What's in the Water?

What is pollution and how does it effect the environment? Conduct an experiment to observe the effects of multiple sources of pollution.

Concepts
- There are many different forms of water pollution.
- Human activities are a primary cause of water pollution.
- Some forms of pollution have a definite point at which they enter the water, while others do not.
- Water pollution can affect plants and animals and humans.

Objectives
- Students will be able to test the effects of several common household chemicals that frequently find their way into aquatic environments.
- Students will be able to classify pollution sources.

Duration
Takes place over the course of a month. Set up about two weeks ahead of experiment.

Method
Experimentation, observation, evaluation, and discussion

California Science Content Standards
5. Chemical reactions are process in which atoms are rearranged into different combinations of molecules. Students know how to determine whether a solution is acidic basic or neutral.
6. Chemistry of living systems. Principles of chemistry underline the effect of biological systems.
9. a. Plan and conduct a scientific investigation to test a hypothesis.
b. Analyze and replicate data
c. Distinguish between variable and controlled parameters in a test

Background

Waterways such as rivers, lakes, and estuaries are important to humans and wildlife alike. Waterways are used for drinking water, transportation, recreation, and as a habitat for many wildlife species. Approximately 40 percent to our nation's rivers, lakes, and estuaries are not fishable, swimable, or potable because of pollution (Source: American Rivers). Pollutants enter waterways from either point or non-point sources. Point sources are clearly defined, localized, inputs such as pipes, industrial plants, sewer systems, and oil spills. Federal and state governments monitor and regulate pollution from point sources. Unfortunately, non-point sources are harder to detect and control, so they are therefore the major source of water quality problems. Non-point sources are indistinct inputs that do not have a clearly defined source, such as runoff of petroleum products from roadways or pesticides from farmlands.

Non-point source pollution occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into surface water or introduces them into ground water. Agriculture, forestry, grazing, septic systems, recreational boating, urban runoff, construction, physical change to stream channels, and habitat degradation are all potential sources of non-point source pollution. Agriculture is the leading contributor to water quality impairments, degrading 60 percent of the nation's rivers and lakes. Runoff from urban areas is the largest source of water quality impairments to the nation's estuaries (Source: U.S. Environmental Protection Agency [EPA]).

The most common non-point source pollutants are sediment and nutrients. These pollutants enter waterways from agricultural land, animal-feeding operations, construction sites, and other areas of disturbance. Other common pollutants are pesticides, herbicides, pathogens, oil, toxic chemicals, and heavy metals. Unsafe drinking water, fish kills, destroyed habitat, beach closures, and many other severe environmental and human health problems result form these water pollutants (Source: EPA Office of Water).

Pollution can be categorized into the following types:
- **Chemical Pollution:** The introduction of toxic substances into an ecosystem (e.g., acidic precipitation, contamination of water supply by pesticides).
- **Thermal Pollution:** Varying temperatures above or below the normal condition (e.g., power plant turbine heated water).
- **Organic Pollution:** Oversupplying an ecosystem with nutrients (i.e., fertilizer inflow).
- **Ecological Pollution:** Stresses ordinarily created by natural processes, such as:

Materials

Two Weeks Before Class

1. Four clear containers one quart or more (plastic soft drink bottles or canning jars)
2. Water with algae from a freshwater aquarium or pond, or purchased pond water from a biological supply company
3. Plant fertilizer such as Peters or other well-balanced mix (the dye in most of these will fade when exposed to light)
4. Aged tap water (let it sit 48 hours)
5. Good light source, either indirect sunlight or strong artificial light

During Class

1. "Pollutants" of choice by students; the safest to handle might include detergent (not green), motor oil, vinegar
2. Camera and roll of 12 exposure print film (35mm or Polaroid best) or digital camera

Preparation

Collect materials, determine and collect chemicals to use in experiment

1. Adding a substance that is not a naturally occurring substance in the ecosystem (e.g., extreme tides pour saltwater into habitats ordinarily protected from salt water)
2. Increasing the amount or intensity of a naturally occurring substance (e.g., abnormal increase in sediments in runoff water to produce silt)
3. Altering the level or concentration of biological or physical components of an ecosystem (changing the amount of something that is already there) (e.g., introduction of aquatic plants via bird droppings, etc.)

In the definitions above, chemical pollution through the introduction of toxic substances is clearly caused by humans. Organic pollution in lakes and rivers typically results when chemical fertilizers used in agriculture enhance living organisms. Thermal pollution is predominantly human caused through nuclear power plants, fuel-based electrical power production and many industries. Some hydroelectric dams also produce unnaturally cooled water with bottom discharge of water.

Surprisingly, these three forms of pollution – chemical, thermal, and organic – can take place without human intervention. When pollution takes place without human intervention, it is most often ecological pollution. Natural ecological pollution may be beneficial, harmful, or have no effect on wildlife and wildlife habitat. Examples include acidic precipitation resulting from volcanic eruptions, runoff from landslides, and avalanches sometimes killing plant and animal life, hot springs and geysers heating water above normal temperatures in lakes and streams, and shifts in oceanic currents affecting water temperature and weather patterns.

The state and federal governments have made advances to control water quality by regulating, monitoring, and enforcing clean water programs. Some recent examples of federal government water pollution control programs are the 1987 Clean Water Act, Amendments to the 1977 Clean Water Act, and the 1990 Coastal Zone act Reauthorization Amendments. Public and private businesses are using more pollution prevention and pollution reduction initiatives to control water pollution. More citizens are also practicing water conservation and participating in more community area cleanups (Source: EPA Office of Water).

Introduction

This exercise is spread out over about one month. It takes a simplistic look at the effects water pollution has on aquatic systems. Use several household chemicals that are safe and that students pour down the drain without thinking. The results vary with your choice of materials. Students should enjoy checking daily for changes. To be scientifically correct, you should do two of each test, which would double the number of jars needed.

Activity

Before Class

Set up the bottles or jars at least two weeks before the experiment begins. Fill the jars with aged tap water. Add one teaspoon of plant fertilizer to each jar and stir it thoroughly. The plants need some nutrients to grow. Nutrients are found in all natural systems (if possible add pond water). Try a bit of soil

from the bottom of a pond or gravel from your aquarium tank along with the water. Put the jars near a window where they will get good indirect light or give them strong incandescent or fluorescent light. Do not place them in a location that gets very cold. Take intitial photographs as soon as changes start to show, date photographs.

When pollutants are selected, be careful to consider safety. Animal products of any kind could grow dangerous bacteria. Do not cover jars tightly as you might grow some undesirable bacteria this way. Regular household items should do fine. Vinegar is an acid which acts as acid rain or an acid discharge such as the "pickling liquor" from steel production or the run-off of acid from strip mines. Detergent is a common component of human sewage. Motor oil is commonly poured down storm drains. Regardless of what you use, make all your observations without coming into contact with the water and dispose of the material carefully after the experiment is over.

During Class

Start with a classification exercise on the blackboard, explaining that you want the students to see if they can organize what they already know about water pollution. Explain that some water pollution comes from specific sources such as outfalls (drains, pipes, effluent from the industry, etc.). This is called point source pollution. Other kinds come from many widespread sources (called non-point source pollution). Write those words at the head of two columns and have the students begin to suggest things that pollute water. Put them in the general categories found in the chart given in the Information for Teachers handout. Students will not name everything on the list.

Explain that they are going to test some pollutants on model water environments. Would it be acceptable to test them by dumping them in a natural environment? No. Models are used for tests to avoid damaging the natural world. Show the students the jars with algae growing in them. Now what does the class choose to test for its effect on an artificial water environment? Let them decide with guidance. For example, if a child wants to test the effect of a dangerous compound, try to discuss why that might not be safe in the classroom environment. Settle on three pollutants. The fourth set of jars is a control.

When the class has decided what to test, you may have to wait until the following day to add the material, since it might have to come from home. Add a reasonable amount: two tablespoons of a strong detergent; enough motor oil to just cover the surface; ¼ - ½ cup of vinegar. Ask the students to explain how each pollutant could get into the environment "in real life." Leave the jars or tanks in the light as before. Have the children write their predictions for what will happen to each test container. Two or three times each week for several weeks photograph the jars with labels and a date showing. If possible, use pH paper to test acidity or alkalinity of the water, and document the results.

Results

These depend on what you used. A few kinds of pollutants favor plant growth and will cause an algal population explosion. This is not healthy as it disrupts the balance of organisms. When the algae die, the oxygen is used as they

decompose. Ask the class: Name some plants and animals that would be affected by this situation. What do you think would happen to them? Some examples: oysters and clams will suffocate, since they cannot move to a place with more oxygen; a thick mat of algae will block out sunlight that other aquatic plants need for growth.

Other pollutants, such as acids, will cause very clear water because they kill everything in it. Needless to say, they are not good for natural systems either. How would plants and animals be affected by this situation? Obviously many would die.

The sample with an oil spill may do better than you expect. If the algae have enough sunlight, they may make enough oxygen to keep things alive below the oxygen impervious oil layer. If this were a larger spill, how would the animals that came in contact with the oil be harmed by it? Ducks and other water birds will be coated with oil and won't be able to fly; fish gills may be clogged by it; etc. When an oil spill occurs, it usually is big news. Why are oil spills so dangerous? It is because they can spread so far. To demonstrate, fill a long pan with water, drop a few drops of oil onto the surface and watch it spread out. Help it along by pretending it is a windy day or there is a current in the water (blow on the water).

Conclusions

Human activities which result in water pollution can affect water environments in ways that are very bad for natural communities.

Discuss with students what would happen if we used a different source of water. Evaluate the accuracy of the results. How was the test controlled?

Using Your Classroom Aquarium

Does your classroom aquarium grow lots of algae? If you feed fish, they will produce waste products which are very much like fertilizer. Have your students discuss the procedures you use to avoid water pollution in your classroom aquarium. You are careful not to overfeed the fish, you remove algae from the sides of the tank, and you do water changes, which reduce the level of waste.

Extensions

1.There are a number of social studies activities related to this experiment. Who regulates water pollution in your city, county, or state? What are the federal regulations on water quality? What is the impact of these regulations on industries? What are the greatest water quality problems in your local area? How do they affect the jobs and health of people living in your area? How do they affect the natural environment in your area? Have students research these topics.

2.Can any of the polluted systems be reversed and improved?
a.Countries such as Sweden have added lime to their acid lakes in an attempt to correct the acidic condition. Your students could use baking soda to turn their acid test back to a neutral environment. Use litmus paper to test for neutrality. Add new algae and see what happens.

b. Oil spills may be mopped up with straw, feathers, or cotton. Can they skim the oil off of their samples and let the oxygen get through again?

3.How might wetlands help to lessen the effects of the pollutants that we tested? Wetlands would have filtered a lot of the pollutants out before they got into the water (some pollutants are used by plants, others are stored in plant tissues or in the soil).

4. How could the wetlands be harmed by these pollutants? Large amounts of some toxic chemicals, including oil, could kill plants and animals living in wetlands

5.Discuss some ways to keep pollutants from ever reaching the water, or ways to reduce the amount that gets into the water.

Additional Resources

Recipe for Trouble (p 87-88) Wow!: The Wonders of Wetlands Environmental Concern, Inc.

What's in the Water? (p 140-144) Project WILD Aquatic K-12 Curriculum and Activity Guide © 2000 Council for Environmental Education

Storm water pollution prevention: www.cabq.gov/flood/swpp

Especially for kids: www.oceansidecleanwaterprogram.org/kids

Song for the Blue Ocean: Encounters along the World's Coasts and Beneath the Sea
Carl Safina, Henry Holt and Co., 1st edition 1998. ISBN 0805046712

Adapted by Friends of Ballona Wetlands from: What's in the Water (p 55-57) Living in Water ©1987 National Aquarium in Baltimore, 2nd Edition 1989

Information for Teachers

Pollution Sources Information		
Kinds of Pollution	**Point Source**	**Non-point Source**
disease organisms	human wastes from sewage treatment plants	failing septic systems; some problems where people camp or backpack
man-made and naturally occurring organic compounds	chemical manufacturing plants and disposal; oil spills	agricultural and lawn runoff containing pesticides, herbicides, and fertilizer
inorganic or mineral compounds; plant nutrients	mining and manufacturing electric power generation; sewage	agricultural and lawn runoff of fertilizer; runoff from paved areas
biological wastes that are oxygen in decomposition	human sewage, animal wastes, agricultural wastes, paper and food processing	runoff of livestock and pet manure
sediment	stormwater carrying eroded soil – from drains or washing directly off of land	erosion from development, fields, bare lawns, and unprotected shorelines
heated water	primarily from electrical generating plants, nuclear power plants; some from manufacturing	hot springs and geysers
radioactive material	mining, manufacturing, and accidental discharge and disposal	airborne following testing or an accident