Advanced Manufacturing and Materials

Water, a Precious Resource

Grade Level: 7th

Academic Content Areas: Science, Technology & Engineering

Topics: Earth and Space Science; Life Science, Physical Science, Science and Technology; Scientific Ways of Knowing; and Engineering Design Process

Recommended area of co-teaching for an AFRL Engineer or Scientist

Main Problem / Essential Question

How does a contaminant cycling through the Earth Systems affect our drinking water and how can that contaminant be filtered out of the water?

Summary

Students will learn that Earth's capacity to absorb and recycle water naturally can be altered by the actions of humans and technology. In this lesson students will learn that people and their actions can harm our drinking water supply. Students should get a clear understanding that what happens above the ground can potentially end up in the drinking water below the ground. Students will then explore the filtration of water through various materials and design a water filtration system.

Big Ideas / Focus

The water cycle begins when the Sun heats the oceans causing some of the water to evaporate into the air as water vapor. This water vapor rises up into the atmosphere with rising air currents and the cooler temperatures at higher altitudes condense the water vapor into clouds. The water vapor and clouds move all around the globe due to air currents, causing the cloud particles to grow, collide, and condense until gravity causes them to fall from the atmosphere as precipitation. Precipitation can take the form of rain, snow, or hail (ice pellets). Most of the precipitation falls back into the oceans or onto land as rain. On land the water flows over the ground as surface runoff and some of this water enters rivers through valleys and moves toward the oceans; some is stored in lakes as freshwater; some finds openings in the land surface and comes out as freshwater springs; and some soaks into the ground (infiltration). Infiltration can be shallow and will become groundwater discharge as it seeps back into surface-water bodies and the ocean. Infiltration can also be deep enough to replenish aquifers which will store freshwater for long periods of time. Over time, all of the water from the precipitation will return to the ocean where the water cycle will begin again.

Aquifers are underground reservoirs whereas lakes, streams, and oceans are surface reservoirs. A watershed is a land area that drains water to a common surface reservoir. Groundwater runoff feeds aquifers, watersheds, and surface reservoirs. The water that reaches an aquifer is usually much cleaner than the water in surface reservoirs because many of the pollutants are filtered out as the water passes through the layers of soil, clay, sand, gravel, rock, etc. Almost no bacteria live in aquifers.

Point source pollution is that which can be attributed to a single source (a factory exhaust pipe), whereas non point source pollution is that which accumulates in watershed run-off, from a variety of sources (fertilizers).

Prerequisite Knowledge

Before starting this lesson, students should be familiar with the basic processes of the water cycle and the Law of Conservation of Matter and Energy. Students have already learned about renewable and non-renewable resources (Grade 5 Earth Science indicators).

Standards Connections

Content Area: Science

Earth and Space Science Standard: Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth's systems, processes that shape Earth and Earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences.

7th Grade – Benchmark C: Describe the interactions of matter and energy throughout the lithosphere, hydrosphere, and atmosphere (e.g., water cycle, weather, and pollution.	1. Explain the biogeochemical cycles which move materials between the lithosphere (land), hydrosphere (water), and atmosphere (air). 2: Explain that the Earth's capacity to absorb and recycle materials naturally (e.g., smoke, smog, and sewage) can change the environmental quality depending on the length of time involved. 4 Analyze the data of the availability of fresh water that is essential for life and most industrial and agricultural processes. Describe how rivers, lakes, and groundwater can be depleted or polluted becoming less hospitable to life and even becoming unavailable or unsuitable for life.

Life Science Standard: Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure and function of cells, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

7th Grade – Benchmark C: Explain how energy entering the ecosystems as sunlight supports the life of organisms through photosynthesis and the transfer of energy through the interactions of organisms and the environment.	6. Summarize the ways that natural occurrences and human activity affect the transfer of energy in Earth's ecosystem. (e.g., fire, hurricanes, road, and oil spills).

Physical Science Standard: Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

7th Grade – Benchmark A: Relate uses, properties and chemical processes to the behavior and/or arrangement of the small particles that compose matter.	1. Investigate how the matter can change forms but the total amount of matter remains constant.

Science and Technology Standard: Students recognize that science and technology are interconnected and that using technology involves assessment of the benefits, risks and costs. Students should build scientific and technological knowledge, as well as the skill required to design and construct devices. In addition, they should develop the processes to solve problems and understand that problems may be solved in several ways.

7th Grade – Benchmark A: Give examples of how technological advances, influenced by scientific knowledge, affect the quality of life.	2. Describe how decisions to develop and use technologies often put environmental and economic concerns in direct competition with each other.
7th Grade – Benchmark B: Design a solution or product taking into account needs and constraints (e.g., cost, trade-offs, properties of materials, safety and aesthetics).	4. Design and build a project or create a solution to a problem given two constraints (e.g., limits of cost and time for design and production or supply of materials and environmental effects)

Scientific Inquiry Standard: Students develop scientific habits of mind as they use the processes of scientific inquiry to ask valid questions and to gather and analyze information. They understand how to develop hypotheses and make predictions. They are able to reflect on scientific practices as they develop plans of action to create and evaluate a variety of conclusions. Students are also able to demonstrate the ability to communicate their findings to others.

7th Grade – Benchmark A: Explain that there are differing sets of procedures for guiding scientific investigation and procedures are determined by the nature of the investigation, safety considerations and appropriate tools.	4. Choose the appropriate tools and instruments and use relevant safety procedures to complete scientific investigations.

Scientific Ways of Knowing Standard: Students realize that the current body of scientific knowledge must be based on evidence, be predictive, logical, subject to modification and limited to the natural world. This includes demonstrating an understanding that scientific knowledge grows and advances as new evidence is discovered to support or modify existing theories, as well as to encourage the development of new theories. Students are able to reflect on ethical scientific practices and demonstrate an understanding of how the current body of scientific knowledge reflects the historical and cultural contributions of women and men who provide us with a more reliable and comprehensive understanding of the natural world.

7th Grade – Benchmark C: Give examples of how thinking scientifically is helpful in daily life.	3. Describe how the work of science requires a variety of human abilities and qualities that are helpful in everyday life (e.g., reasoning, creativity, skepticism, and openness).

Preparation for activity

Collect 2-L plastic bottles for filter project.

Gather supplies for watershed model (make in advance for teacher demonstration)

Gather supplies for student filter project

Make copies of instructions and student handouts (see attachments)

Critical Vocabulary

Aquifer – an underground water reservoir

Concentration – the amount of one substance in a certain volume of another substance

Condensation – the process by which water vapor in the air is changed into liquid water

Contaminant – any substance that has a negative effect on water or the living things that depend on water

Drought – dry weather for a long period of time because the average rainfall drops far below the normal range for a specific region

Evaporation – the process by which water changes from a liquid to a gas or vapor

Filtration – the process of passing water through a series of screens that allow the water to pass, but not the solid particles

Groundwater – water in underground soil and rock layers

Impermeable – materials that do not allow materials to pass through easily

Infiltration – the process of water entering the soil

Non point source pollution – a widely spread source of pollution that cannot be tied to a specific origin, such as runoff from roads (many sources)

Permeable – materials that allow water to pass through easily

Point source pollution – a specific source of pollution that can be identified, such as a leaking pipe (one source)

Precipitation – water released from clouds in the form of rain, freezing rain, sleet, snow, or hail

Sludge – the residual, semi-solid material left from industrial wastewater or sewage treatment processes

Transpiration – a process similar to evaporation…the loss of water from parts of plants

Watershed – the land area that drains water to a common waterway, such as a stream, lake, estuary, wetland, aquifer, or even the ocean

Water Quality – the measurements of substances in water other than water molecules

Timeframe

Day	Time Allotment	Activities
1	~40 minutes	Pre-assessment Begin "Events in the Life of a Lake" activity (from ODE lesson).
2	~40 minutes	Use resources to correct chronology. Discuss as a whole class. Read "Who Killed Lake Erie" and assign discussion questions for small groups. Go over discussion questions as a whole class. Show animated video "The Story of Groundwater" or another video from list.
3	~40 minutes	Classroom discussion or student research about how water travels through the water cycle underground to aquifers and watersheds. Classroom discussion or research on how pollution affects underground water. EPA web site interactive lesson
4	~40 minutes	Build a watershed model and run one or more simulations. Questions in science notebook or on separate piece of paper (from ODE lesson).
5	~40 minutes	Classroom discussion of the watershed simulations. Classroom discussion and brainstorming of questions on pollution and what can be done to clean up water supply. Introduce the filtration system project. Allow time to look at supplies and tell students they can bring in some of their own. If time allows, let groups begin to design a filtering process.
6	~40 minutes	Design a process to test filtering materials. Test filtering materials. Compare and contrast water before and after filtration.
7	~40 minutes	Design, build, and test a water filtration system. Sketch filtration system. Test with whole class. Record observations. Analyze how well filtration worked and recommend changes for further experimentation.
8	~40 minutes	Re-design/Improve water filtration system and re-test.

Materials & Equipment

A variety of materials will need to be collected ahead of time:

See Attachment C for materials for building a watershed model

See Attachment E for materials for filter project for students.

You will need a supply of dirty water to test filter projects. You can make dirty water by adding one teaspoon of Fuller's earth per cup of tap water. (Fuller's earth is available at most hardware stores. You may make or collect you own dirty water. All students should receive same type of dirty water.

Safety & Disposal

Proper use of equipment should be discussed before project is started. Students will be working with glassware and should take special care when using equipment.

Goggles and aprons should be made available to students during filter project.

Students need to clean up water spills as they work.

Have containers available to deposit materials after testing of projects. A container for gravel, charcoal, and other materials should be labeled and students made of aware of proper disposal.

Teacher may want to pre-cut the 2-L plastic bottles for students or monitor the students when they cut the 2-L plastic bottles.

Remind students not to drink from any of the science glassware or taste the dirty water being used in the project.

Pre-Activity Discussion

Begin with the LabTV Video entitled "Green Ships" (http://www.ndep.us/Green-Ships). This video illustrates how the Navy now treats their refuse for safe discharge into the ocean or small packaging for carrying back to port for recycling. It shows a water filtration system on board a ship.

For centuries ships, including cruise ships, dumped all their waste into the ocean! It was around the 1970's that this practice was stopped for environmental reasons. For the Navy, this was a hardship because their ships are like a small city, with anywhere from 100 to 5,000 people aboard and staying afloat for months at a time. They produce refuse such as dishwater, shower water, raw sewage, garbage, and ordinary trash. Even the most benign, shower water, could cause serious environmental problems…imagine putting your pet goldfish into a bowl filled with your leftover shower water, shampoo and all!

Ask students what they remember about the water cycle. A good animated diagram can be viewed at http://earthguide.ucsd.edu/earthguide/diagrams/watercycle/. Begin with a review of processes in the cycle. Have students trace a drop of water through the water cycle and explaining the process as they go through the cycle. Tell students they must include at least one process that has the water drop traveling under the ground. Ask students how water naturally recycles itself. What happens when pollution enters this cycle? Brainstorm why the cycle can not keep up with the natural recycling of water. Discuss how humans have tried to solve this problem.

Teacher Instructions

Conduct the pre-test with students (Attachment A). This will allow you to see what knowledge needs to reviewed or covered in more detail during the lesson. It will also allow for misconceptions to be identified and cleared up.

Have students work in pairs or small groups on the "Events in the Life of a Lake" activity (Attachment B). Instruct students how to create a timeline, then to cut out the descriptions of events and assemble them onto the timeline. (Walk around the room to gauge student understanding. Listen and guide students in the understanding of the chronological environmental changes.) Allow students 20-30 minutes to work without resources, using only their prior knowledge; announce when it is time for students to be allowed to use resources such as books and Internet (if available). Make certain you have books available that will meet the needs of this activity (i.e. history of Ohio). After giving students time to complete the timeline activity in their small groups, use an overhead, chart paper, Elmo, or smart board to allow students to agree as a whole class on the correct chronology.

After completion of the timeline activity elicit discussion about the pollution and recovery of Lake Erie. There is a short two-page document for students to read entitled "Who Killed Lake Erie" and a video about a Kent State project studying Lake Erie's water quality. Questions for discussion may include:

1. What indicators made scientists say that the lake was dead?
   Low in oxygen and high in pollution and algae
2. What were some factors that caused the situation?
   A consequence of geology, human use/abuse, and geometry of the lake: lake is bordered by an especially large number of major cities, each of these contributed both sewage and industrial wastes to the lake; Lake Erie's area is large and its volume of water is low, especially in relation to the waste discharges, making it especially vulnerable to pollution.
3. How long did it take for the lake to go from healthy to unhealthy? To become more healthy again?
   Some pollution was observed as early as the 1920s. Matters grew progressively worse until the early 1970s, when neighboring states were shocked into action by the lake's appalling condition. The cure is incomplete. Once a widely cited environmental disaster, Lake Erie is now acclaimed as a dramatic example of the kind of environmental recovery possible with concerted efforts.
4. How is the health of the rivers, lakes and creeks near our area?
   Answers will vary but Grand Lake St. Marys should come up.
5. Are the lakes and/or the rivers near your home still in danger? *Yes.* From what?
   Fertilizers, salt from roads, sewer systems, septic systems, etc.

These questions can be done as a whole class orally or students may write answers in their science notebooks. Then have a whole class discussion. This is a good time to open the discussion to the Grand Lake St. Mary's blue-green algae toxin problem. An Ohio EPA FAQ Sheet from September 2010 provides excellent information.

Make sure students understand how water travels underground in the water cycle. Show animated video on ground water and pollution. "The Story of Groundwater" http://www.groundwater.org/kc/groundwater_animation.html

Other web sites:

http://earthguide.ucsd.edu/earthguide/diagrams/groundwater/index.html
http://www.leapingmedia.com/groundwater.html
http://epa.gov/climatechange/kids/water_cycle_version2.html

Share information about aquifers and watersheds with students, especially concerning pollution and its remediation. An interesting and interactive online game about watersheds could be used at this time. Make sure students understand a watershed. Students may retrieve information, conduct a search of resources, or review information that you provide. Class text could also be a resource. The EPA website could be used as part of instruction: http://epa.gov/climatechange/kids/water_cycle_version2.html

Building a model watershed. See Attachment C, Directions to Build a Model Watershed and decide if you want to build one teacher demonstration model or allow the students to build models in small groups. If at all possible, allow students to build their own in small groups; this will provide a wide variety of terrains for all groups to view during the whole class discussion.

Once the model(s) are built, run the simulations (see Attachment D). Allow students to decide which pollutants will occur at what locations in the watershed.

Make sure students understand the difference between point and non point source pollution. Point source pollution is that which can be attributed to a single source (such as a factory exhaust pipe), whereas non point source pollution is that which accumulates in watershed run-off, from a variety of sources (such as animal waste and fertilizers).

Have students respond to the following in their science notebooks:

1. Describe the difference between point source pollution and non point source pollution.
2. Identify the key events that occurred in our watershed simulation.
3. To clean up this environment, describe the problem you would chose to take care of first and explain your reasoning.

When students are done recording their answers, have them share their answers and ideas with the class. Write these on the chalkboard, overhead, or smart board. Ask if anyone thought of any other ideas and include these. Doing nothing to the environment is an option.

Lead a discussion among students about the changes that each environmental event encountered in the watershed demonstration has on the water quality and/or the people living in their own community. List both positive and negative changes on the board. This is a brainstorming session and all answers should be considered acceptable. No evaluative statements should be made by the teacher.

After the students have identified environmental impacts on watersheds and have discussed ways to clean up the environment, discuss how communities clean their water supply. Put students into small groups to design a filtration device that will clean dirty or polluted water. See Attachment E - “Which Materials Filter Water Best?” (Teacher should prepare dirty water solution in advance.)

Place a piece of nylon fabric over the narrow opening of the plastic bottle, and secure it with a rubber band. Then place the plastic bottle in the beaker upside down. Cut off the bottom end of the bottle (the end facing the ceiling).

Write a description of the dirty water before it is filtered through any materials.

Study the materials provided (you can have students bring in additional materials) and design a process to use the materials to filter dirty water. Once your process has been approved by your teacher, begin testing the materials. It is recommended that the students test the materials individually (manipulate one variable at a time) with only a layer of gravel at the bottom of the filtration system. They should use small, equal amounts of dirty water with each test, save and label the resulting filtered water, and compare them when testing is completed. The gravel and nylon should be rinsed after each test.

Once the small groups have tested a minimum of three different materials, gather them together to report their results to the whole class. This allows everyone to benefit from all the experimental results.

Now task the small groups to design a filtration system with three layers of materials above the gravel and use the layers in the order they believe will be most effective. Students must provide a sketch that shows their filtration system and labels the layers of the materials used. Explain why you picked the materials used.

Testing of the filtration systems should be done as a whole group. All small group systems should be brought to the front of the class for the final test. The sketch should be shown to the whole class, then the dirty water should be poured through the system and observations should be made by all students. Groups should answer the following on a separate piece of paper or in their science notebooks.

Describe the water after filtration. Comparisons can be made between groups.

What revisions/improvements would you recommend for the next filter design?

Provide class time for re-design/improvements of filter designs. Testing should be done within the small groups this time and comparisons should be made to the tests from the first set of designs.

Background Information

Aquifers are underground reservoirs whereas lakes, streams, and oceans are surface reservoirs. A watershed is a land area that drains water to a common surface reservoir. Groundwater runoff feeds aquifers, watersheds, and surface reservoirs. The water that reaches an aquifer is usually much cleaner than the water in surface reservoirs because many of the pollutants are filtered out as the water passes through the layers of soil, clay, sand, gravel, rock, etc. Almost no bacteria live in aquifers. Unlike surface reservoirs there is no silty mud to cloud the water, no pollution from boaters, and no evaporation of the water supply by the sun.

Many communities obtain their drinking water from aquifers or surrounding lakes or rivers. Water suppliers or utility officials drill wells through soil and rock into aquifers to supply the public with drinking water. Homeowners who cannot obtain drinking water from public waters have private wells that tap the groundwater supply. Unfortunately, groundwater can become contaminated by improper use or disposal of harmful chemicals such as lawn care products and household cleaners. These chemicals can percolate down through the soil and rock into an aquifer—and eventually into the wells. Such contamination can pose a significant threat to human health. The measures that must be taken by well owners and operators to either protect or clean up contaminated water supplies are quite costly, but necessary.

Law of Conservation - There was the Law of Conservation of Matter and the Law of Conservation of Energy. Once nuclear fission and fusion disproved them as separate laws, they were combined into the Law of Conservation of Matter and Energy which states that you cannot create or destroy matter or energy, but you can convert one to the other. For example, with nuclear fission you convert matter to energy, and with nuclear fusion you convert energy to matter.

Instructional tips

Invite the local Soil and Water Conservation District spokesperson to come in and talk about water, soil and air quality in your area. Most will have a demonstration model of a watershed (or aquifer) and some excellent activities on point and non point source pollution.

Local parks usually have information available, too. A good place to start your search for information is at the Environmental Protection Agency's Web site, http://www.epa.gov

Assignment of Student Roles and Responsibilities:

Students will all assume the same role:

Role Name	Brief Description
Engineer	Responsible for performing experimental tests, manipulating equipment safely & properly, recording qualitative observations and data, writing results and reevaluating filter.

Student Instructions

Time line activity – "Events in the Life of a Lake" – Attachment B provides directions for students.

Filter Model – "Which Materials Filter Water Best?" – Attachment E provides directions for students – Attachment F: Rubric for Water Filter Project

Formative Assessments

Students will demonstrate their grasp of the content by the teacher doing informal evaluation as he/she moves around the room during group work and during classroom discussion. The students will be given a post-test and a rubric will be used for the performance assessment of the filter.

Post-Activity Discussion

Classroom discussion of the class projects will drive this discussion. Discuss what designs worked best and why.

Discuss the importance of conserving water and not polluting our water supply. Remind students what they have learned about the path water takes through the water cycle. What happens above the ground can potentially affect our drinking water supply below the ground and what happens to wastewater in most communities. Polluting our water supply can pose a significant threat to human health. The measures that must be taken by well owners and operators to either protect or clean up contaminated water supplies are quite costly, but necessary.

Pre-Test / Post-Test

See Attachment A.

Pre-Test / Post-Test Rubric

See Attachment A.

Technology Connection

The **ADISC** Model of technology created by ITEL:

	Integration Model	**Application Description**
A	Technology that supports students and teachers in **adjusting, adapting, or augmenting** teaching and learning to meet the needs of individual learners or groups of learners	Classroom strategies and instruction can be supported by using the Internet, an interactive white board or an Elmo in lessons
D	Technology that supports students and teachers in **dealing effectively with data**, including data management, manipulation, and display	MS Word MS Excel
I	Technology that supports students and teachers in conducting **inquiry**, including the effective use of Internet research methods	Information about watersheds is available through the Environmental Protection Agency's Web site, at http://www.epa.gov Follow link to "Water", and then link to the "Surf Your Watershed" feature
S	Technology that supports students and teachers in **simulating** real world phenomena including the modeling of physical, social, economic, and mathematical relationships	Real-time and historic weather data are available through the National Oceanic and Atmospheric Administration's Web site, at http://www.noaa.gov Follow the link to "Weather", and then access the appropriate national weather stations.
C	Technology that supports students and teachers in **communicating and collaborating** including the effective use of multimedia tools and online collaboration	Teachers may permit students to use a computer program to present their filtration system to the whole class.

Interdisciplinary Connection

Social Studies – You may want to work with a social studies teacher to help familiarize students with timelines.

Language Arts – Write an essay that is based on events in the time line and what students saw happening on the watershed model. The essay could begin with a statement of conditions as they may be 50 years in the future. Conditions could include things such as your home, family, luxuries, vacation destinations, scenic views (this is not a complete list of examples - be original). The writing also specifies whether human intervention has played any role in the environment for better or worse. It is also very important to explain how Earth's natural systems have played a role (for better or worse) in this future world

Mathematics – If lesson extensions such as a pond survey are used, students have the chance to use math skills, including counting, multiplying, dividing, algebra and estimation.

Home Connection

Have students' interview parents and grandparents about environmental changes they have seen. Have the students share this information with the class.

Differentiated Instruction

Differentiate instruction during the activity/unit by altering group sizes.

Some students can also make their own watershed model, test different types of pollution, and explore how easy it is to trace the origin of different sources of pollution.

The water filter project can be structured more for students struggling with the content.

More advanced students could design a second step to clean water after the filtration process.

Extension

A video is available from LabTV entitled "Save the Bay: Robotics Challenge" (http://www.ndep.us/LabTV-SeasonOne). In this video students worked primarily on designing and building functional robots with a focus on the robots solving environmental problems specific to the Chesapeake Bay.

Graph temperature fluctuations for a specific month over a ten-year period, using records available over the Internet. The Web site for the National Oceanic and Atmospheric Administration, at http://www.noaa.gov, is a good place to search for this information.

Visit a stream or pond in your community and conduct an assessment, including water quality and biotic diversity.

Bring in pond water and have students examine it for macro invertebrates and micro invertebrates. Keep it in the classroom for several days. Have students note what changes take place. Then, add an aerator and have them note the changes. They should see different activity levels of organisms in anoxic and oxygen-rich conditions

Have students design a water treatment system by using the best ideas presented in class. Have them include steps needed for coagulation, distillation, and filtration.

EPA – "Surf Your Watershed" activity. Students will find a local watershed using this site. Once they locate the watershed, they will locate "citizen-based groups at work in this watershed," to find a listing of organizations that are working to protect water quality. You may wish to contact one of these groups to find out about cleanups, monitoring activities, restoration projects and other activities.

Career Connection

Water Quality Researcher, Geoscientists, Hydrologists, Civil Engineer, Structural Engineer, Materials Engineer, Biologist, Biological Engineer, Agricultural Engineer, Environmental Engineer

Additional Resources

Resource:	Purpose and Application:
The first portion of this lesson is an adaptation of the “Containment Cycling Through Earth Systems” lesson provided by the Ohio Department of Education.	http://dnet01.ode.state.oh.us/IMS.ItemDetails/LessonDetail.aspx?id=0907f84c805329d0
Local Soil and Water Conservation District (SWCD) office or the Ohio EPA office and/or Web site	Teachers needing additional background information will find resources that will help
The EPA’s web site – www.epa.gov	This web site has a lot of back ground information and information that can be used during the lesson. It can also be used for remediation and enrichment activities
http://www.epa.gov/safewater/kids/flash/flash_filtration.html	Provides a lesson on the water filtration process used by water treatment plants.

Credits

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Teacher Reflections

- Were students focused and on task throughout the lesson? *Insert answer here.*
- If not, what improvements could be made the next time this lesson is used? *Insert answer here.*
- Were the students led too much in the lesson or did they need more guidance? *Insert answer here.*
- Did the students learn what they were supposed to learn? *Insert answer here.*
- How do you know? *Insert answer here.*
- How did students demonstrate that they were actively learning? *Insert answer here.*
- Did you find it necessary to make any adjustments during the lesson? *Insert answer here.*

- What were they? *Insert answer here.*
- Did the materials that the students were using affect classroom behavior or management? *Insert answer here.*
- What were some of the problems students encountered when using the …? *Insert answer here.*
- Are there better items that can be used next time? *Insert answer here.*
- Which ones worked particularly well? *Insert answer here.*

Additional Comments

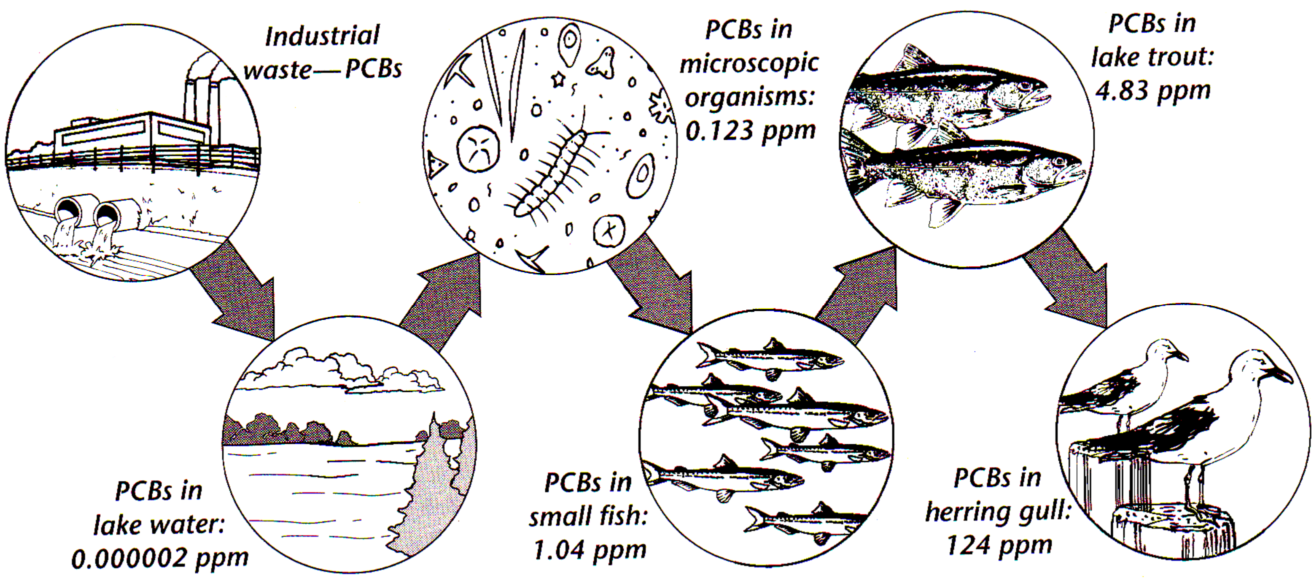
Attachment A

Pre-Test / Post-Test – Answer Key

Multiple Choice: Circle the letter of the BEST response (1 pt each).

1. The amount of one substance in a certain volume of another substance is called a
   - A. drought
   - B. concentration
   - C. filtration
   - D. coagulation
2. Wastewater and the different kinds of waste in it are called
   - A. sludge
   - B. groundwater
   - C. sewage
   - D. infiltration
3. Any substance that causes water pollution is called a
   - A. contaminant
   - B. groundwater
   - C. watershed
   - D. precipitation
4. What is the correct order of this simplified water cycle?
   - A. Surface runoff, precipitation, condensation, evaporation/transpiration
   - B. Condensation, precipitation, surface runoff, evaporation/transpiration
   - C. Evaporation/transpiration, precipitation, surface runoff, condensation
   - D. Precipitation, condensation, surface runoff, evaporation/transpiration
5. Which of the following would be a correct path that water might take during its recycling?
   - A. Leaves, sky, clouds, precipitation, runoff, river, ocean
   - B. Rain, infiltration, percolation, groundwater, well, home, waste water treatment plant, river, sky, clouds
   - C. All of the above
   - D. None of the above

6. Which of the following is an example of a point source of water pollution?
    A. Runoff of pesticides from wheat fields
    B. Runoff of salt spread on roads and parking lots to melt ice
    C. Chemicals from a factory flowing into a stream
    D. Fertilizers from corn fields that runoff into streams
7. Many farmers apply chemical fertilizers to their soil to help crops grow or to produce more. Which of the following is a negative impact that fertilizers could have on human living conditions?
    A. The fertilizers dry out the soil and make it more vulnerable to wind erosion.
    B. The fertilizers pass into groundwater and pollute people's drinking water.
    C. The fertilizers damage the ozone that protects the earth from harmful radiation.
    D. The fertilizers can make the crops mutate and grow too much.
8. **Short Answer: (2 points)**. PCBs are a type of industrial pollutant. Refer to the flow chart and explain how humans could be affected by PCB pollution; and identify whether the origin of this pollutant is a point or non-point source.



RUBRIC	
2 points	Student correctly explains one way humans could be affected by PCB pollution based on the information given by the flow chart (i.e. contamination of drinking water, eating contaminated fish or herring gull) and indicates that the type of pollution in the flow chart originates from a **point** source.
1 point	Student only provides part of the answer. Type of pollution source is indicated **OR** how humans can be affected by this PCB pollution.
0 points	Student's answer does not address the question.

Pre-Test / Post-Test

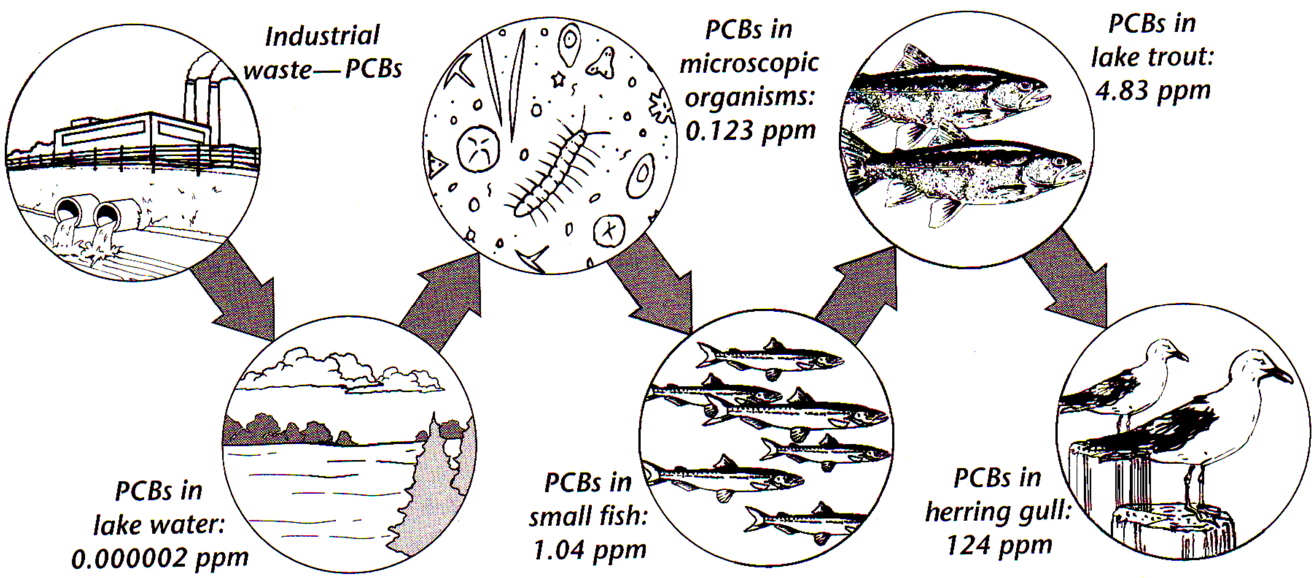
Multiple Choice: Circle the letter of the BEST response (1 pt each).

1. The amount of one substance in a certain volume of another substance is called a
   A. drought
   B. concentration
   C. filtration
   D. coagulation
2. Wastewater and the different kinds of waste in it are called
   A. sludge
   B. groundwater
   C. sewage
   D. infiltration
3. Any substance that causes water pollution is called a
   A. contaminant
   B. groundwater
   C. watershed
   D. precipitation
4. What is the correct order of this simplified water cycle?
   A. Surface runoff, precipitation, condensation, evaporation/transpiration
   B. Condensation, precipitation, surface runoff, evaporation/transpiration
   C. Evaporation/transpiration, precipitation, surface runoff, condensation
   D. Precipitation, condensation, surface runoff, evaporation/transpiration
5. Which of the following would be a correct path that water might take during its recycling?
   A. Leaves, sky, clouds, precipitation, runoff, river, ocean
   B. Rain, infiltration, percolation, groundwater, well, home, waste water treatment plant, river, sky, clouds
   C. All of the above
   D. None of the above

6. Which of the following is an example of a point source of water pollution?
   - A. Runoff of pesticides from wheat fields
   - B. Runoff of salt spread on roads and parking lots to melt ice
   - C. Chemicals from a factory flowing into a stream
   - D. Fertilizers from corn fields that runoff into streams

7. Many farmers apply chemical fertilizers to their soil to help crops grow or to produce more. Which of the following is a negative impact that fertilizers could have on human living conditions?
   - A. The fertilizers dry out the soil and make it more vulnerable to wind erosion.
   - B. The fertilizers pass into groundwater and pollute people's drinking water.
   - C. The fertilizers damage the ozone that protects the earth from harmful radiation.
   - D. The fertilizers can make the crops mutate and grow too much.

8. **Short Answer: (2 points)**. PCBs are a type of industrial pollutant. Refer to the flow chart and explain how humans could be affected by PCB pollution; and identify whether the origin of this pollutant is a point or non-point source.



Attachment B

Events in the Life of a Lake*

Directions: Cut out the events and place them on a time line in the appropriate order and spacing. You can cut or glue them down. You may want to use a longer sheet of paper or adding machine tape for your time line. It should extend forever in both directions (show with arrows) and should be divided into 50-year intervals from 1650 to 2050. Include the following dates: 1669, 1820, 1970, 1936, 1969, 1970s, 1972, 1988 and present day. Some events may fall on the same date; some may fall between some of the dates listed.

- President Nixon of the United States and Pierre Trudeau of Canada sign the Clean Water Act.

- Human population increases dramatically. Raw sewage (oil, sawdust, animal carcasses, and human waste) are dumped directly into the lake.

- Mills built to grind corn and wheat on most of the streams and rivers leading into the river.

- Population of fish species that need to migrate to spawn are reduced or eliminated.

- Phosphorus used in soaps causes algae to bloom and over populate.

- A nearby river catches fire.

- The lake is considered one of the cleanest of its size or larger.

Attachment B Continued

- Consumers are warned not to eat catfish over 16 inches caught anywhere on the lake.

- A nearby river catches fire for the second time.

- The lake is declared dead as dead fish and decaying algae ring the shores. (Bacteria on decaying algae consumed oxygen in the lake, effectively suffocating many fish).

- Ohio passes a ban on the sale of detergents containing phosphorus.

- The first European sees Lake Erie.

- Thousands of acres of wild rice grow at the mouths of the rivers feeding the lake, acting as filters for sediment.

- The lake is popular for boating, fishing and swimming.

- The lake is still in danger from continued non point source pollution and past pollution by PCBs, dioxin, mercury, and DDT.

* "Containment Cycling Through Earth Systems" from the Ohio Department of Education - http://dnet01.ode.state.oh.us/IMS.ItemDetails/LessonDetail.aspx?id=0907f84c805329d0

Attachment B

Teacher Answer Sheet for Events in the Life of a Lake

1. First European sees Lake Erie. (1669)
2. Thousands of acres of wild rice grow at the mouths of the rivers feeding the lake, acting as filters for sediment. (pre- 1820)
3. Human population increases dramatically. Raw sewage (oil, sawdust, animal carcasses, and human waste) dumped directly into the lake. (1820s)
4. Mills built to grind corn and wheat on most of the streams and rivers leading into the river. (1820s)
5. Population of fish species that migrate to spawn are reduced or eliminated. (1820s)
6. The Cuyahoga River catches fire. (1936)
7. Phosphorus used in soaps causes algae to bloom and over populate. (1960s)
8. The Cuyahoga River catches fire for a second time. (1969)
9. Lake Erie declared dead as dead fish and decaying algae ring the shores. (Bacteria on decaying algae consumed oxygen in the lake, effectively suffocating many fish). (1970)
10. President Nixon of the United States and Pierre Trudeau of Canada sign the Clean Water Act. (1972)
11. Ohio passes ban on the sale of detergents containing phosphorus. (1988)
12. Lake Erie considered on of the cleanest of the Great Lakes. (present time)
13. Lake Erie is popular for boating, fishing (walleye, pike, trout, perch, others) and swimming. (present day)
14. Lake Erie still in danger from continued non point source pollution and past pollution by PCBs, dioxin, mercury and DDT. (Trapped in the sediment, biomagnification.) (present day)
15. Consumers are warned not to eat catfish over 16 inches caught anywhere in Lake Erie. (present day)

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Attachment C

Directions to Build a Model Watershed

Watersheds are those land areas that catch rain or snow and drain to specific marshes, streams, rivers, lakes or to ground water. You can buy models of watersheds or you and your students can work together to make models. Building models will help students take more ownership in the unit and begin to understand how a watershed works.

To build a model of a watershed, you will need the following materials:

- garbage bags (for clean up)
- papier-mâché (plants) or other plastic item to represent plants
- blocks or other representations of factories, cars, houses and agricultural areas
- large plastic containers at least three inches deep
- potting soil
- sand
- clay
- powdered drinks (types of pollution)
- powdered soap
- cocoa (animal waste and sewage)
- spray bottles or small watering cans (for rain)
- clear plastic containers marked at ½-and ¾-level (for a pond)

Model Watershed Construction

1. Obtain a large plastic container, at least three inches deep, in which to build your model.
2. Place the container (pond) where desired.
3. Build terrain up and around the container using potting soil, sand, and clay. Make sure you can take out and replace the pond container easily.
4. Model terrains may include an area of forest where logging will take place, an agricultural area, urban/suburban storm water runoff, household and automotive care, a factory site and a construction site. Water that washes from these areas should converge in a small pond represented by the clear container. This should be the lowest point in your model.
5. Spread dry papier-mâché (or whatever represents plants) to represent forest or other vegetation. To show where logging takes place, clear away some of the papier-mâché to leave bare ground.
6. Complete your model with objects to represent trees, homes, cars, factory, and construction site. The pond should be half-full of water.

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Attachment D

Model Watershed Simulation

Teacher Demonstration

1. Allow students to decide where to place pollutants. Ideas should include most of the following:
   - Dirt near the farm and under the forest area and the construction site;
   - Cocoa (animal waste) in the farm area and near the homes;
   - Powdered soap near the homes;
   - One color of the powdered drink mix for pollution near the factory;
   - A powder of another color to represent lawn care products.

2. When pollutants have been placed, review with students the concepts of point source pollution and non point source pollution. They should be able to identify possible sources on the model. Factory pollution is usually point source. Pollution from neighboring homes is usually non point source.

3. Next, explain to students that it is going to rain. Ask them what they think will happen. Any answers are acceptable, but the use of the term watershed and point source and nonpoint pollution should be included in the discussion.

4. Have a student volunteer to use the spray bottle or watering can. It should rain until the pond is about three-quarters full.

5. Ask students what they observe. Have someone write the observations on the board.

6. Ask students the following questions, which will also be answered on the board or on a separate piece of paper.
   - How will we clean up the mess? (Run water over it until it is clean).
   - What happens to the water we use to clean up? (Down the drain and finally back into the water cycle).
   - Will it still be polluted when it goes back into the water cycle? Why or why not? (No pollution or little pollution, will be present in the water. Pollutants will be removed by our water treatment plants before the water is returned to the cycle.)

* "Containment Cycling Through Earth Systems" from the Ohio Department of Education - http://dnet01.ode.state.oh.us/IMS.ItemDetails/LessonDetail.aspx?id=0907f84c805329d0

Attachment D – Alternative

Watershed Directions for Student-Made Models

Continued

Student Trials

If student groups have built their own models, ask each group to choose or assign each group one contaminant. They should record their results so that they can report briefly to the class.

Directions:

1. Have students fill their ponds ½ full of water.
2. Have students spill their contaminants in appropriate areas.
3. Have students use their spray bottles or small watering cans to let it rain until their ponds are ¾ full.
4. Have students take visual readings for clarity of their ponds. They will rate their ponds on a scale of 0 – 5. Five indicates that you cannot see through the water, whereas zero is perfectly clear.
5. Have students continue to "rain" until the pond is ¾ full. Pour the water out of the pond until it is only half full. Repeat these steps five times, to represent five years of rainy seasons.

Discussion:

1. Have students report out to the class, answering the following questions:
   - How does your pond look now?
   - Did anything about this activity surprise you?
   - How could you make the cleanup process easier or faster?
2. Depending on time constraints, you may want students to make simple line graphs to show how the clarity of the pond changed over the simulated years.

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Attachment E

Which Materials Filter Water Best?

Problem: Which materials filter dirty water best?

Observe the dirty water. Record some qualitative observations about the dirty water before it is filtered through any materials.

Materials: *Must use a combination of 3 materials in your final design.*

dirty water* (approximately 1-L)

2-L clear plastic bottle (with bottom cut off)

large beaker

nylon fabric

rubber band

fine sand

gravel of various sizes

charcoal

coffee filter (to be used to keep sand and gravel separate)

fabric pieces (burlap, felt, cotton, leather, silk, vinyl, etc.)

cotton balls / cotton squares / cotton pads

Devise a Plan:

1. Place a piece of nylon over the narrow opening of the plastic bottle, and secure it with a rubber band. Next place the plastic bottle in the beaker, narrow side down into the beaker. If not already done so, cut-off the end of the bottle facing towards the ceiling.

2. Study all the filtration materials provided (including the ones you brought in) and design a process to use the materials to filter dirty water. Once your process has been approved by your teacher, begin testing the materials.

3. Test as many different materials as possible in the time allowed, testing a minimum of three different materials. Be sure to record your observations because you will be sharing them with the whole class.

4. Small groups share results of materials testing with whole class.

5. Design and build a water filtration system with three layers of materials above the gravel. DO NOT TEST THIS SYSTEM. The water filtration systems will be tested with the whole class. Use the materials in the order you believe will be most effective. Sketch your filtration system, labeling the layers of the materials used. Explain why you picked those materials.

6. When it is your turn, bring your sketch and your water filtration system to the front of the class. Present your system to the class using the actual model and the sketch. The dirty water can now be poured through your system and observations should be made by all students.

7. Respond to the following in your science notebook:

   Describe the water after filtration. Comparisons can be made between groups.

   What revisions/improvements would you recommend for the next filter design?

8. Go back to your small group and re-design/improve your water filtration system.

9. Testing should be done within the small groups this time and comparisons should be made to the tests from the first set of designs.

Attachment F

Water Filter System Rubric:

Category	4	3	2	1
Design of Filter System and Justification of Materials Included	Filter is clearly sketched with at least three different materials included and justification of materials is provided	Filter is clearly sketched with at least three different materials included and some justification of materials is included.	Filter is clearly sketched with only two materials included and some justification is included	Filter is sketched, but no justification of materials is included.
How Filter Worked	Filter thoroughly cleaned and recovered close to the amount of water put in filter.	Filter adequately cleans and recovers ¾ to ½ of water.	Filter partially cleans and recovers at least ½ of water	Filter minimally cleans and recovers less than ½ of water.
Classroom Presentation of the Filter	Makes a thorough and interesting presentation of filter that includes a clear explanation of design, how clean water was, and revision.	Makes a thorough presentation of filter that includes an adequate explanation of design, how clean water was, and revision.	Makes a presentation of filter that includes a partial explanation of design, how clean water was, and revision.	Makes a presentation of filter that includes a weak or confused explanation of required information.