were set after much scientific research.

Carbon monoxide interferes with the transfer of oxygen in the body. Lead, absorbed through the lungs, interferes with cell metabolism. Ozone, sulfur dioxide, oxides of nitrogen, and **particulates** all irritate the lungs and nasal passages in various ways.

Motor vehicles contribute directly or indirectly to all of those air pollutants in varying amounts. The exhaust from a car that is running properly is essentially colorless. It contains mostly carbon dioxide and water vapor formed by fuel combustion, and these are harmless. But vehicle exhaust also

Emissions from Internal Combustion Engines

contains small amounts of the other pollutants mentioned above.

Motor vehicles are the main source of carbon monoxide in the air. It is an invisible, odorless, poisonous gas created by incomplete burning of fuel in a car's engine. It can build up to dangerous levels in an enclosed space like a garage, so be sure to perform the experiment in this section outdoors, where the carbon monoxide and other pollutants can blow away harmlessly.

Vehicles also emit oxides of nitrogen. Some of this is in the form of nitrogen dioxide, a toxic gas which in higher concentrations is brownish-red. It also is involved in the formation of ozone. Vehicles emit small amounts of sulfur dioxide due to sulfur in the fuel as well.

Vehicles emit particulates—solid particles smaller than dust. Most such particulates are the result of incomplete fuel combustion. Diesel engines are especially prone to emit particulates. Formerly, most gasoline contained lead additives to help control the combustion process, and motor vehicles would emit lead particulates from their tailpipes. Leaded gasoline is no longer sold, however, and airborne lead levels have fallen dramatically in the last two decades. The experiment in this section has to do with particulates.

Ozone is not emitted directly into the air. It is formed by the action of sunlight on oxygen in the air, in the presence of hydrocarbons, oxides of nitrogen, and carbon monoxide. Of these "ozone precursors," hydrocarbons are the most active in ozone formation, and this is why they are important. Motor vehicles emit unburned or partially burned hydrocarbons from their tailpipes. Hydrocarbons also evaporate from fuel tanks and systems.

Preparation

NOTE: Student safety needs to be considered during this activity! Do not allow students to inhale or stand in the direct path of exhaust. Do not allow students to touch the tailpipe during or after this activity. The metal will be extremely hot and can burn skin and clothing. Use extreme caution and think through all aspects of this activity before beginning!

1. Locate three to five vehicles (school bus, diesel, new, old, alternative energy) that the teacher can start or have started during class.

"Sock It" to Air Pollution Automotive Prediction Grid

Make (Chevy, Ford, etc.)	Model (Blazer, Taurus, etc.)	Year (2000, 1965, etc.)	Engine Type (V8, 4 cylinder, etc.)	Fuel Used (Unleaded, diesel, natural gas, etc.)	Rank (Predicted)	Reason/Rationale	Rank (Actual)

2. Make copies of the prediction grid, one per student or group.

3. Create identification labels for the socks.

Procedure

1. Ask the students to identify sources of air pollution in the community. List these on the blackboard. The list should include automobiles, power plants, wood or coal burning stoves, factories, farming, and natural sources such as brush fires.

2. Explain to the students how a vehicle burns gasoline or diesel fuel. Some of the fuel is changed into energy to move the vehicle. By-products of the process include heat and air pollutants which exit the vehicle through the exhaust system via the tailpipe.

3. Use the background information to discuss the types of pollutants in vehicle exhaust.

4. Have the students assemble in the parking lot. Distribute prediction grids (one per student or team). Have students rank which car they predict will produce the most particulate matter (i.e., the dirtiest sock). Have them explain their choices. Place a white tube sock over the tail pipe of each vehicle. The elastic sock tops should fit snugly over the tailpipes; if they do not, secure them with rubber bands.

5. Ensure that the students are standing away from the vehicles and start the engines. While the engines run have students compare their predictions.

6. After five minutes turn off the engines and remove the socks from the tailpipes using oven mitts or heavy gloves. CAUTION: Tail pipes may be extremely hot; do not have students perform this step.

7. Turn the socks inside-out and attach the appropriate label. Arrange socks from most to least dirty.

8. Compare the students' predictions to the actual results. Remind the students that they are only seeing particulate matter, and that cars also produce large amounts of invisible air pollutants such as carbon monoxide and oxides of nitrogen.

Wrap Up

Assessment

• In small groups, have the students review the findings and compare them to their predictions. Have the groups come up with written answers to the following questions, using complete sentences:

1. How closely did your predictions match the actual results?

2. What could have affected the differences in findings between the different vehicles? (Possible answers: type of fuel used, engine type, age of vehicle, maintenance).

3. Are the cars with the cleaner socks always the best choice? What else might you look for in selecting a car? (Answer: No, because this test does not measure all kinds of emissions, only particulate matter. Also, cars are selected for different uses and to fulfill different needs; the 'cleanest' car in your test may be too small or expensive for some people, or may not have acceptable fuel efficiency.)

Extensions

Community

• Find out if emission inspections are required in your area. Hypothesize and investigate why emissions testing is required and if it is required all over the state. Plan a field trip to a vehicle inspection site, if feasible.

Technology

• Discuss alternative modes of transportation and alternative fuels. How do they differ in terms of emissions produced?

Multidisciplinary

• In small groups, have students research the amount of unleaded and diesel fuel that is sold in their neighborhood or town each month. Have teams compile their results and determine how many gallons of each type of fuel are burned every month/year. If students determine this number is high, have them research ways in which to reduce the amount of fuel consumption in their lives.

Resources

• *Air Facts - Criteria Pollutants Fact Sheet*
Information on six criteria air pollutants recognized by the U.S. EPA. IEPA (see order form in appendix)

• *AIRNow*
Provides a wealth of information nationwide, including hourly data on ozone and particulates.
www.airnow.gov

• *Alternative Fuels Data Center*
This site provides useful information about alternative fuel and alternative fuel vehicle (AFV) technologies, programs, funding, regulations, contacts, and more.
www.eere.energy.gov/afdc

• *Automobiles and Air Pollution* (PDF)
Background information on the causes and consequences of pollution caused by automobiles.
www.epa.gov/region01/students/pdfs/rd_auto.pdf

• *Global Warming*
This web site offers information on several topics regarding global warming, such as the following: climate, emissions, impacts, actions and a resource center. www.epa.gov/globalwarming/ (or) http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html

• *IEPA Bureau of Air - Air Team*
This site provides information on emissions testing and the vehicle inspection process.
www.epa.state.il.us/air/vim/index.html

• *Illinois Green Fleets*
www.illinoisgreenfleets.org

• *Inventing a Monitor (PDF)*
An activity from Project A.I.R.E. that has students devising and testing methods to monitor air pollution.
www.epa.gov/region01/students/pdfs/activ7.pdf

• *Partners for Clean Air*
www.cleantheair.org

• *Project A.I.R.E.*
Offers several different air-related warm-up exercises, activities and reading material.
www.epa.gov/region01/students/teacher/aire.html

Adapted From: "Let's Sock Car Exhaust," Environmental Resource Guide - Air Quality. Air and Water Management Association. Pittsburgh, PA. 1991.

Charting the Water

Subject: Mathematics
Science

Skills:
- Classifying
- Comparing/ Contrasting
- Computing
- Matching

Concepts:
1. A, D, F, J, N, P, R
2. B 3. R

Objectives: Students will:
1) identify forms of pollution and describe the effects that pollutants can have on people, wildlife and plants.

2) describe relationships between various forms of pollution and human actions.

State Standards:
Mathematics: 10.A.2 a, c
Science: 11.A.2 c, d
13.B.2 e, f
Social Science: 17.C.2 c
Physical Dev. & Health: 22.C.3 a

Vocabulary:
- inorganic
- organic
- sediment
- thermal
- toxic

Setting: Indoor

Materials:
- 100 tokens each of eight different colors
- large container
- Types of Water Pollution handout (p. 32)
- graph paper

Time: One class period

Activity Overview

Students classify and graph the pollutants found in a fictional river and hypothesize what caused the pollution in the first place.

Background

Water can be polluted in a number of different ways. One way is for bathroom and factory wastes to flow through pipes into waterways with no treatment. Another is for soil, animal wastes, fertilizers and pesticides to wash from farms into waterways. Soil, oils, chemicals and other substances can be washed in from city streets and construction sites. Some wastes are diluted by water and others can be eaten by bacteria. However, nature can only do so much. The wastes that remain are sometimes poisonous; others can cause diseases such as cholera, or change the makeup of streams so that animals or plants cannot survive.

There are many types of substances that can be pollutants: oil products, poisonous chemicals, decaying plants, even leaves. Many things that are not harmful by themselves or in small quantities become pollution under proper circumstances or in high concentrations. Generally, these can all be classified into the following five causes of water pollution:

- **Organic** includes human, animal and plant wastes and chemical substances created by or made from them;
- **Inorganic** includes litter and chemical fertilizers;
- **Thermal** refers to changes in the temperature of water (either warmer or colder);
- **Toxic** includes herbicides, insecticides, lead, and other chemicals that are directly harmful to humans or animals;
- **Sediment** includes the buildup of silt, clay, and other particles in ways that affect the survival or health of an ecosystem.

It is easy to think that pollution is only caused by humans, but this is not the case. Volcanic eruptions are a source of acid precipitation, and naturally occurring erosion can contribute to sedimentation. It is important to understand that what makes pollution is not the source (whether it is natural or caused by humans) but what kind of effect it is having on living things that depend on water.

Preparation

1. Make 100 tokens each of eight different colors of construction paper. Tokens should be shaped into 1/2 inch squares. Put all of the tokens into a large container and stir so the colors are thoroughly mixed.

2. Make one copy of the Types of Water Pollution Worksheet for each student.

Procedures

1. On the chalkboard list the five major types of water pollution: organic, inorganic, thermal, toxic and sediment. Discuss each, referring to the background information if necessary.

2. Distribute the Types of Water Pollutants Worksheet to each student (p. 32). Discuss them in detail, and have the students match each of the pollutants with one of the five causes of pollution. Explain how some of the pollutants can fit into more than one category (for example, animal waste can have characteristics of organic and sediment pollution because it can oversupply an ecosystem with nutrients and cause a buildup of particles in the waterway possibly affecting the health of the ecosystem).

3. Assign one of the eight colors of construction paper to each of the eight pollutants (e.g., red = petroleum, yellow = acid precipitation).

4. Divide the students into three groups. Explain that each group will be a research team and will analyze the pollution content of a fictional river. Give each team a piece of graph paper and a small amount (about one tablespoon) of the 1/2 inch square tokens.

5. Instruct the teams to separate the tokens by color. Have them count the number of each pollutant and construct a simple bar graph showing the relative concentration of the pollutants. Make sure that each team lists the colors on the chart in the same order.

6. Explain that more than two units or tokens of any pollutant is considered harmful to the aquatic environment. Ask them to determine which pollutants in their river would be likely to cause the most damage to humans and environment.

Wrap Up

Assessment

• Have students hypothesize what may have caused types of pollution in their river.

• Have students debate the following: Water is taken from a river, treated, used by people of the community, sent to a city sewage treatment plant, and then returned to the river. Do you think this is a form of water pollution or recycling? Explain your answer.

Extensions

Community

• Have students visit a wastewater treatment plant to deepen their understanding of the process of water purification and their own place in the water cycle.

Multidisciplinary

• Have students obtain and write a report on current national and state laws protecting water quality.

Outdoor

• Have students visit a nearby body of water and conduct water quality tests. Have them hypothesize, based on their findings, what kinds of pollutants are affecting that area.

Technological

• Have students research how fertilizers, pesticides and other chemicals are tested for safety before they are available for sale.

Resources

• *Getting to Know Your Local Watershed*
Provides overview information on "What is a watershed?" Explains different sources of pollution that affect watersheds, and uses of watersheds' natural resources. http://lanshark.ctic.purdue.edu/KYW/Brochures/GetToKnow.html

• *Illinois Water Quality Report*
This report provides an assessment of the quality of the state's surface and groundwater resources, including waterbody specific information and maps. www.epa.state.il.us/water/water-quality

• *Drinking Water & Ground Water Kids' Stuff*
This web page offers several games and activities relating to groundwater and drinking water, including the water treatment cycle. http://www.epa.gov/safewater/kids/kids_4-8.html

• *Water Quality: Potential Sources of Pollution, Middle School Edition*
This 24" x 36" color poster depicts point and nonpoint sources of pollution. The reverse side contains two activities, Dispersion of Nonpoint Pollutants and How Substances Are Measured in Water. Available online at: http://water.usgs.gov/outreach/OutReach.html

• *Wetlands, Oceans and Watersheds*
Provides information on watersheds, different types of waterbodies and how to protect our resources. www.epa.gov/owow

• *EnviroMapper for Water*
This interactive tool is a web-based Geographic Information System (GIS) application that displays information about bodies of water in the U.S. It allows you to create customized maps and can display the health of a river near you. www.epa.gov/waters/enviromapper/index.html

• *Living Lands and Waters*
This non-profit organization offers wonderful educational workshops with an up-close river experience. Learn how one person with a passion for a cleaner river environment is making quite a difference in our rivers today. www.livinglandsandwaters.org

• *Project WET (Water Education for Teachers)*
Project WET is a K-12 national water education program that teaches about people's relationship to water, including the history of water, uses of water and water management. The activity guide contains hands-on water-related activities that give teachers and students opportunities to investigate our most precious natural resource. These activities have been correlated to the Illinois Learning Standards.

Teachers can obtain a copy of the activity guide by attending a Project WET workshop in their area. Project WET is co-sponsored by the IDNR and the IEPA. For information about the program go to: http://dnr.state.il.us/lands/education/CLASSRM/WILD/INTRO.HTM or http://www.projectwet.org/.

• *Get Involved*
Learn how to participate with students around the world in World Water Monitoring Day http://www.worldwatermonitoringday.org/ Celebrate Water Monitoring Month and order outreach and educational materials. www.epa.gov/owow/monitoring/volunteer/monitoringmonth.html

• *Lake Education Assistance Program (LEAP)*
The Illinois EPA offers a $500 grant available to all Illinois schools and not-for-profit organizations for the study of lakes/ponds and their watersheds. This money can be used to purchase lake-related educational materials, field trips, equipment and activities. Application deadlines are September 30 and January 31. www.epa.state.il.us/water/conservation-2000/leap.html. 217-782-3362.

Adapted From: "Deadly Waters," Project WILD Aquatic. Western Regional Environmental Education Council. Bethesda, MD. 1992.

Types of Water Pollutants Handout

Sediments
Small particles of sand, soil, clay, and other minerals are washed into rivers, lakes and streams from the land. Often these come from construction projects or paved areas, but they can also come from natural runoff or erosion. Stream channels and harbors that have been filled with sediment often need to be dredged. Sediment can harm wildlife by covering nests of fish or by clogging the gills of fish and shellfish.

Petroleum (gas/oil) Products
Oil spills, such as the Exxon Valdez spill, kill fish, seabirds, shellfish, and aquatic plants. However, there are many other ways that petroleum products (such as oil, gasoline, and kerosene) can contaminate water. They can seep into groundwater from damaged or corroded underground storage tanks, be washed into waterways from driveways, streets or service stations, or be released from ships, refineries, or drills. Petroleum products are poisonous to many animals. Additionally, waterbirds cannot fly if they get oil on their feathers.

Heated or Cooled Water
Electric power plants generate large amounts of heated water. This warm water can't carry as much oxygen as cooler water. If oxygen cannot be returned to the water, fish and other aquatic animals can be harmed. Cooler water is sometimes released by deep dams; this too can damage aquatic animals and plants that require warmer temperatures to survive.

Organic Wastes
Other organic wastes can also get into the water. These include natural animal and plant products such as wood pulp or food by-products. These products also contain nutrients for bacteria and algae. The concentration of bacteria will increase if too much organic waste gets into the water. These bacteria will then use up the oxygen in the water, and fish will die.

Animal/Human Wastes
Untreated sewage and runoff from farms, stockyards, and barns can contain viruses and bacteria that are very dangerous to humans. People can contract cholera, typhoid fever, dysentery, hepatitis, and other diseases if they drink or come into contact with water that has been polluted this way, or if they eat fish or shellfish from polluted water. Human and animal wastes also contain nutrients and act as a fertilizer in water. Bacteria feed on the nutrients and use up all of the oxygen in the water. This kills many aquatic animals and plants.

Inorganic Compounds
Detergents, pesticides, herbicides, salts, mineral compounds, and other inorganic compounds are harmful to water ways. They come from factories, mines, agriculture, factories, households, and sometimes from natural sources as well. Many of these chemicals are poisonous to fish and other animals or cause damage to structures, such as boats or water purification equipment.

Fertilizers
Runoff from farms, gardens, lawns and golf courses sometimes contains excess fertilizers. When high concentrations of these fertilizers get into water, they cause large amounts of algae to grow. The algae feed on the nutrients in the fertilizer, just as crops would; once they use up all of the nutrients, the algae die and are themselves eaten by bacteria. The bacteria use up all the oxygen in the water, which makes the water unsuitable for fish, shellfish, and other animals.

Acid Precipitation
Normal water is not usually acidic. However, plants and animals can be harmed or killed by water that has been made acidic by inorganic chemical pollution.