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Environmental Savior

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by Sara Barton

> Man has inherited the earth . . . For the first time
>
> in the history of the planet a single species
>
> dominates all . . . and the shambles is evident.
>
> —N.J. Berrill

This Environmental Science unit has been designed for sixth grade students and is expected to be twelve weeks in length. It is expected that the students will be exploring environmental issues in science through hands on science labs and in subjects other than science. If taught from an experiential perspective, environmental science can help enable students to make changes now and in the future. Experiential teaching demands that students be given the opportunity to explore. The best explorations are done through projects. Students do not remember facts; they remember projects. Projects should incorporate experiments, textual research, and student presentation of material learned. The overall objective of the unit is to give students an understanding of the interconnectedness of science as a field of study and of the environmental systems and also to give them a clear understanding of an individual's impact upon the environment.

Frequent field trips and cross curricular projects in literature, math, social studies and art will help to underscore the applicability of science. I have suggested related topics and trip sites at the end of the unit to help make teaching this unit as fulfilling as possible. The labs for this unit have been designed to be taught in a self-contained classroom without lab equipment, paying particular attention to equipment costs.

Any study of science should begin with a discussion of science as a discipline. Students should understand that the field of science is continually changing as technology provides ways to measure and observe with greater precision. Science is a discipline based on questioning and observing not on steadfast truths. Students should also understand that the presentation of data can affect how results are perceived. Exercises in data collecting, graphing, and probability should preclude any other study.

Optical illusion puzzles such as the famous "Old Lady or Young Lady" can help students understand differing perceptions. Exercises on measurement or polling can help clarify difficulties scientists have in claiming accuracy. Games with flipping quarters and rolling dice may serve as studies in expected outcome. An excellent way to demonstrate probability and bell curves is to build a probability board. A piece of large, flat plywood with nails placed in an even grid and slots glued to the bottom will illustrate a bell curve when marbles are dropped from the top and allowed to find their own path to the bottom. [1] Time used to explore these issues is well spent as it will prevent confusion and the need to backtrack later on. Any discussion of probability could be done as a math project or a science project.

The school building is a good place to start an experiential science unit as it is an easily accessible and inexpensive system to study. For environmental science, students can explore paper waste and water usage in the school. From the school they can branch out to explore the systems of garbage, pollution, and water in New Haven and finally the world. The method of beginning with the school and then branching out will help underscore how individual behavior can have a global impact.

I recommend the unit be divided into three parts, (with continual discussion of their effects on each other): 1) Water Use and Misuse; 2) The Growth and Depletion of Vegetation; and 3) Chemical Development: Pollution and Atmospheric Change. The depth of study depends on the length of time planned for the unit and the particular class. Each of these topics should be viewed as a guide to exploring environmental systems. The following questions have provided the outline for each of the three sections: Where does the resource/substance come from?; Where does the waste form the resource/substance go after use?; What is wasteful use of the resource/substance?; What are the long term effects of waste?; and, How can we, as individuals and a school community cut back on misuse and waste? Students will be expected to investigate the questions listed through guided experiments and projects. Upon completion of each section, I suggest the class plan and implement educational campaigns, for the rest of the school community.

Water Use and Misuse

> Sea of stretch'd ground-swells!
> Sea breathing broad and convulsive breaths!
> Sea of the brine of Life! . . .
> I am integral with you—I too am of one phase,
> and of all phases.

—Walt Whitman Water is an integral part of our lives. We are dependent on it for physical survival and, in more resent times, for economic survival. But water is a limited resource. The water section of this unit will look at where this resource comes from and how it is used and misused. It will begin with a discussion of the properties of water and labs which will distinguish fresh water and salt water. Students will explore common water pollution problems and research ways of conserving water.

When I taught this unit, I found that many of my sixth graders had little understanding of water movement or even the difference between salt water and fresh water. Thus one of the first labs I had my class do was the exploration of water movement. Sand and clay at a depth of four inches in large aluminum baking pans provided students with malleable material with which to create landscapes of watershed areas and allowed them to explore the flow of water. I encouraged students to experiment by creating mountains without river beds and then to sprinkle water on the mountain until a river bed was formed by the flow of water. Prior to the “Water Table Labs” I had a student ask how water ever got into the ocean if rivers were dammed up for reservoirs. By creating a river in the clay bed and damming up the water, this student was able to see that the water level would eventually rise above the level of the dam and continue to flow down into the ocean.

Water is continuously being recycled through the hydraulic cycle or water cycle. Water, in the form of vapor, evaporates from open water sources such as oceans, lakes, and rivers and through animal and plant transpiration. The vapor rises through the air, cooling as it rises, and condenses into clouds. Once a cloud reaches saturation, it releases the water in some form of precipitation.

One way to demonstrate the water cycle is to build a classroom terrarium. The students can witness the process of evaporation, condensation, and precipitation in a school day. Watching the terrarium recycle water will help students understand that there has been a constant amount of water on the earth for billions of years. If an aquarium or other large transparent container is available, it would be interesting to compare a large, more populated terrarium with a single plant terrarium.

Another way to show the water cycle is to bring a pot of water to a boil and place a clear pie plate containing ice cubes over the pot. The steam will condense and “rain” back into the pot. This would be an excellent family homework assignment.

Salty sea and ocean water makes up about 97% of all the Earth’s water. Ice glaciers make up another 2%, and the remaining 1% is freshwater, much of which is stored in aquifers, or underground reserve, that have taken thousands of years to develop.

The differences between fresh water and sea water should be defined through labs. Labs with sea water should begin with home made salt water so that the students can safely taste the water. The evaporation of sea water provides a good lead into a discussion of the ocean’s role in the water cycle. A more detailed lab on plant life could be carried out over a two month period by obtaining two similar sized plants and two gallons of sea water, and watering one plant with fresh water and the other only with sea water. The plants should be given the same amounts of water and kept in the same window. By the end of two months (or maybe sooner), students should see that sea water kills land plants. This lab could lead into a discussion of the need for clean, fresh water and of the effectiveness of distilling sea water for human consumption or for agriculture.

Rivers, lakes, and streams do not provide enough fresh water to sustain all land life. Tapping aquifers and pumping the water to the surface has temporarily provided enough water to support the expanding human population. The water stored in aquifers is limited, and will soon fail to support us. Already water claims are causing tensions to mount between nations. Of the 200 largest rivers systems in the world, 120 flow through two or more countries. When dams and reservoirs are built by one country, another may have its water supply depleted or cut. The world’s fresh water supply will not continue to sustain us unless conservation and pollution control are practiced by all the Earth’s inhabitants.

The Ogallala Aquifer in the central United States is the biggest in the country. It has helped turn arid prairie lands into the Bread Basket through extensive irrigation. Parts of the Ogallala Aquifer have been depleted by half since World War II. In the 1970’s it was predicted that the Ogallala would dry up by the year 2000 if the rate of use remained constant. Fortunately use of the Ogallala has slowed. None the less, scientists believe that at the current depletion rate, the Ogallala would need between 60 and 80 thousand years to resupply.

Discussion of the depletion of the Ogallala is an excellent way to discuss the complexity of many environmental problems. Another issue the Ogallala raises is the problem of human over-reliance upon finite resources.

Water conservation has become increasingly important as the world's fresh water supply shrinks. One of the more interesting conservation projects I read about while researching this project was the collection of rainwater for household use. Even in the dry outback lands of Australia and the arid ranch lands of Texas, where annual rainfall is 32 inches, a household can collect enough rainfall for use 11 out of 12 months a year. Galvanized steel roofs and highly efficient rain gutters collect the rain which is then stored in above ground tanks. Individual homes have treatment centers to filter and treat the rain water. Use of rain water helps to preserve the area aquifers and makes citizens more aware of water use. Other water conservation projects center around water rationing or increased municipal water rates. The rationing of city dwellers' use of water for things such as lawn watering and car washing has become common place during dry summers in the Western United States.

Students should be encouraged to research large scale conservation projects. They should know that their own behavior can have a major impact on local conservation. Have the students test how much water they use showering by placing a bucket under the shower and letting it run until the bucket is full to the one gallon mark. Most students will find it only takes 20 seconds for a gallon of water to run through their shower head Then have them time the length of their daily shower and calculate the amount of water they use every morning.

A related estimation project for math would be to post bathroom monitors for a day to count the number of times the toilets are flushed at school. About five gallons of water is used with every flush. Students can calculate an estimate for the amount of water that is used in one week just for toilets in the school. Encourage students to brainstorm ways of conserving water around the school and at home.

The problems of water pollution are as great a threat to the world's water supply as is over use. Extensive use of water for cleaning, industry, recreation, and agriculture has polluted much of our available water. Any contaminates that are dumped into a water source or on to the ground may find their way into the remaining fresh water supplies. Landfills, agriculture, industry, and nuclear power waste are all culprits. Landfills, or dumps, are designed to hold garbage until it decomposes, or rots. However, as garbage rots, it produces a liquid, called leachate, which seeps through the soil and into ground water. Water continues to flow underground; therefore, any toxic substances from the town dump can easily end up in the town's well water. Fertilizers and radioactive waste can follow the same path through the ground and into our water supply. Fertilizers from agricultural run off can cause the added problem of promoting unwanted plant growth in lakes and oceans. Too many water plants cause the oxygen in the water to be used up through the decay of the extra plants. A further result of this process is that the fish no longer have enough oxygen to survive. Reducing the use of lawn fertilizers is one way to prevent this problem. The goal of water conservation is to minimize usage while protecting available sources of water from pollution.

Studying the pH of different substances is an excellent way to help students understand how contaminates can harm our drinking water. Drinking water should be neutral, with a pH of 7.0. Household products can be used to simulate how water contaminants affect the pH level of water. Testing substances for pH can be done easily using pH test paper. Some common bases and their pH's that can be tested as school are: bleach (12), ammonia (11), milk of magnesia (10), and baking soda (8.3). Some acids are: lemon juice (2), vinegar (3), cola (4), and carrots (5). Experiment with adding acids and bases to try to create a neutral mixture.

Water pollution clean-ups have become a big industrial problem. Oil spills are one of the most common industrial problems and are a good case study because they can be imitated in the classroom. Oil can suffocate fish and tidal creatures such as crabs and starfish. It coats sea otters and birds making it impossible for them to move normally. Wildlife that feed on sea fish can become poisoned and die when they eat contaminated fish. Oil from cars and industry also finds its way into fresh water and can contaminate public water supplies. Oil spills on calm waters are cleaned by skimming off the oil. On more turbulent water, chemical detergents can be used to break up the oil into small drops which can then be diluted faster. Microbes are also used to eat up the oil spills. Following the Exxon Valdez spill in 1989, oil eating bacteria were applied to the spill with excellent results.

To simulate oil spill cleaning in your classroom, fill a large tub (an aluminum baking pan will work well) with water. Then pour in a thick oil, such as olive oil or sesame oil. Make sure to contain the oil in one section of the pan. A piece of plastic wrap dragged across the top of the pan will gather the oil and contain it in a corner of the pan. Have the students experiment with a variety of clean-up methods. Skimming the oil off with a ladle or a sponge will demonstrate how the skimmers work. Try soaking up the oil with wood (or pencil) shavings or imitate the chemical cleanser by adding a small amount of detergent. No matter what method is used, oil removal is a challenge!

The study of water should include a section on how water is used and how important it is to our everyday lives. It is important that students understand that water is vital to the survival of all life forms on the Earth. Discuss the ways in which students use water and what happens to life without water. A discussion of where New Haven water comes from, where it is treated, and how water travels through the city will help the students feel connected to a greater system. The Regional Water Authority can provide more information on the city water system. [2]

The Growth and Depletion of Vegetation

> Holy Mother Earth, the trees and all nature, are
> witnesses of your thought and deeds.

—Winnebago Saying (North American Indian Tribe) The remaining forested areas of the world are being depleted for the production of paper and wood products, farming, and urban growth without thought to Mother Earth or her future inhabitants. Deforestation results in a loss of land nutrients due to the lack of decaying mater, causes erosion, and contributes to global warming by adding to the levels of CO_2 in the air. Trees left standing add to our environment’s health by absorbing carbon-dioxide, contributing to an efficient water cycle, and preventing erosion. Despite the devastating effects of deforestation, it continues around the world. Students will more readily understand the issues involved with deforestation if the study begins with issues they have experienced. The paper industry is one of the main consumers of wood, and students will easily be able to study the use of paper in school.

Paper recycling is slowly creeping into our collective social mind set. First it was voluntary; now cities across the country are mandating it, and recycled packaging has become a selling point for consumer goods. But, in order to make the national recycling campaign a success, we and our students need to understand how paper consumption affects the environmental structure. Having students record the amount of paper waste thrown out by the school community each day will quickly illustrate the mass quantities of paper consumed daily around the world. Experiments with paper making will provide an understanding of how paper is recycled. [3] A discussion of land-fills and the fact that 34% of our garbage is paper will demonstrate what happens when paper is not recycled.

To help students understand the need to recycle and to understand the natural decomposition cycle, set up a landfill in the classroom. Obtain large containers with lids (for example, industrial size glass food jars) and enough top soil to fill each jar. Collect organic and non-organic material such as apple slices, dried leaves, a piece of an old cotton t-shirt, a soda can, a plastic bag, and nylon stockings. Have students take notes on each piece of garbage noting the condition, weight and size of each piece of trash. Keep samples of the nonperishable articles to use for comparing later. Bury the trash in the jars and place the jars in sunlight. Have the students hypothesize what will happen to each article. After a month excavate the samples. Weigh, measure, and compare the decomposed samples to those not buried. Discuss the properties of the articles which decomposed more. The natural substances will have a higher level of decomposition than the soda can or the nylon stockings. Underscore that the decomposition of organic material is necessary for new plant growth. When organic material is decomposed, nutrients that are stored in it are released into the soil to be used again by growing plants. The natural process of decomposition is hindered by the depletion of plant products for commercial use. For further study, compare a jar of trash placed in the sunlight to one left in the dark. The sunlight will induce the growth of algae which helps to break down the organic substances. Encourage discussion concerning recycling and consumer packaging. Have the students do a study of the packing of household products and graph the number of recyclable packages.

After an investigation of paper use as a contributor to deforestation and a study of the decomposition, the students will be ready to embark on a more in-depth study of deforestation. The availability of information on the South and Central American jungles makes the Amazon Rain Forests an excellent study.

Moist tropical regions such as the Amazon Basin are usually located in areas of low land fertility. In these areas the majority of the nutrients are stored in the vegetation. Plants grow rapidly so there is always a layer of decaying matter on the ground which releases stored nutrients that are absorbed by the roots of growing plants. When topical forests are cleared for agricultural purposes, the land will not produce for more than a season or two because there are not enough nutrients. Farmers then move on and clear more land leaving behind barren scars. Extensive deforestation will eventually lead to a decrease in the amount of rainfall in the area because at least half of the rainfall in an area like the Amazon Basin comes from transpired moisture from the forest itself.

The South and Central American Rain forests are not the only forests currently endangered. Russia’s Black Forest, and the jungles of Asia, and the wood lands of the Northwestern United States are also being deforested at an alarming rate. When discussing the use of natural resources with students, it is important not to paint the local farmers or loggers as the “bad” people. Guide students through an economic model which shows all the players and encourage the students to come up with solutions on their own.

Assign role playing which encourages students to take on different roles in the fight for land use of the Amazon Jungle. Group the class into four groups: native Indians, farmers, urban developers, and international nature watchers. Declare to the class that there is one plot of land desired by each of the four groups. Allow the students ample time to research and prepare an argument for why their group should be granted use of the land. The native Indians depend on the forest for food, shelter, and medicine. The village farmers need to clear more land to farm because their old fields are not producing. These farmers owe the city banks for their farm tools, and thus they must produce a cash crop. Urban developers want to clear more land for roads and buildings. Environmentalists from all over the world want the forest preserved and will pay the government to protect the forest. Simplistic “green” solutions do not necessarily take into account the needs of the farmers or the city dwellers. Each group should present their position to the class. Students should be coached in presenting their group’s dilemma as a series of facts. They should be steered away from making judgmental statements on what is right or wrong. After the arguments are presented, the teacher should solicit solutions and conduct a class vote on which solution to adapt.

A study of erosion would be an excellent way to connect information learned in the water section and the information learned from paper recycling to a discussion of deforestation. Erosion is the washing away or blowing off of top soil from the land. It is a natural process which has been accelerated and exploited by human land manipulation such as deforestation. Erosion can cause water and air pollution, flooding, and loss of soil productivity. The rate of erosion is influenced by climate, type of soil, and ground layers as well as the use of the land for agriculture and development.

Plant vegetation prevents erosion by slowing the flow of water over the top of the soil and holding the soil in place. The plant roots keep the soil loose which ensures that water will be absorbed into the ground. Once water is absorbed into the ground, plants utilize the water and continue to slow the flow. The ground has layers of lose rock under the soil which let water travel below the soil without disrupting plant and animal life or displacing the soil.

Erosion is prevented by planned soil conservation for all land. Soil conservation demands that urban areas be contained and not over built on land that is not stable, such as coast lines, or flood shed areas. It demands that agricultural areas be planted on flat land in contour strips to prevent water flow across the surface, and it requires that some land be natural forest. Forest must be managed so that the rate of restoration matches that of depletion. Production of materials that depend on the growth of forests should be encouraged. In the Amazon Basin, for example, the harvesting of food and medicine products will be of greater economic benefit in the long run than the clearing of trees for agricultural use.

To help students understand how water travels through the ground, they can do labs on ground layers and water flow through various layers. To show how the layers of ground separate into layers, combine equal amounts of sand, pebbles, and soil with water in a clear jar with a lid. Close the jar tightly and shake vigorously to mix all the materials. Left over night, the substances will each form their own layer, from the top down: water, soil, sand, and pebbles. Discuss the fact that there is a layer of clay and then bedrock under these three layers. (I have read that clay will work in this experiment too, I have found, however, that the clay traps and holds the other three substances.)

To demonstrate how each layer acts in water absorption, set up a ground layer filter experiment. Poke lots of holes in the bottom of four plastic cups with a thumb tack, and place a coffee filter in each cup. In each cup place equal amounts of one of the following substances: moist clay, pebbles, moist sand, and moist soil. Make sure the clay is tight around the edges of the filter or the water will simply flow around the clay. Pour equal amounts of water into each cup and time how long it takes the water to pass through the different substances. Have students take notes on how the water flows out: in a swift stream, a slow trickle, or not at all. Set a limit of about ten minutes because the water in the cup with the clay will take a very long time to flow through. Measure the amount of water that comes out of each filter to see which substances hold onto water. Graph the results according to the speed of the water and amount of water which flowed through each substance.

A lab which compares the flow of water across land with and without vegetation can be set up in a classroom with a bit of foresight. Obtain two disposable aluminum baking pans. Fill one with a layer of pebbles and soil. Grow a crop of grass or alfalfa seeds in the pan, (or fill with sod scraps). When the pan's vegetation is thick, bring the pan with the plant growth into school along with a second pan filled with a layer of pebbles and moist dirt. Cut a short side off of each of the pans and elevate the opposite side using books. Set a pan or other collecting bin under the cut-off side of the pan. Pour equal amounts of "rain" into the pans. The runoff from the pan with vegetation will run clear in comparison to the pan with no plants because the plant roots hold onto the dirt as the water passes through. Students will be able to see the damaging effects of erosion on top soil and the water pollution caused by erosion.

Further research projects on vegetation might include the Northwest logging industry and the debatable issues of lumbering jobs vs. trees, or the loss of wild life and the effect on air quality caused by deforestation.

Chemical Development, Pollution, and Atmospheric Change

> Clean the air! clean the sky! wash the wind!
> take the stone from the stone, take the skin from
> the arm, take the muscle from the bone, and
> wash them.

—T.S. Eliot ("Murder in the Cathedral") This section will focus on the properties of the Earth's atmosphere and how human produced pollution affects the atmosphere. Students will have the chance to explore the carbon cycle, the greenhouse effect, acid rain, and the ozone hole. The section should begin with discussions of the properties of air.

Allow students to experiment with air pressure, weight, and the absence of air in vacuums. One way to show the weight of air is to have students weigh a new light bulb, then carefully make a small hole in the light bulb, air will rush in to fill the vacuum. When weighed again, the light bulb will weigh more. Another demonstration that will help students understand the properties of air involves placing a lit candle under a glass and allowing it to burn up all the oxygen and flicker out. Discuss the high concentration of carbon dioxide that is left in the glass.

Pure air is composed of many gases including nitrogen, oxygen, carbon dioxide, methane, and water vapor. Nitrogen and oxygen make up 99% of the atmosphere. They are inert gases, and do not tend to interact with other substances. Carbon dioxide and methane are called trace gases because there is such a small amount of them in the air. The pollutants added to the air through natural chemical reactions and by human interference change the composition of these gases in the air.

Although it's a trace gas, carbon dioxide is one of the important players in the study of the Earth's atmosphere. A review of the water cycle demonstrated by the terrarium will help to explain the cycle of oxygen and carbon in the air. The carbon cycle begins with plants. Just as humans breathe and use oxygen, plants breathe and store carbon. Carbon dioxide is released into the air by the decay of organic material and the respiration of plants and animals. A carbon atom can be recycled within a period of six years unless it becomes stored in rock or other such substances.

The very existence of oxygen is dependent on organisms which use carbon dioxide. The earliest one cell organisms on earth gradually developed photosynthesis and utilized carbon dioxide and sunlight as energy. The product of photosynthesis is oxygen; thus, over time, oxygen was added to the air. Eventually as oxygen-dependent organisms developed, a level of balance between oxygen and carbon dioxide was reached. The carbon dioxide and oxygen cycle remain dependent on each other. Without carbon dependent organisms, primarily plants, oxygen would not be cycled through the atmosphere.

The cycle of carbon dioxide and oxygen is disrupted when humans put excessive CO_2 into the air through the use of fossil fuels and the burning of plants which store carbon dioxide. Carbon dioxide is an infrared trapping gas—it absorbs radiation that would otherwise escape from the earth. By adding too much carbon dioxide to the air, we are trapping too much heat. Thus, through disruption of the delicate balance of O_2 and CO_2, we are increasing the Earth's surface temperature.

The layer of gases in the upper atmosphere which prevents heat from escaping is referred to as the Earth's greenhouse. Carbon dioxide is only one of the gases we add to the atmosphere which works to build the greenhouse. The major greenhouse gases are carbon dioxide, methane, nitrous oxide, the Chlorofluorocarbons, and tropospheric ozone. These gases are more transparent to the short wave radiation of the sun's energy than to the long-wave radiation of the energy radiated from the Earth. Without greenhouse gases the surface temperature of the Earth would be too cold for existing life forms. Recently, however, human activity has increased these levels beyond the necessary amount.

The effects of the global greenhouse can be related to a car in the summer heat. If parked in direct sunlight with the windows rolled up, a car's interior will heat beyond the temperature outside. The windows act much like the greenhouse gases do. They let in ultraviolet rays but do not reflect them out. Consequently, the heat from the ultraviolet rays becomes trapped in the car, and the car's temperature increases.

Life forms on Earth depend on a moderate temperature. A quick study of our neighboring planets Emphasizes the relationship of climate to life forms. Venus has an average temperature of 460 degrees Celsius and has an atmosphere very rich in CO_2 . Mars, on the other hand, has a temperature of -50 degrees Celsius and a CO_2 thin atmosphere. Neither planet can sustain life with these climates.

The large number of variables that act upon the Earth's surface temperature makes it difficult to be certain which variables have the greatest effect. There are occurrences, such as volcanic eruptions and seasonal changes in weather patterns, which have an effect on the amount of CO_2 in the atmosphere. To know what direct effect modern human activity has had on the levels of CO_2 in the atmosphere, scientists study the average temperature of the Earth and the levels of CO_2 throughout the Earth's geological history. Studies on levels of oxygen in glaciers have helped scientists to understand the natural changes in the Earth's surface temperature and to understand the degree of human responsibility.

Samples of air are trapped in ice as glaciers are formed. Modern day scientists extract ancient glacier ice and measure the levels of oxygen and carbon dioxide at varying levels and thus can give estimates of average temperatures through the last 10 000 years. There have been changes in the Earth's average temperature as far back as can be measured, some quite dramatic. By studying ice samples from Greenland and Antarctica scientists have learned that there has been a steady increase in the level of carbon dioxide and the temperature in the atmosphere for the past two hundred years. Industrialization led to an increase in the burning of fossil fuel which in turn led to an increase in CO_2. The increase in temperature over the past two hundred years appears to be more constant than in the past. Thus, scientists maintain that human behavior is altering the surface temperature of the Earth.

By tampering with the levels of CO_2 in the Earth's atmosphere, we may well make it impossible for life to exist on Earth in the next millennium.

Current predictions suggest that the amount of CO_2 in the atmosphere will double in the next century if the use of fossil fuels remains constant. Using computer generated models called general circulation models (GCM's), scientists predict that the global surface temperature of the Earth will possibly increase from 2.8 to 5.2 degrees Celsius within the next few centuries. The Earth has warmed about five degrees since the last Ice Age. In the 5000 to 10 000 years since then, the sea has risen 100 meters; forests have moved thousands of kilometers, and new species have evolved to replaced ones that became extinct. Currently, we may be faced with a similar temperature increase in a mere fraction of the time needed to allow for such drastic environmental changes.

An increase in temperature will melt arctic glaciers which will cause sea levels to rise as much as 1.5 meters or 5 feet flooding many coastal areas around the world. More than a third of the world's economic centers are along coastal regions with altitudes less than 1.5 meters. Parts of Washington D.C. and much of Long Island may well become submerged. The transpiration rate of plants will be reduced in CO_2 rich air causing drought and desertification in some areas. Whole agricultural regions may dry up and become infertile leading to wide spread famine. Forests and the wild life which these areas support will be killed off before they have time to make the slow migration to cooler , wetter climates. Author John Firor warns that," the collective activities of people now rival or exceed conditions that have governed the climate and the interaction of the atmosphere with living things for ages." Computer generated predictions are not a guarantee, but they are serious enough to warrant a change in our life styles.

One of the best images of the dangers of global warming I have read comes from Anita Gordon's and David Suzki's book, "It's a Matter of Survival," (Harvard University Press, 1991). They equated life forms on Earth to a frog in a pot on a stove. The frog adjusts to a gradual increase of heat and will not jump out of the pot. Eventually, however, the water gets hot enough to kill the frog. Humans and other life on earth, like the frog, can adjust to gradual increases in the earth's temperature. However, at a certain unpredictable point we will have boiled ourselves without realizing it. We run the risk of "cooking" ourselves and our environment if we continue to allow the greenhouse gases to build up.

Greenhouse gases are only some of the many chemicals being pumped into the atmosphere by the use of fossil fuels. When coal and oil are burned in factories, they release stored sulfur and nitrogen which become sulfuric acid and nitric acid, the two leading causes of acid deposition. Sulfuric acid and nitric acid return to the ground as either wet or dry depositions. Acid absorbed by water vapor and trapped in clouds gets carried down with rain, fog, or snow in acidic precipitation, commonly referred to as acid rain. Dry deposition occurs through the circulation of acidic particles in the air. A certain amount of the gases are directly absorbed by vegetation, soil, and water. Acid depositions can kill plants, fish, and animals corrode stone and metals. Acidic precipitation is precipitation which has a pH less than 5.65. Natural rain water is actually somewhat acidic which explains why there is natural corrosion of rock. Studies have shown that the pH content of precipitation near factory areas is much lower than that of non-industrialized areas. However, rural areas that are in the weather patterns of cites also tend to also have low pH. The effect that the acidic depositions have on an area depend largely on the soil and ground content. Areas that have large amounts of bedrock minerals such as granite or quartz are, for example, are more susceptible to acid damage than areas with large lime deposits because lime is a natural alkaline and will neutralize excess acid.

Students should have an understanding of pH from the water unit so that discussion of acid deposition should focus on the damage caused by acid. If this section is introduced during a week of rain or snow fall, an excellent introductory lesson could be to test the pH of New Haven's precipitation. Precipitation should be collected in an area away from trees or buildings. The handling of the collection bucket and the water collected should be done with rubber gloves to avoid skin oils from effecting the pH. The samples should be tested within 24 hours of collection. Testing can be done using pH test strips.

To demonstrate the harm that acid rain can cause, set up acid labs using vinegar. The acid in vinegar will eat the shell off a hard boiled egg if the egg is allowed to sit in vinegar for 48 hours. It is a good idea to bring in a hard boiled egg that has not been soaked in vinegar so that students can compare the feel of a regular hard boiled egg with one whose shell has been eaten away. Vinegar will also dissolve a piece of chalk in a short period of time.

The problem of the ozone hole is another example of human produced chemicals disrupting the balance of the atmosphere. Because of the complex chemical nature of the "ozone hole" a discussion of the ozone must be proceeded by a detailed discussion of the atmosphere. There are layers within the atmosphere defined by air pressure and temperature. Air pressure decreases with an increase in altitude. The atmospheric layer surrounding the earth up to about 10 kilometers is called the troposphere. It contains about 90% of the air in the atmosphere with temperature ranges from -50 degrees Celsius to 20 degrees C. The next layer up, the stratosphere, ranges in altitude from 10 kilometers to about 50 kilometers. The air in the stratosphere is thin and ranges from -50 to 10 degrees. The lower boundary of the stratosphere, called the tropopause, and the upper boundary, called the stratopause, are characterized by rising temperatures. The result of the inverted temperature zones is that the stratosphere is nearly cloudless and without precipitation. The troposphere and the stratosphere together account for about 99% of all the air in the atmosphere. As the altitude continues to increase into the mesosphere, the temperature actually increases. The molecules in the mesosphere are active, and the air is full of electricity. Above the mesosphere is the exosphere where there is no air at all.

To understand the ozone hole, one needs to look at the chemistry and chemical reactions of the atmosphere. Ozone is actually a gas composed of three oxygen atoms, as opposed to the two atoms in oxygen that we breath. There is a layer of ozone gas in the stratosphere which shields the Earth from the sun's ultraviolet rays. The ozone helps to keep the temperature of the atmosphere regulated by limiting the amount of ultraviolet rays the hit the Earth's surface.

Each day ozone gas is created by reactions driven by intense sunlight. The creation of ozone looks like this:

$O + O2 + M = O3 + M$ (M= molecular oxygen)

Each day some ozone is also destroyed in cycles of reactions which involve hydrogen-containing radicals such as OH, and nitrogen containing ones , such as NO. Therefore an equilibrium of ozone is reached naturally within the stratosphere blocking out enough ultraviolet rays to protect all life forms.

The destruction of the ozone layer and the appearance of the ozone holes was first suggested to be related to human activity in the late 1970's, and connected unmistakably to CFC's by 1987. Ozone all over the Earth is thinning, the layer of ozone over the Antarctic is so thin in the springtime that it has come to be called the ozone hole. The depletion of the ozone is a natural chemical reaction, but is increased by CFC gases released into the atmosphere.

Chlorine, one of the major components in CFC's, is a primary culprit in the destruction of the ozone's balance. Chlorine interacts with ozone molecules as a catalyst. It pulls away the third molecule from the ozone bond so the ozone gas is converted back into oxygen. The chlorine remains unchanged and can destroy thousands of ozone molecules. The reaction is as follows:

$Cl + O_3 = ClO + O_2$	Chlorine meets with a molecule of ozone and grabs onto one of the oxygen molecules.
$ClO + O = Cl + O_2$	Later, the chlorine and oxygen molecule meet with a solo oxygen molecule that has been zapped out of an O2 bond by the sun or left alone by an O3 and Chlorine reaction. The solo oxygen grabs hold of it's fellow oxygen molecule, and together they leave the chlorine molecule.

The extra chlorine in the stratosphere is mainly caused by Chlorofluorocarbons (CFC's). When CFC's are released into the air, they float up into the stratosphere where they remain until the molecular bonds are broken by solar radiation. One of the atoms in CFC's is chlorine which can be released from the CFC bond by ultra violet rays in the stratosphere.

Understanding chemical bonds may be difficult for some middle school age students. I have found that physically acting out the chemical process helps them comprehend the series of changes. Assign students to play the part of individual molecules and ultraviolet rays and talk through the formation and destruction of ozone molecules. This activity could be repeated in small groups so that every student has the opportunity to play a molecule.

Without the ozone layer protecting the Earth, all living creatures are in danger of over exposure to the ultraviolet rays. Environmental Protection Agency researchers estimate that for a 1% decrease in ozone, there will be a 5% increase in human skin cancer. The loss of the ozone may also cause the upper atmosphere to become cooler. Thus, in addition to exposing ourselves to grave danger, we are causing harm to the primary chemistry of the atmosphere.

Fear of the dangers presented by the ozone hole has focused our attention on chemicals of all kinds. The same chemicals which destroyed the ozone also produce many products which humans have come to take for granted. Students need to understand the change in life style that may well be demanded for them as adults because of these chemical luxuries.

Chlorofluorocarbons, for example, have brought us refrigeration, inexpensive packaging, and the short lived aerosol spray cans. The problem of eliminating CFC's is entrenched with our own desire for comfort . An interesting political issue surrounding human comfort and CFC's arose when the government of China began promising a refrigerator in every home. The number of refrigerators needed would increase the omission of CFC's into the atmosphere at a dangerous rate. Thus, the peasants of China are denied a commodity thought to be a necessity in the developed world. The problem for our students will be to envision alternative resources to replace our now outdated models which endanger the Earth's atmosphere.

Of the three sections the chemical section will be the most difficult to relate to the school as a system unless air quality or toxins can be tested within the school. A project on toxic chemicals frequently found in school will bring up issues of pesticides, lead, asbestos, and radon. Studies have suggested that toxic chemicals in schools lead to increased hyperactivity and aggressiveness, shorter attention spans, and high absenteeism.

Advanced students may be interested in doing further research on the issues of toxins in school.

Conclusion

One of the main goals of teaching environmental science is to give students an understanding and appreciation of their natural surroundings. Cross curricular studies reach students through a variety of subjects and projects and help to build a strong base for science. Ideally, literature where environment is a major component would be taught in conjunction with this unit for reading. Three excellent novels for middle age students that focus on environment are, “Island of the Blue Dolphins” by Scott O’Dell, “My Side of the Mountain,” by Jean Craighead George, or “The Wheel on the School,” by Meindert DeJong. Poetry can be used to stimulate images of the outdoors for a shorter reading unit. Haiku poetry is easy for middle school students to read and write. One good collection of Haiku is “The Haiku Anthology,” edited by Cor van der Huvel. For more light hearted poems try, “Imagination’s Other Place: Poems of Science and Math” by Helen Plotz or “The Salamander Room” by Anne Mazer.

Expand the unit to include writing and art as well as literature. In addition to writing science reports, students should be assigned creative writing assignments that are connected with the environment. Have the class write adds for newly invented “Green Products” or essays on outdoor adventures. Art projects could include making garbage colleges or leaf rubbings. An excellent project to do in connection with oil spills is Paper Marbleizing. Drop small amount of oil based paint onto the surface of water and swirl with popsicle sticks. Write each student’s name on the back of a blank piece of paper and drop the paper carefully onto the surface of the water. Remove the paper and hang to dry. The result is a colorful design in the shape of oil ripples on the surface of water.

Science should be engaging and interesting to students. Creative projects and field trips will help keep them involved in science and encourage them to pursue science throughout their education. There are lists of possible trip sights and further resource materials as well as three examples of projects in the appendix. Enjoy and good luck!

Appendix 1

(figure available in print form)

APPENDIX 2 INSTRUCTIONS FOR BUILDING A PROBABILITY BOARD

PURPOSE: The probability board will demonstrate the construction of a bell curve and will help students understand discussions of statistics.

NOTE: It is advisable that the board be teacher constructed for accuracy. Once the board is built is can be used yearly.

Labs done with the probability board should follow labs on outcomes with two variables, such as flipping coins, to ensure that students understand the basic concepts if predicting outcome. Labs should be followed with student conducted surveys and graphing.

MATERIALS:

-large flat board at least 2” thick (size depends on how big a board is desired, the diagram depicts a board 15” x 11”)
-thick cardboard or balsa wood cut into 1” wide strips
-wood glue
-nails
-marbles (at least 20)
-hammer
-ruler

PROCEDURE FOR ASSEMBLY: (as shown in the diagram)

Step One: Measure 1/2” from each side of the board, to create margins, side guards will be glued here to prevent run away marbles
Step Two: Measure 1” wide columns, there should be 10 columns.
Step Three: Mark off a line 6” from the bottom of the board. Below this line will become the marble catching area.
Step Four: Measure 1” wide rows from the top to the 6” line. There should be 9 rows.
Step Five: Place nails in the grid intersections as is shown in the diagram by the X marks.
Step Six: Using the cardboard or balsa wood, glue diagonal top guards, side guards, and collecting columns as shown.

DEMONSTRATION:

Set the board on a notebook to create a slight tilt. Experiment with the slope so that the marbles roll, but not too fast. Drop the marbles into the top and let them find their own path to the bottom. If the bell shape is not produced, check the placement of the nails.

When doing labs with the probability board it may be helpful to have a diagram of the board on an overhead projector so that the route of the first few marbles can be mapped. Encourage student predictions throughout the labs. Perfect bell curves may not be formed, but students should be able to see the general shape. More marbles will produce a clearer shape.

Probability Board

(figure available in print form)

APPENDIX 3 WATER FILTER LAB

Days Needed: 2-3

Materials:

-empty 2-liter soda bottles, one for every two students
-fish tank filter charcoal, rinsed
-pebbles
-sand
-nylon stockings, cut into 2 inch squares
-rubber bands
-tall empty plastic cups, two for each pair of students
-one cup measuring cups
-substances to filter, such as: food coloring, cooking oil, dish soap, dirt

Day One: Making Filters

step 1—cut bottoms off of soda bottles
step 2—wrap a piece of nylon stocking over top of bottle and secure with rubber band
step 3—put one cup each of pebbles, sand, and charcoal in that order, in the bottle as shown in the picture.
step 4—place bottle in empty plastic cup to stand

(figure available in print form)

Day Two- Filtering (This may take more than one day)

TEACHER NOTE: Before class, organize material to be filtered. Mix oil and water 1/2 and 1/2, mix dish soap and water 1/2 and 1/2, mix dirt and water to make water very cloudy, and mix enough food coloring with water to make the color very dark.

Once filter is used, it is difficult to clean and reuse because the pollutants stay in the filter. I suggest that each group be given one substance to filter and each group may then report its findings to the class.

Procedure:

Step 1: The substance our group has is:___________________________
Step 2: Measure substance to be filtered and record the amount. Record the amount:
Step 3: Record on your lab sheet your observations on the substance to be filtered. Be exact about what you see.
Step 4: Be sure the empty cup is under your filter to catch the liquid which comes out. CAREFULLY pour your substance into the filter. Write down any observations you make on how the substance flows through the filter.
Step 5: Once the liquid has run out of the filter, record what the liquid looks like, note particularly how the liquid compares to how the liquid looked before filtering.

Measure the liquid. Was any lost in the filtering process? If yes, then how much?

Questions

1) Do you think that this filter did a good job cleaning the pollutant out of the water? Explain your answer in sentence form.
2) What might make this filter more effective?

3) In a water treatment plant, the filtering process is only one part of the treatment process. Before water is filtered, it is mixed with coagulant, sort of like jello, which attract the impurities in the water. The water is then run through filters, much like the filters we built. How do you think the coagulant helps the filtering process?

*The coagulant form clumps which collect the impurities and are more easily filtered out.

4) After water is filtered in a treatment plant it is treated with chemicals which kill any bacteria remaining in the water. Why is it that the filter is unable to remove the bacteria from the water?

*The bacteria is microscopic, and seeps through the filter with the water.

APPENDIX 4 PAPER MAKING

Days needed:
at least a week, it will likely take more than one attempt to get the paper to work correctly.

Day One:

Step 1—Tear up old news paper until you have 1-1/2 cups worth of news scraps. Mix with 2 quarts of water and allow to soak over night. (If heavy paper or cardboard is used, boil the water with the materials for 10 minutes before soaking over night.)

Step 2—Make screens. Obtain balsa wood, cut and stable together into square frames. Attach screens frames, if metal screening is used be sure to fold edges under first to avoid cuts.

Day Two:

Materials Needed:
-wet paper from day one

-wax paper

-screens from day one

-deep tub or pan

-felt pieces

-blender or hand held egg-beater

-(optional- hair drier)

Procedure:

> Step 1—Put newspaper and water mixture into a blender, or mix up with an egg beater. This makes the slurry, the fibrous solution from which paper is made.
> Step 2—Put slurry into a tub that is about 5 inches deep and large enough to allow the screen to move easily.
> Step 3—Place screen in slurry, and shake gently to stir slurry and make sure that the screen is covered. Raise frame evenly and slowly. Be sure to keep the frame even. Allow the water to drain off over the tub. Blot back of screen with felt pieces, and overturn onto wax paper. If hair drier is available, dry a bit first. Allow to dry over night.
> Step 4—NEXT DAY. Carefully lift paper off of wax paper and trim edges.
> HINTS: If paper is too thin and tears, add more newspapers, to slurry if paper dries like cardboard, add more water to slurry. If paper is not dying flat, place a piece of felt on the top of the paper, and weight with books.

For variance, have students bring in plant leaves, onion skins, or colored paper to mix into the slurry.

Enrichment Activities:

> —Have students research the origins of paper. Paper was invented in China in 105 C.E., during the rule of Emperor Ho Ti. The word "paper" comes from the Egyptian use of the papyrus plant as paper.
> —Assign a creative writing project on a plant which becomes a piece of paper. What processes were involved in making the paper and what was the paper used for.

Appendix 5: Field Trip Sites and Sources For More Information

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Bronx Zoo Rain Forest Exhibit

Bronx Zoo, Bronx, NY.

East Shore Waste Water Treatment Plant

345 East Shore Parkway

New Haven, Ct.

787-6490

Liberty Belle Cruises—(cruises around New Haven Harbor)

Long Warf Drive, New Haven

562-4163

New Haven Water Shed Areas

Manager of Educational Programs

New Haven Regional Water Authority

(203) 624-6671

Rainbow Recycling

810 State Street

New Haven, Ct

865-6507

Schooner Incorporated

60 South Water Street

New Haven, Ct. 06519

865-1737

Shoreline Outdoor Education Center

730 County Line Road

Gilford, Ct. 06437

457-0692

West Rock Nature Center

PO box 2969

New Haven, Ct. 06515

787-8016

Whitney Water Center

contact : Manager of Education Programs

New Haven Regional Water Authority

90 Sargent Drive

New Haven, Ct. 06511

(203) 624-66

Notes

1. For instructions, appendix 2.
2. See appendix 3 for lesson plans on building and using water filters.
3. See appendix 5 for instructions on paper making in the classroom.

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