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Abiotic Factors & Plants: A Local Pollution Study with Global Implications

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Introduction

Plant study is among the easiest and most cost effective units which may be employed by Integrated/Life/Earth Science educators. From a simple study of plants and interactions with their environment, students can examine how plants respond to pollutants which also affect us. From this simple study, students may discover and explore complex subjects, from local and global perspectives. Given information presented in this unit, Science, Math and Social Studies students can observe impacts of pollution on different plant types, describe how they contribute to local pollution, debate local land use issues, and describe how local actions effect and are effected by global changes.

This unit is written for Grade 7/8 integrated science curriculum. It is inquiry-based. Lessons and activities accommodate the City of New Haven_s performance standards, many of which are National Science Association standards. The unit includes laboratory investigations which prepare students for the CAPT Science Performance Task. The lab experiments are presented in CAPT format, requiring critical thinking, data analysis and reporting, and assessment and application.

Abiotic Factors & Plants examines environmental impacts on life--specifically plants. Students will complete individual experiments in which they manipulate factors for plant growth: space, soil, water, light, air and temperature. After discovering conditions which maximize growth, students may transplant their flowers, vegetables and herbs to a school/community garden. While outside, students will also observe factors which affect their plants which are not optimal, but are beyond their control. It is these outside, variable factors which will set the stage for an introduction on global interdependencies. For example, students will know carbon monoxide from nearby cars is not ideal air. However, local air currents and winds, like global winds, make their garden susceptible to damaging toxins.

Students will conclude diverse plant life is critical to their comfort, health and survival. They will identify their own use of plants, those grown locally and globally. Students will conclude plant health is critical to their giant ecosystem--planet Earth, and any pollutants that erode plant life harm the whole ecosystem.

Abiotic Factors & Plants includes a Life Science component in which students study plant anatomy and

processes necessary for survival. It includes an Earth Science component as students analyze different soils, water and global interdependencies given hydraulic and nitrogen cycles, and global winds.

We, and students, contribute to local pollution which affects the environment. However, cycles in nature, combined with global winds, makes us and our local environments suffer from global pollution elsewhere. For example, the Chernobyl incident contributed to radiation which damages plant life around the world; our Connecticut power plants and extensive use of cars contributes to acid rain which damages forests in other parts of the world as well. Students will debate a current issue which examines potential damages associated with local development. Students will examine benefits and environmental costs associated with one of the development proposals facing New Haven: Long Wharf Mall development, expansion of Interstate-95, or installation of a high-speed rail service to New York City.

Key concepts introduced and explored are: plant structure, function and use of abiotic factors; environment and ecology, including interdependencies on and within a system; contamination of air, land and water and its affect on various plants; costs and benefits of student demand and current development issues which contribute to pollution.

Plant Diversity and Importance

Wherever there is sunlight, air, and soil, plants can be found. On the northernmost coast of Greenland the Arctic poppy peeps out from beneath the ice. Mosses and grasses grow in Antarctica. Flowers of vivid color force their way up through the snow on mountainsides. Many shrubs and cacti thrive in deserts that go without rain for years at a time, and rivers, lakes, and swamps are filled with water plants.

The scientists who study plants--botanists--have named and described nearly 500,000 different kinds of plants. They estimate that another 500,000 undiscovered species exist in less explored ecosystems such as tropical forests. In addition, about 2,000 new kinds of plants are discovered or developed every year. Botanists have classified more than 350,000 organisms in the plant kingdom. One thing all plants have in common, however, and what separates and distinguishes them from other living things, is their ability to make their own food.

The cells of plants contain chlorophyll. Plants use chlorophyll to trap energy from the sun. They use this energy to combine carbon dioxide from the air and water from the soil to make food. This food making process is photosynthesis. Without photosynthesis, the replenishment of the Earth's fundamental food supply would halt, and the planet would become devoid of oxygen. During photosynthesis energy is used to convert carbon dioxide, water, and minerals from the environment into organic compounds and gaseous oxygen--the food we eat and the air we breathe. The process is exclusive property of the varied members of the plant kingdom.

Human beings are completely dependent upon plants. Directly or indirectly, plants provide food, clothing, fuel, shelter, and many other necessities of life. Mankind's dependence on crops such as wheat and corn is obvious,

but without grass and grain the livestock that provide people with food and other animal products could not survive either.

The food that plants store for their own growth is also the food that humans and other organisms need in order to live. In North America the chief food plants are cereal grains. Major cereal crops include corn, wheat, oats, rice, barley, rye, and buckwheat. Legumes are the second greatest source of food from plants. Legumes such as peas, beans, soybeans, and peanuts are high in protein and oil. Sago, taro, and cassava are major starchy foods in certain tropical parts of the world. Seaweeds are an important part of the diet in some cultures, especially in Asia. Seasonings are derived from plant materials. People have used herbs and spices for centuries to flavor and preserve food.

Most beverages come from plants. Coffee, tea, and cocoa are prepared by steeping plants in hot water. Other drinks are "ready-made" by nature: orange, lemon, and grape juice; coconut milk; apple cider; and apricot nectar are examples. Some beverages come from processed plants, as do the cola drinks made from the kola nut of tropical America.

We rely on plants for more than just food. Virtually our whole way-of-life is dependent on plants. Many of us live in homes made from the wood of trees. Clothing, particularly cotton, is made from plants. Cosmetics, medicines, paper, pencils, furniture and--even the air we breathe--originate from plants. Have students brainstorm their own list of plant uses. The list can be extensive!

Students will understand there are so many plants, they must be classified. Plants are classified by their reproductive capability. Plants have their own Kingdom. Within this kingdom are plant divisions. For example, one Division is Anthophyta which includes flowering plants. Plants are organized into four Classes: Mosses, Ferns, Angiosperm, Gymnosperm. Mosses are primitive plants without a vascular system. Ferns are simple plants with a vascular system which are tree-like and found in shaded, moist habitats. Gymnosperms are seed plants, usually trees, whose seeds are not enclosed. Cones are an example of unprotected seeds. Angiosperms are plants that produce seeds that are enclosed, usually in fleshy fruit. Fruits, vegetables and flowers are usually angiosperms. Angiosperms are divided into two groups: monocot and dicot. Within each class is a Family, a group of plants with similar characteristics. For example, canes are similar within the Evergreen family. Within the Family, there is further division, called Genus. Within the Evergreen family, there are Spruce, Redwood and Cedar, among others. The most specific classification is called the Species. A species is defined by its ability to reproduce. A California Redwood, for example, is a specific species that will make only more California Redwoods. However, there are other species of Redwoods.

Activities

Internet Research: plant classification

(see trident.ftc.nrcs.usda.gov/npdc/index)

Using the classification system, students research 25 plants at the USDA website. Using information provided, see if students can discover and classify plants within the four major classes: moss, fern, gymnosperm and angiosperm.

Research and Reporting: Trace the origin of a food/snack

Students will realize that plants are grown world wide. Students will understand some of their favorite foods come from far away places. Using a Nestle Crunch Bar made by Hershey's Inc. as an example, print and read the ingredients and the origin of these ingredients:

Sugar- sucrose - from sugar cane from Florida

Cocoa butter - from cacao from Ivory Coast or Brazil

Soy lecithin - from soybeans from Midwestern United States

Vanilla - from Vanilla orchid from Brazil

Crisped Rice - from rice from Japan

Peanut Traces - from peanuts from Georgia

Have students bring in one food wrapper from one of their favorite snacks. Each student will list the ingredients and research the origin of these ingredients in the school or public library.

(For additional activities, see Ranger Rick_s NatureScope, Rain Forests: Tropical Treasures, p. 46, "Jungle in the Pantry", extensive listing of products that originate in rain forests)

Abiotic Factors and Plants

Although there are thousands of plants which are as different as people, they all share the same requirements in order to survive, grow and flourish. These are often referred to as abiotic factors. Abiotic factors are non-living elements found within an ecosystem. There are six abiotic factors that affect plant growth: air, water, space, temperature, light and soil (nutrients). These are the basic requirements that plants need to grow. Each of these factors, however, is subject to pollutants which affect plants growth. Some of the effects are quite visible and students can easily conclude pollution is detrimental to life through a simple experiment. The remainder of this unit will refer to results obtained from this experiment.

For simple, very brief student reading, see "Factors Affecting Plant Growth" . (www.urbanext.uiuc.edu/gpe/case1/c1facts3a.html) Read aloud the description of each growth factor. After discussing each factor, brainstorm how that variable might be affected by pollution. Students may be able to identify global warming as a result of pollution which affects temperature and may affect plants growth. This lesson, reading and brainstorming, is a great way to assess prior student knowledge and further introduce the unit.

As students read through these factors, ask students how they might change one element in an experiment. For example, water is important in the plant_s ability to make and move nutrients. Plants can die from too much water, not enough water or from polluted water as pollution interferes with the plant_s ability to move nutrients. How might students design an experiment that varies water?

Activity

Experiment: Observing the Effect of Pollutants on Plant Growth

These abiotic factors are tested in the following controlled experiment which employs the Scientific Method. Allow two 45-minute periods to plan and set up the experiment. On Day One, select a variable and seeds. Students read section I of the Pre-Lab Plan. Read seed planting requirements on packets to confirm procedures. Each student labels their planters: their initials on one side of both planters; on one, they label "V" for Variable, "C" for Control on the second. On Day Two group students at stations in which one type of variable is present. For example, at one station provide the two types of polluted water and spring (or distilled) water. At another station provide sand, acidic soil and fertilizer. Students plant their seeds and complete the preliminary lab report. (We used cardboard 2" X 2" planters; You can use cardboard egg carton sections.) All plants, except those deprived of light, are placed together in shallow plastic containers to prevent water spills; polluted water plants are grouped in the same plastic dishes. Plan to start observing and recording growth in two weeks. Discuss results and complete Post-Lab Discussion in two- to three weeks.

**note: You may use one type of seed and test up to 12 variables presented: three types of water, three types of soil, no light, colored light, cool temperature environment, hot environment, space restricted, air pollution. You may need grow lights, colored light bulbs, a cooler growing location and a thermometer. If you test air pollution you will need a "Hands-In-Bag". (UCAIR Environmental Kit, Hubbard Scientific, Chippewa Falls, WI, 54729; (715) 723-4427) When I did this experiment, students selected their own plants and we tested more than 10 different species because I wanted to demonstrate plants have different needs and respond differently to pollutants. Furthermore, our school is in an urban area with heavy traffic and toxins. Plants which grew in polluted or undernourished soils were best candidates for transplanting to an outdoor school garden. Plants/seeds which responded quickly with obvious results: Coriander, Beans (White, Green Bush), Leaf Lettuce, Cucumber, Marigold, and Aster. Pollutants which produced dramatic results: sand, water with used car oil, light (lack of), nitrogen-enriched soil, "acid rain".

Maintain a spreadsheet throughout the experiment which organizes plant types: herb, vegetable, or flower; and pollutant. (r)INVALID_FIELD: Object

Name_____ Class____ Date_____

Pre Lab Plan

The six factors which effect plant growth are heat, water, air, soil/nutrients, light and space. A number of different variables, such as the amount or type of water, or the quality of soil can affect these factors which affect plant growth. You will design and conduct an experiment which explores the effect or quality of these factors on plant growth.

During this activity, you must design a lab plan, and record the problem you wish to investigate, your hypothesis (prediction), materials and document your procedure. Your procedure is a step-by-step plan of your experiment_s directions, written for a fifth grade audience. After deciding which plant to grow, read the direction on the back of the seed packet to help specify procedures.

You will set up a graph to record data. Plant growth is dependent on the factor, therefore, it is the dependent variable, recorded on the "Y" axis. The independent variable, that which is recorded on the "X" axis, is the date you record plant growth.

You will use all of the following equipment to plant your seeds:

2 planters		soil
water (10 mL)	graduated cylinder	
metric ruler		plant seeds

You will choose one of the following variables:

polluted water (oily)	acid rain (water with 10% vinegar)	spring water		
sand		plant food (nitrogen-enriched)	polluted soil (test pH)	
artificial plant light	sunlight			minimal light (closet)

Directions:

1. Label your planters. Put your initials on both planters. Label the control "C" and the variable (the abiotic factor you will change) "V".

2. Measure your soil using a graduated cylinder or beaker and pour soil into both planters until they are 3/4 full. If you are varying soil, make sure potting soil goes into the control planter and your experimental soil (polluted, sand, enriched) goes into the planter marked "Variable"!
3. Follow directions on the back of the seed. Plant no more than three seeds per planter unless your variable is space. Double the amount of seeds if you wish to investigate how space restriction (overcrowding) effects plant growth.
4. Water your seeds using a graduated cylinder. Measure the same amount of water for each planter. Remember if water is the experimental variable--polluted or purified--use the same amount of water but varied in the planter labeled "V"!
5. Set up a graph for recording data. Put dates when you will observe plant growth on the X (horizontal) axis. Label the Y axis in centimeters to record growth. Title your graph.
6. Record all information on the preliminary lab report:

Lab Report

Purpose

The purpose states the reason why you are doing the experiment. Purposes can be stated as a question.

(r)INVALID_FIELD: Object

Hypothesis

The hypothesis is stated as an If..., then... statement. The 'If' part of the statement is based on related facts that you know to be true. The 'then' part of the statement is an educated guess on the outcome.

(r)INVALID_FIELD: Object

Materials

This is a list of all equipment and chemicals needed to do the experiment. Be sure to give quantities.
(r)INVALID_FIELD: Object

Procedure

The procedure tells exactly what you did to achieve your results. So, it is important to be accurate in explaining what you did. The procedure is written step-by-step, numbered (like cooking directions).

(r)INVALID_FIELD: Object

Conclusion

The conclusion explains results. It addresses the purpose and indicates if your hypothesis was correct.

(r)INVALID_FIELD: Object

Name_____ Class____ Date_____

Post Lab Discussion

1. Clearly state the problem investigated. Identify the dependent and independent variables.

_____
_____
_____

2. Describe the experiment clearly. Indicate, step-by-step, how the procedure was completed 1.

_____
_____
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_____
_____
_____
_____continue on back

3. Describe the results of your experiment on the next page. Use tables, charts, or graphs.

4. State your conclusion in the experiment. You conclusions should be supported by data._____
_____
_____

5. How valid are your conclusions? Do you have of confidence in your results? Could you improve your experiment?

_____
_____
_____
_____

6. How could you apply your results to your life/ community? What did you learn?

_____
_____
_____
_____continue on back

Plant Structure & Function

All plants have roots, stems and leaves. The roots are the underground parts of most plants. They absorb water and minerals, to store food. They anchor the plant to the soil. The first structure to appear from a germinating seed is the embryonic root. The cells at this primary root undergo rapid cell division and growth is downward. Secondary roots grow from the primary root and may produce root hairs. The root hairs increase absorption of the root system. Internally roots have bundles of food (phloem) and water (xylem) tubes surrounded by cortex cells. The vascular system provides for transport of absorbed water and minerals to the stem. It also provides for the passage of food manufactured in the leaves during photosynthesis to storage areas in the root. (see Plants, Milliken Publishing Company, St Louis, MO, 1986 for plant unit with excellent overhead transparencies/graphics)

Stems are channels through which food and water passes through a plant. There are five parts to the stem: epidermis, cortex, phloem, xylem, and pith. The epidermis is the external layer of cells. This single layer of cells prevents excessive evaporation from internal tissues. The cortex is made up of cells which provide strength, protection and storage areas or the plant. Phloem tissue, which forms food-flowing tubes, conduct the downward flow of food manufactured in the leaves. The xylem tissue, forming water flowing tubes, conducts the upward flow of water and dissolved minerals from the soil via roots to a ll parts of the plant. Stems may grow above or below the ground. Stems which grow above the ground are aerial stems. These include ivy and strawberries. Stems which grow below the ground are called underground; these include bulbs and tubers. Daffodils, tulips and iris are common types of bulbs.

Leaves have the important function of manufacturing food for the plant using water, carbon dioxide and light. Parts of the leaf include the upper epidermis, lower epidermis with stomata and guard cells, chlorophyll-rich palisade and spongy tissue, and the veins containing phloem and xylem tubes. The single layer of cells that forms the upper outside surface of a cell is the upper epidermis. The lower epidermis has many minute openings that permit photosynthesis. The middle section contains layers of tissues that are rich in chlorophyll.

Leaves are food producers. In photosynthesis, leaves use chlorophyll to convert water, carbon dioxide and light energy into sugar and oxygen. The chemical formula for photosynthesis is:

6CO2 + 6 H2O + light energy --chlorophyll-- C6H606 + 6 02
Photosynthesis is the process by which light energy is converted to chemical energy.

In plants, energy is stored chemically in glucose, a form of sugar. Plants need sunlight in order to combine carbon dioxide and water to produce sugar. Without the energy stored in glucose, plants cannot grow.

Leaves have the following parts: upper epidermis, palisade cells, spongy cells, stomata, and veins. All these parts are needed for photosynthesis.

Palisade and spongy cells contain chlorophyll.

Photosynthesis occurs in green leaves and stems inside the chloroplasts in the cells.

Carbon dioxide enters through the stomata.

Oxygen is a byproduct of photosynthesis. It exits leaves through the stomata.

Oxygen produced during photosynthesis is used by humans and other animals.

To grow, plants must have carbon dioxide and water.

Transpiration, the release of water vapor from a plant, occurs through the stomata. 90% of the water absorbed by the roots is evaporated and released back into the atmosphere. A single corn plant can release as much as 200 liters of water into the atmosphere during the growing season.

(Use the Encarta Encyclopedia [http://encarta.msn.com/encyclopedia] contents page for the Photosynthesis article and the animation on photosynthesis. Using the animation, guide students through the steps of the process.)

Activities

Experiment: Tracing water through plants

Elementary students place a carnation in water with food coloring. To prepare these middle school students for the CAPT and reinforce the concepts of absorption through the root and stem systems, pose the following question: Do roots or stems absorb water quicker? This may be presented as group lab experiment or a demonstration. Use the Lab format presented with Observing the Effect of Pollutants on Plant Growth. Ask students to develop graphs as well. Set up experiment on Day One and allow time (approximately 10 minutes) for observation, measurement and recording data on Days Two and Three.

Materials

2 200 mL beakers
150 mL water
red food coloring
metric ruler
2 small potted, flowering plants; plants must be similar size growth (tulips work well)
plastic (latex) gloves

Procedure

1. In each of the two beakers, add 150 mL water with four drops of food coloring
2. Wearing gloves, carefully remove one flowering plant with roots from planter and place in

beaker #1.
3. Cut the second flowering plant at the base of the stem and place in beaker #2.
4. After 24 hours remove plant with roots from beaker #1, blot excess water with a paper

towel. Measure how far the food coloring traveled through the root and stem systems

5. Remove the stem from beaker #2 and repeat procedure 4 above.
6. Record your results on a table or graph.
7. On day two, repeat procedures 4, 5 & 6.

Concentration

Create a game of concentration using facts describing the process of photosynthesis. Using index cards, copy terms and facts from column A. Copy definitions and explanations from column B. Ask students to add to these lists. Create multiple sets of cards for student teams. Review these facts and terms with students. Assemble student teams with their own set of cards. Place all cards upside down and have each member of a team turn over two cards attempting to match a definition with a term.

A		B
autotrophs		organisms that make their own food
photosynthesis		process by which light energy is converted to chemical energy
glucose		a form of sugar in which energy is stored
6CO2 + 6 H2O + light energy	C6H606 + 6 02 + H2O	
leaves		part of a plant needed for photosynthesis
chlorophyll		found in palisade and spongy cells
chloroplasts		contain the pigment chlorophyll
stomata		part of plant through which carbon dioxide enters
oxygen		biproduct of photosynthesis

ozone	oxygen from plants which reacts with sunlight in upper atmosphere & protects us from the sun

Photosynthesis Race

Put Rhododendron clippings in beakers with water and place under red, blue, and green filters. Place one under a white light (control) as well. Record starting growth and record growth twice a week for a month. Record and graph the findings. You may also set this up as an experiment employing the Scientific Method. Pose the question: Which is a plant_s favorite color?

Pollutants

Pollutants are substances with which organisms have had no prior evolutionary experience, in terms of kinds or amounts, so adaptive mechanisms are not in place that can deal with them. Much of the world_s land, air and water are partially polluted by chemical wastes. Pollutants affect all of the abiotic factors on which plants survive. Each of the abiotic factors necessary for plant survival, which is necessary for our survival is increasingly subjected to pollutants, locally and globally.

Pollutants affect cycles in nature which are necessary for our survival. Plants are an integral part of these cycles. All of the world around us is continually involved in cycles of some sort or another. There are three cycles, however, that are responsible for the recycling of those key elements that make up all life: carbon, hydrogen, oxygen, nitrogen (C,H,O,N). Every living organism needs these elements on a continual basis in order to survive. Without them being continually renewed on our planet, life could not exist. The three cycles responsible for providing the continual flow of these elements are: the water cycle, the carbon-oxygen cycle, and the nitrogen cycle.

The Water Cycle includes precipitation, evaporation and transpiration. Plants need the water from precipitation. Precipitation is rain, sleet, snow and other forms of moisture that come from the sky. They also, however, contribute to this process through respiration. Water is released during photosynthesis and evaporates into the atmosphere.

Plants drive, and are critical to the Carbon-Oxygen cycle. Through photosynthesis and respiration, atmospheric carbon dioxide (CO_2) is converted to oxygen (O_2). Plant decay creates stored carbon as well. Carbon Dioxide is essential for the growth of food, through the process of photosynthesis. Through this process, oxygen upon which all organisms survive, is released. In photosynthesis, plants take in carbon dioxide and release oxygen. This process gives energy to plants, but gives energy to us as well.

Plants are critical to the Nitrogen Cycle as well. Approximately 78% of air is Nitrogen. Nitrogen is important to life because it is a key part of amino and nucleic acids. Also, it is an important part of ATP, the basic energy molecule for living things. Neither plants or animals can obtain nitrogen directly from the atmosphere. Instead, they depend on a process known as nitrogen fixation. Key players in this process are legumes and bacteria are known as nitrogen-fixing bacteria. These organisms convert nitrogen in the soil to ammonia, which can then be taken up by plants.

After nitrogen has been fixed, other bacteria convert it into nitrate, in a process known as nitrification. In the first step of this process, Nitrosomonas convert ammonia into nitrite, and in the second step, nitrite is converted into nitrate, by Nitrobacteria. This nitrate is then consumed by plants.

The final aspect of the nitrogen cycle is the process of denitrification. This process is performed by a variety of microscopic bacteria, fungi, and other organisms. Nitrates in the soil are broken down by these organisms, and nitrogen is released into the atmosphere. This complete the cycle. Have students diagram and label each of the three cycles in nature.

Plant life is critical to all three life cycles. It is absolutely necessary for these cycles to function. However, plants can also causes imbalances in these systems. They absorb water from the ground which is released during transpiration and evaporates, contributing to the water cycle. However, too much growth is blamed on desertification which robs areas of necessary water. They absorb nitrates from the soil and do not replace all they absorb when they decay. Nitrogen is needed as a compound for the growing of plants. But nitrogen-fixed fertilizers are overburdening the environment with nitrogen and upsetting the complex nitrogen cycle. Nitric Oxide is one component of smog.

Land Pollution/Soil Degradation

Our demand for more and more products and things to do has resulted in less space for our oxygen-producing plants. Manufacturing plants and roads take up considerable space and destroy the soil around development. Everything we use gets thrown away, and the bacteria needed to supply nutrients to the soil is robbed by these demands.

A mere 12% of the Earth's landmass is entirely arable for agricultural land horticultural purposes. The remainder of the planet's surface consists of areas that cannot be cultivated, such as rocky terrains, tundras, arid regions, forests and deserts. The steady increase in agricultural industrialization and its constant, unrelenting utilization of chemicals completely leach the soil. Populations_ demand for space and poor agricultural practices limits available soil for plants upon which we need to survive!

Air Pollution

Air pollution directly affects plants as smog and toxins are absorbed by the leaves. It also affects light as pollutants, particularly smog, may block the sun_s rays. Through the greenhouse affect, in which fluorocarbons affect a layer of our atmosphere, the ozone, temperature is also affected which may harm plants and surely will change the number and composition of the plant kingdom. Agriculture may be adversely affected by air pollution. Plants may suffer from leaf burn due to acid rain resulting from sulfur or nitrogen compounds emissions or may be weakened and made more subject to disease by exposure to ozone.

The United States releases 7,000,000 metric tons of air pollutants each day. These include carbon dioxide, oxides of nitrogen and sulfur, and chlorofluorocarbons.

Radiation is another dangerous pollutant in some areas.and air and water, which can harm plant functioning. Many pollutants, such as those which form smog or acid rain, exert regionally harmful effects. The effects of other pollutants such as fluorocarbons and greenhouse gases, are global in scale.

Oxides of sulfur and nitrogen are among the worst air pollutants. Coal burning power plants, metal smelters and factories emit most sulfur dioxides. Motor vehicles, power plants that burn gas and oil, and nitrogen-rich fertilizers produce nitrogen oxides.

In dry weather, fine particles of oxides may briefly state airborne, then fall to earth as dry acid deposition. When they dissolve in atmospheric water they form weak solutions of sulfuric and nitrate acids. Strong windows may distribute them over great distances. When they fall to earth in rain or snow, we call it wet acid deposition, or acid rain. The pH of normal rain water is about 5.0. Acid rain can be 10 to 100 times more acidic than this, even as acidic as lemon juice. Rain in much of eastern North America is 30 - 40 times more acidic then it wasseveral decades ago. As a result forests and crops are being damaged and fish populations are rapidly declining.

The ozone (O3) layer is critical in filtering out radiation from the sun. The ozone may absorb up to 30% of the sun_s rays. Without the ozone, our planet would overheat. Chlorofluorocarbons (CFCs) are the major cause of atmospheric ozone reduction. These compounds of chlorine, fluorine and carbon are used in refrigerators, air conditioners, solvents, and plastic foams. CFCs slowly escape into the air and they resist breakdown.

Our air does not know any boundaries. Wind can carry pollutants hundreds of miles from their origin. The distance air pollutants travel depends on how high in the atmosphere they go. Pollutants that are lifted high into the atmosphere may travel thousands of miles before they drop back to Earth. Air does not know local, state, national or international boundaries.

Activity

Chernobyl: Tracing Movement of Radiation

By tracing the movement of radiation released during an accident at the Chernobyl nuclear power plant, students will see how air pollution, like particulate matter, can become a global issue. Students will name and locate countries where radiation traveled to and describe how air pollution travels from one area to another.

materials:

student copy of Explosion at Chernobyl	Pollution Points handout	
sticky dots or stickers to mark map	map of Europe	
world map		atlas of encyclopedias

procedure:

1.Students may work individually or in groups. Discuss with the students how air pollution travels. Pass out the Explosion at Chernobyl information sheet . The students can read and discuss the article.
2.Using the Pollution Points handout, students will plot the course the radiation took each day. Points should be plotted numerically and in sequence, chronologically. (Be sure to make reference materials available to locate countries.)

Extension:Split the class into two teams. Each team will work together to map the pollution points. Mark Chernobyl's location with a sticker. The mapping will start with someone from the first team reading pollution point location number 1 out loud. He/she will have 40 seconds to find that city on the map and mark it with a sticker. Team members can help the player by giving directional tips, but they can NOT point to any specific location. If the team member finds the location point within 40 seconds, that team gets one point. If not, the other team gets a chance to find the correct location. Teams take turns locating the points until all 29 points have been mapped.

The Explosion at Chernobyl

THE BIG BLAST

On April 26, 1986, at 1:23 a.m., Chernobyl became the site of the world's worst nuclear power plant accident. Operators were shutting down one of the reactors for maintenance when the power suddenly surged and the reactor exploded. The blast blew the reactor apart and sent radioactive gases and particles as high as three miles into the atmosphere. Two plant workers were killed by the explosion. Twenty-nine others later died from

radiation exposure.

Within days, more than 120,000 people were evacuated from an 18-mile radius around the plant. As fires inside the reactor burned, helicopters dumped tons of lead, sand, and other minerals on the flames. Despite these efforts, the fires burned for 10 days after the blast, continuing to release radioactive pollutants into the air.

WHERE IT WENT

The explosion resulted in a huge cloud that soon split into two parts. One part of the cloud moved northwest toward Poland and Scandinavia, and then southwest across central Europe. The other part of the cloud moved east across Asia, over Japan and the North Pacific, and eventually reached western North America. And as the reactor continued to burn, it released radiation that moved south and west of the plant. But scientists believe that in most cases, the amounts of radiation deposited outside the Soviet Union were relatively low.

EFFECTS OF THE EXPLOSION

The first few weeks following the Chernobyl blast were filled with confusion. Some European countries ordered the destruction of millions of dollars worth of contaminated produce, milk, and livestock. But in other nearby European countries, people were told that there was no danger and that it was safe to consume these products. Farmers suffered huge financial losses when countries in other parts of the world refused to import produce from Europe. A significant portion of the released radioactive material has a very long half-life, i.e., it will be around for a very long time, thousands of years. Radiation, even at low levels, can increase incidence of cancer. Particularly sensitive are the effects on the digestive system, blood pressure, and the heart.

The explosion also strained relations between the Soviet Union and other nations. Many countries were angered by the Soviet Union's delay in reporting the accidents. Officials announced it on April 29.

CHERNOBYL'S LEGACY

The damaged reactor at Chernobyl now stands entombed in thick layers of concrete and steel, while the other reactors at the same plant are again producing energy. But the disaster is still taking its toll. Some scientists predict that within the next few decades, thousands of people who were exposed to the radiation could develop cancer.

Pollution Pathways--Pollution Points

Day 2 -- April 27	1. Winds blow radioactive cloud northwest over Gdansk, Poland.	
Day 3 -- April 28	2. Radioactive cloud reaches Stockholm, Sweden.	
		3. Radioactive cloud reaches Helsinki, Finland.
		4. Radioactive cloud reaches Oslo, Norway.
Day 4 -- April 29	5. Radiation continues north through Scandinavia reachingTrondheim, Norway.	

		6. Radiation detected in Copenhagen, Denmark.	
		7. Winds carry radioactive cloud to Prague,	Czechoslovakia.
Day 5 -- April 30	8. Cloud moves over Munich, West Germany.		
		9. High amounts of radioactive particles wash out when it rains in Vienna, Austria.	
		10. Radioactive cloud reaches Geneva, Switzerland.	
Day 6 -- May 1	11. Cloud travels to Rome, Italy.		
		12. Radioactive cloud reaches Budapest, Hungary.	
		13. Winds carry radioactive cloud to Zagreb, Yugoslavia.	
		14. Radiation detected in Paris, France.	
		15. Radioactive cloud reaches Tromso, Norway.	
Day 7 -- May 2	16. Small amounts of radiation measured near Reykjavik, Iceland.		
		17. Radiation reaches Bucharest, Romania.	
		18. Winds carry radioactive particles into Brussels,	Belgium.
		19. Radioactive cloud moves over London, England.	
		20. Radioactive cloud detected in Sofia, Bulgaria.	
Day 8 -- May 3	21. Radioactive cloud reaches Glasgow, Scotland.		
		22. Winds carry radioactive cloud to Athens, Greece.	
		23. Radioactive particles detected in Ankara, Turkey.	
Day 9 -- May 4	24. Radiation reaches Beirut, Lebanon.		
Day 10 -- May 5	25. Radiation detected in Damascus, Syria.		
Day 11 -- May 6	26. Radioactive particles reach Kuwait, the capitol of Kuwait.		
		27. Radioactive cloud moves over Xian, China.	
Day 12 -- May 7	28. Radioactive particles reach Tokyo, Japan		

Day 18 -- May 13	29. Slight amount of radiation detected in Richland, Washington, in the United States

Water Pollution

Pollutants in water interferes with plant growth in many ways. Water pollution leaks into the soil and may prevent absorption or damage roots the roots system which helps provide nutrients throughout the plant. Water pollution is also in the form of acid rain. Acid rain damages leaves as well as the root and stem systems. .Acid rain is more acidic than normal rain and forms through a complex process of chemical reactions involving air pollution. The two most important pollutants that contribute to the formation of acid rain are oxides of nitrogen and sulfur dioxide, which react with moisture in the atmosphere to form nitric and sulfuric acid. The sulfur and nitrogen compounds that contribute to acid rain primarily come from man-made sources, such as industries and utilities. Emissions also come from automobiles and other forms of transportation and industrial processes, such as smelting. Pollutants that contribute to acid rain may be carried hundreds of miles before being deposited on the earth. Because of this, it is sometimes difficult to determine the specific sources of these acid rain pollutants. Water and air pollution are related due to interdependencies in cycles of nature

Activity

Experiment: Monitoring Acid Rain

Is your rain water acidic? Normal rain is slightly acidic, about 5.5 on the pH scale. Acid Rain measures anywhere from 3.5 to 5.5 on the pH scale and falls in the form of nitric or sulfuric acid. This has been shown to have a harmful effect on the environment.

Materials:

- rain gauge
- tweezers
- water pH test kit
- graph/chart paper
- marking pen
- ruler

Set up a monitoring station somewhere in the school yard or on a window ledge. Rainwater is easily contaminated so place a rain gauge in an open area away from trees and debris.

Make a chart to monitor results. The chart will be used for two weeks and will monitor precipitation, wind speed and direction. Check the newscast or newspaper for wind information. Observe the rain gauge daily and record type and amount of precipitation. Check the precipitation from pH by putting a strip of pH test paper in the rain gauge. Hold the test paper with tweezers and keep in rain water for two minutes. Remove the pH strip and compare its color to the color on your pH color chart which comes with the test kit.

Empty the rain gauge, rinse and place in back for the next day. Rinse it our daily to remove contaminants. Record data daily. After two weeks, analyze your results and state a conclusion. Use the Lab format presented with Observing the Effect of Pollutants on Plant Growth.

Contemporary Issues and Student Impact

Students will increasingly realize the impact of their individual choices on their surrounding environment. Among the most influential choices they make are their consumer choices. These choices include the foods they purchase, the fuels they burn, choice of transportation, clothing, personal care products, entertainment items, etc.

Aggregate, or community choices also affect their environment tremendously. Three major project proposals currently face the city of New Haven: expansion of Interstate 95, development of a large mall at Long Wharf, and installation of high speed rain service to New York. Most communities face, or have recently debated a development proposal. These community choices are often complex, with benefits and costs. However, these benefits and costs are not equally shared, and given the scale of New Haven_s development proposals, open space and clean air will certainly suffer should we realize these developments.

Read "Don't DumpOn Me: Communities of Color Fighting Back" by Jim Motavalli, in the New Haven Advocate, published 8/13/98. (//www.newhavenadvocate.com/articles/pollution.html). Students identify and discuss pollution problems associated with development that are presented in the article and propose which of these problems will confront the city of New Haven should any or all of these developments take place. How did communities in the article respond to these environmental challenges? What could students do to influence development? Begin research for debating these proposals. Assign student teams to research current or recent development efforts in their community. As students research, ask them to consider who will benefit from such proposals? Who might suffer losses? How will these proposals affect their environment? Do they want these developments? Why?

Ask students to examine their own personal demands of their environment. After, they will debate one of these contemporary development issues.

Have each student write up a list of the products they regularly use and/or purchase. Chart and classify this information: Food, Personal Care Products, Household Cleaners, Clothing, Entertainment, Transportation. After each item or product have a check-off list of the following categories (listed on the top of the page on the X axis): Frequency of Use (Everyday, Frequent, Infrequent); Cost (in $ amount); Biodegradable? (Y or N); Recyclable? (Y or N); Packaging (type: plastic, paper, cardboard, etc. and weight); Is This Product

Necessary?(Y or N -- and then explain why).

Activities

Your Environmental Impact

Name_____ Class____ Date_____

The six factors affecting plant growth each head the following table. Complete the table by listing at least three ways you affect these factors. Consider how your behavior directly or indirectly affects these elements upon which plants rely. For example, if you take the bus or ride a car to school, your impact has been written in the table in italics.

Water	Air	Soil	Temperature	Space	Light
Leaking Fluid	Exhaust	Old tires	Emissions	Roads	Smog

_____
_____

_____
_____

Need help? Consider the following...

1. Your need for oil, for heat or for your car, increases the chances of an oil spill, which does a lot of damage to the water.
2. Do you use plastic foam containers--for fast food restaurants, for example? Some foam is made with CFCs which deplete the ozone layer and may increase temperature?
3. Do you use fuel for heat...coal, oil or other fossil fuels? They also contribute to the Greenhouse effect.
4. If you use electricity or ride in car, you could be contributing to acid rain.
5. Do you ever litter? You rob nutrients in the soil.
6. Do you use any pesticides or fertilizers in your yard? You may be polluting water and robbing soil of nutrients.
7. Does your family use salt in the winter to melt ice? You are polluting groundwater.
8. Do you use plastic trash bags or does your family use disposable diapers? If so you may be contributing to a landfill which takes away space plants could have used.
9. If you play basketball, run track, play tennis or other sport on an asphalt surface, you are taking away space for plants...and the asphalt ruins soil surrounding it.
10. How much water do you use at home? Where does all the used and dirty water go? It goes to a sewage treatment plant that sometimes spills...polluting groundwater.
11. Do you recycle? If not, you are taking away space plants may use and may be polluting soil and water.
12. Where do you get your fruits and vegetables from? If it is from a supermarket, they are probably sprayed with pesticides--which harms water and soil.

Which factor do you think we affect the most? Why? How and why do we harm this resource which is so valuable to plants? What actions can we take to lessen this impact/damage?

_____

_____

Debate

The major goal of this activity is to better understand the conflicting solutions involved in resolving several complex environmental issues. In order to successfully participate in the debates, you will be required to complete the following steps:

1: Research one development proposal facing your community. Collect local new articles and try to gather facts which support development and those which oppose development.
2: Create a chart listing development benefits and costs, or liabilities. Also indicate which groups stand to benefit or lose.
3: Create groups of four and select an argument (pro/con). Complete further research supporting your argument. Notes gathered which include both pros and cons will be used for rebuttal.
4: Each group will read, analyze, evaluate and discuss their assigned case study. They will create a persuasive argument which supports your assigned viewpoint.
5: Each group will use their research and evidence to construct a creative and persuasive three part presentation.

Each presentation must include the following:

A) Opening Statement-4 Minutes
B) Presentation of Evidence-5 Minutes
C) Closing Statements-3 Minutes
7: Finalize the details and positions of responsibility for your debate issue and be prepared to present your side of the case on the date and time assigned below. Remember, you must adhere to all the stated debate rules and procedures.

Students should also be evaluated on their individual observations.This can be accomplished by having each student keep a daily journal of his or her thoughts and observations during this process. Some questions to have in mind for the journals are:

1. How does it feel to have to argue a position you don't necessarily agree with?
2. What is your group research teaching you that you didn't know before?

After the debate, conduct a survey: What were student positions before the debates? After? If they changes their mind , what information or issues were factors which caused them t change their opinion? Which group was the most persuasive?

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