

Action n

in the

classroom

**An Introduction to Environmental Science
for High School Students**



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For additional teaching materials including fact sheets, guides, posters, videos and more,
contact DHEC's Office of Solid Waste Reduction and Recycling at **1-800-768-7348**
or visit **www.scdhec.gov/recycle**.

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About 'Action in the Classroom'...

"Action in the classroom" began as a program to introduce recycling and other solid waste management issues to fifth- and seventh-grade classrooms across the state. The program offers presentations to students as well as lessons for teachers that are designed to be specific to South Carolina and their community.

The third and latest edition to this program targets high school environmental science students and teachers and is a much more comprehensive effort. This edition began in 2010 as a pilot project in partnership with the S.C. Department of Education. The goal of the project was to meet a significant need that South Carolina high schools faced – the lack of a high quality but general environmental science curriculum.

As part of the "Action in the classroom" program, this edition provides hands-on lessons, lesson resources (fact sheets for teachers that present more detailed background on issues), student activities and worksheets. Included in this edition are lessons on composting, recycling and air quality as well as fact sheets on alternative fuels, how landfills work and hazardous waste.

The goals of the "Action in the classroom" program include helping students:

- understand the connection between natural resources and the products they use everyday;
- understand that there are preferred options to managing waste;
- to think critically of their own actions in conserving natural resources, and protecting our air, land and water; and
- recognize the concept of personal responsibility toward the environment and to "take action" to make a positive impact in their home, school and community.

The "Action in the classroom" program is part of "Action for a cleaner tomorrow: A South Carolina Environmental Curriculum Supplement" ("Action"), which is the centerpiece environmental education program offered by the S.C. Department of Health and Environmental Control.

DHEC, in conjunction with a statewide curriculum development team of teachers and the S.C. Department of Education, began creating "Action" in 1992. Currently in its 13th edition, more than 52,000 teachers and educators have been trained to use "Action" since 1993. "Action" lessons have been taught to thousands of students throughout South Carolina.

"Action" and "Action" workshops as well as "Action in the classroom" are provided at no cost to schools and teachers. For more information, please contact DHEC's Office of Solid Waste Reduction and Recycling at 1-800-768-7348 or visit www.scdhec.gov/recycle.



CLASSROOM COMPOST

PREPARATION TIME:

MODERATE

NOTE: In this lesson, students will construct and monitor a classroom compost pile and discuss the benefits and uses of compost.

Learning Objectives

Students will:

- identify the components of an active compost pile;
- explain the composting process;
- identify current and potential markets and uses for finished compost products; and
- describe the benefits of composting as a waste management technique.

Background*

Garden and yard trimmings (e.g, leaves, grass clippings) account for up to 20 percent of the waste disposed of in landfills. Obviously, it makes sense to divert these materials to mulch or compost. Through these processes, organic trimmings can be recycled to improve and beautify the garden and landscape. **Composting** is a biological process in which microorganisms convert **organic** materials (such as leaves, grass, manure and food scraps) into an end product called compost – a dark, crumbly, earthy-smelling form of organic matter that reveals no hint of its origin. Composting is the same process that decays leaves and other organic remains in nature, except that composting controls the conditions so that the materials **decompose** faster. Composting can occur under either aerobic (in the presence of oxygen) or anaerobic (without oxygen) conditions.

Microorganisms involved in aerobic composting require oxygen. The amount of oxygen needed in the compost pile must be greater than 5 percent. (By comparison, fresh air is about 21 percent oxygen.) Anaerobic microorganisms prefer an absence of oxygen. Aerobic decomposition is the preferred composting technique because it is the most rapid and efficient. When mixed with soil, compost increases the organic matter content, improves the physical properties of the soil and supplies essential nutrients, enhancing the soil's ability to support plant growth. The practice of applying materials such as compost, leaves or grass clippings to the soil surface is called mulching. Mulching conserves moisture, controls weeds, reduces erosion, improves appearance and keeps the soil from gaining or losing heat too rapidly.

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Learning Essentials

Focus: Composting

Subject: Environmental Science

Materials: See the list provided

Teaching Time: Two class periods (21 days apart), 5 to 10 minutes per day for days two through 20

Vocabulary: Composting, organic, decompose, aeration



* From the "S.C. Master Gardening Training Manual" prepared by Robert Polomski, Extension Associate, Consumer Horticulture Coordinator, Department of Horticulture, Clemson University

By constructing a compost pile on school grounds (or in your backyard), you can reduce the amount of waste sent to the landfill. More than 30 percent of total residential waste generated can be diverted from landfills by simply composting yard trimmings and food scraps.

Backyard composting can be as basic or as fancy as you like. You may want to begin with a simple approach.

- **Location, location, location.** Pick a spot in the school yard (you will need an area about 3 feet by 3 feet) that is at least 2 feet from a structure like your school, house or a fence. The spot should be partially shaded so that the sun doesn't dry your compost too quickly (but try to stay away from large trees that may penetrate your compost with roots). The spot should be convenient for you to add materials, have access to water and have good drainage. You may want to plan for extra space around your pile to make turning and harvesting your compost easier.
- **Begin with the bin.** You can build a compost pile on the ground, but using a compost bin will help keep your compost pile neat and tidy, deter rodents from digging into your pile and help your pile retain heat and moisture. Compost bins can be homemade or purchased. Homemade bins can easily be built out of wood, wire mesh and scrap pallets. You even can build a compost corral with concrete blocks or chicken wire. Some manufactured bins include turning units, cone shaped bins and bins with stacking tiers. Some are wood and some are plastic (sometimes recycled plastic). These bins can be purchased at nurseries and garden centers or directly from the manufacturer. Bins are available in a wide range of prices. Take the time to consider your options and what works best for you.
- **How big should the bin be?** Ideally, your compost pile should be at least 3 feet wide, 3 feet deep and 3 feet tall – big enough to work and small enough to be easily turned. Backyard compost piles probably should not be larger than 5 feet by 5 feet by 5 feet. You could have finished compost ready to use in as little as 12 weeks. Four basic ingredients are required for composting – greens, browns, water and air. Mixing the proper amounts of these ingredients will provide the composting organisms (microbes and insects) with enough nitrogen, moisture and oxygen to break down the material effectively. Greens include green leaves, fresh clippings and vegetable scraps. Do not add any meat or dairy products. Browns include dead leaves, wood

chips, dry twigs and paper. Water is important. Too little moisture will inhibit the composting process. Too much moisture will cause the compost pile to smell. Here's a simple rule to follow – the compost pile should be as moist as a sponge. Air is essential. Turn your compost pile once or twice a week to inhibit odor-causing bacteria and to speed up the composting process. When is it complete? It depends. It could take several weeks to three to six months, but compost generally is done when it becomes a dark, crumbly material that is uniform in texture.

Compost can be used to enrich the garden, to improve the soil around trees and shrubs, to amend the soil for house plants, seed-starting mixes or to top-dress lawns. Compost increases **aeration** (the ability of air to circulate), water-holding capacity and helps plants absorb nutrients. Home gardeners, landscapers, road and park departments, building contractors and farmers can use compost. In fact, quality compost will improve your soil.

DHEC's Office of Solid Waste Reduction and Recycling also offers two composting publications: "Home Composting Made Easy" and the "Smart Gardener Handbook" at no charge. (Call 1-800-768-7348 for availability.)

Materials

- "Striking It Rich With Compost" handout (one per student)
- "Classroom Compost" worksheet (one per class)
- Compost bin for outside compost (use wire screen, concrete blocks, wood or plastic)
- Yard trimmings and food scraps (leaves, wood ash, sawdust, eggshells, fruit and vegetable peelings – no meat, dairy or grease)
- Dirt or non-sterile potting soil
- One or two dozen earthworms
- A thermometer
- Shovel or pitch fork

Learning Procedure

A few days before starting this composting activity, collect material for a 1 cubic yard pile. The source for yard trimmings and food scraps must come from the schoolyard or the cafeteria. In accordance with regulation, material may not be brought from home or other sources. Visit the "Solid Waste Composting

Guidance for Schools” technical assistance sheet at www.scdhec.gov/environment/lwm/recycle/pubs/school_composting_tas.pdf for more information.

DAY 1

1. Introduce and define the term compost. Ask students to identify the ingredients they think are essential for a good compost pile. Ask students to explain why these ingredients are necessary.
2. Distribute the “Striking It Rich With Compost” handout and review the components of an active compost pile. Next, explain the composting process and ask students what they think finished compost would look like. Explain that when it is properly prepared, finished compost looks and smells like dark, nutrient-rich soil (humus).
3. Locate an appropriate place for the compost bin. The bin could be pre-built or pre-purchased from a local home improvement store or the Web. (Some years, grant funding is available for schools to purchase compost bins. Call **1-800-768-7348** for more information.) It should hold 3 X 3 X 3 cubic feet (1 cubic yard) of material.
4. Follow these steps to build the pile.
 - A. Chop or shred any coarse materials to increase their surface area.
 - B. Start the pile with a 4- to 6-inch layer of brown (high-carbon) materials.
 - C. Next, add a 4- to 6-inch layer of green (high-nitrogen) material. If food waste is added, place a thin layer of soil, sawdust, leaves, straw or finished compost over the items to absorb odors.
 - D. Remember to water each layer as you construct the pile.
 - E. Continue to layer the material in this way until the pile is about 3- to 4-feet high.
 - F. Then slant the top of the pile to the center to catch rainfall.
 - G. Place a thermometer into the middle of the pile.
 - H. **DO NOT SEAL THE COMPOST PILE. AIR CIRCULATION IS CRITICAL.**
5. Place the completed compost pile in an easily accessible area in the schoolyard. Post the “Classroom Compost” worksheet near the compost bin. Have a student record the initial temperature, odor and texture of the compost.

Also have the student list the material added to the pile at the top of the worksheet.

DAYS 2-20

6. Assign a different student to examine the compost pile and use the worksheet to record the data for temperature, odor, texture and the changes observed each day. Once each week, (Days 6, 11 and 16) students should use a shovel or pitch fork to gently turn and aerate the compost. Have students make and record their observations BEFORE the compost is turned and aerated on these days. Remind students to record the temperature of the compost pile from the same location, depth and time each day. Check the moisture level of the compost pile every few days and add water as needed to keep it moist.

DAY 21

7. Record the final temperature, odor and texture of the finished compost. Allow each student to feel, smell and look at a sample of the finished compost. Have students create a graph showing the temperature of the compost pile over the course of the experiment. Reproduce the completed “Classroom Compost” worksheet on the board.
8. **Ask:** What happens to food scraps and yard trimmings when they are buried in landfills? Explain that most landfills are not exposed to air – a critical component of the natural composting process. Without adequate aeration, most decomposing organisms cannot function properly. As a result, organic wastes buried in landfills can take decades to decompose. Inorganic compounds in a landfill never decompose. In addition, without ventilation, methane gas – a natural product of the decomposition process – is trapped in landfills. As methane gas builds up in landfills, it expands and has been known to “float” or lift entire landfill cells. Today, all new landfills must include systems for collecting and releasing methane gas.

Questions for the Class

1. List the components necessary for an active compost pile.
2. Write a paragraph explaining the composting process.
3. Identify at least two current and two potential markets or uses for finished compost.
4. Explain the benefits of home and large-scale composting.

5. Why was it important to record the temperature of the compost pile from the same location, depth and time each day?
6. How did the temperature of the compost pile change over time?
7. Why did the temperature of the compost pile change?
8. Were any odors produced during the composting process? Why does compost have an odor?
9. How did the texture of the compost change?
10. What happened to the original organic waste added to the compost pile? Which materials

were broken down and decomposed the fastest? Which were the slowest? Why?

11. What can be done with the finished compost? (The compost is a good soil amendment – that is, it helps to retain water, moderate soil temperature and allow plant roots to grow deeper and stronger. Tell students that in natural settings – especially wooded areas – dead leaves, branches and other organisms are naturally composted to produce humus – a nutrient-rich soil.) Discuss the uses of composted sewage sludge as well as composted plant and yard trimmings in South Carolina.

Extension Activities

1. Have small groups of students design and monitor different kinds of compost piles – one low in nitrogen, one without moisture, one without aeration, one with sterile potting soil, one with a single organic waste ingredient such as banana peels, one without earthworms, etc. Compare the decomposition rate of each pile.
2. Prepare one compost pile containing large pieces and another with small pieces of the same organic waste. Have students investigate how the size of materials affects the decomposition rate.
3. Collect samples of natural humus from a wooded area. Have students observe and compare the texture, odor and color of natural humus to that of prepared compost. Examine the humus for evidence of decomposers (fungi, earthworms, insects, etc.).
4. If your community has a municipal composting center, take a field trip to observe its operation.
5. Have students prepare a composting fact sheet and distribute it to classmates and family members.
6. Perform soil tests on natural humus, commercially obtained humus and compost. How do they compare? Grow seedlings in each one under identical conditions to see if there are any differences. What may cause the differences you observe?

Composting Q&As

- Q. Will everything in the waste stream compost?
 - A. No. Much of the typical waste stream, however, is compostable. This includes yard trimmings, food scraps, paper and wood.
- Q. What is the best method of composting?
 - A. There are several methods of composting. Choose a method based upon the materials you have and the time you want to devote to composting.
- Q. Is composting considered recycling?
 - A. Yes. The U.S. Environmental Protection Agency includes composting in its definition of recycling.
- Q. What is the advantage in having a city or county composting facility?
 - A. Composting can reduce the dependence on landfilling and/or incineration.
- Q. How does compost benefit the soil?
 - A. A high-quality compost properly applied to the soil improves soil structure and aeration, and increases its water-holding capacity. Compost improves the permeability of clay soils and the water retention of sandy soils.
- Q. Is compost considered a fertilizer?
 - A. No. While compost can contain varying amounts of nitrogen, phosphorus and potassium, it is considered a soil amendment – not a fertilizer.
- Q. What are typical uses for compost?
 - A. High-quality compost can be used in horticulture, landscaping and golf courses.



Student Handout

Striking It Rich with Compost

KEY COMPONENT	FUNCTION
1. Soil	It contains microorganisms (bacteria) that help decompose organic materials.
2. Organic waste (leaves, fruit and vegetable scraps, egg shells and yard trimmings) containing both carbon and nitrogen NOTE: Meat scraps, fats and oils inhibit decomposition and their strong odors can attract dogs, rats, raccoons and other animals. They should not be used in school compost piles.	Alternating layers of high-carbon and high-nitrogen waste creates good environmental conditions for decomposition to occur.
3. Earthworms (optional)	Red wiggler earthworms eat the waste and help break it down. Their droppings enrich the soil. They tunnel through and aerate the waste thus aiding decomposition. They become part of the compost when they die.
4. Water	Water is an essential component of the decomposition process. Too much water can make the compost pile soggy and slow decomposition by reducing needed oxygen.
5. Air	Fungi, bacteria, small insects and other decomposing organisms require adequate amounts of oxygen to survive and function.
6. Time	Decomposition takes time. Aerating the compost pile every few days can speed up decomposition.
7. Heat	Heat is a by-product of the chemical reactions occurring during decomposition. A properly functioning compost pile can reach a temperature of 149°F. These high temperatures help sanitize compost by killing weed seeds, pathogens and harmful insect larvae.
8. Mass	To generate enough heat for optimal decomposition, a compost pile should contain at least one cubic meter of organic material.



Classroom Compost

Material added to pile on Day 1: _____

AGE OF COMPOST PILE	TEMPERATURE (°C)	ODOR OF COMPOST	TEXTURE OF COMPOST	CHANGES IN ORGANIC WASTE MATERIALS (size, color, etc.)
DAY 1 (start)				
DAY 2				
DAY 3				
DAY 4				
DAY 5				
DAY 6 (aerate)				
DAY 7				
DAY 8				
DAY 9				
DAY 10				
DAY 11 (aerate)				
DAY 12				
DAY 13				
DAY 14				
DAY 15				
DAY 16 (aerate)				
DAY 17				
DAY 18				
DAY 19				
DAY 20				
DAY 21 (finished compost)				

DECIDING TO CLEAN THE AIR

PREPARATION TIME:

MODERATE

NOTE: This activity lets students practice making choices and experience the sometimes difficult process of making decisions related to air pollution.

Learning Objectives

Students will:

- understand the impact of choices on the nature and quality of life;
- understand the process for making decisions; and
- recognize that different people have different perspectives on the same air pollution issue by researching, comparing ideas, considering alternatives as well as making and justifying decisions.

Background

Whether we are students or adults, our lives are influenced by a constant series of choices. Some choices we make for ourselves. Some choices are made by parents for their children and many are made by people we don't even know. The combinations of all of these choices determine the quality of each of our lives.

Making these choices is not easy. Sometimes, what is perceived as the right choice for the community or nation is perceived as an inconvenience for an individual. For example, a person may not want to join a carpool to get to school or work because it means coordinating his/her schedule with someone else's or getting up earlier in the morning to be on time.

Over the years, the combination of choices made by individuals, businesses and the government has had a huge impact on the quality of the air we breathe and air pollution problems the world faces today. For example, as a country, we have chosen to pay higher prices for cars with emission control systems in order to reduce pollution from motor vehicles.

Automobile emissions are a major contributor to air pollution. Cars and trucks emit several pollutants that the U.S. Environmental Protection

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Learning Essentials

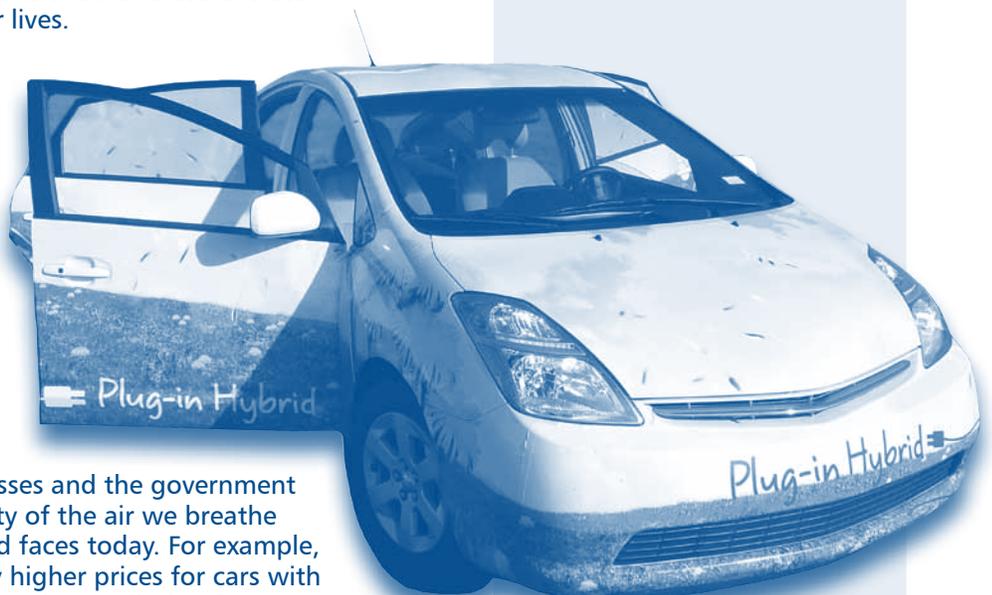
Focus: Air pollution

Subject: Environmental Science

Material: One worksheet (included)

Teaching Time: Two class periods

Vocabulary: Automobile emissions, carcinogens, benzene, formaldehyde, acetaldehyde, particulate matter, soot, smoke, hydrocarbons, nitrogen oxides, ozone, national ambient air quality standards, criteria pollutants, non-attainment area, clean-fueled vehicles



* This lesson was adapted from the EPA publication "Project A.I.R.E. – Air Information Resources for Education (K-12)."

Agency (EPA) classifies as probable or definite **carcinogens** including **benzene, formaldehyde, acetaldehyde** and **particulate matter (soot or smoke** – especially from diesel vehicles). The EPA estimates that toxic emissions from cars, trucks and buses could be responsible for as many as 1,500 cases of cancer each year. (See reading material on “Automobiles and Air Pollution” in the Lesson Resources.)

In addition, automobile exhaust contains **hydrocarbons** and **nitrogen oxides** that react with sunlight to create **ozone**. Ozone at ground level is responsible for the wheezing, coughing and throat irritation that some people experience. It can worsen bronchitis, emphysema and asthma. Ozone also inhibits plant growth and can cause widespread damage to crops and forests. In typical urban areas, at least half of the hydrocarbons and nitrogen oxides come from motor vehicles. Nitrogen oxides also are produced by power plants, factories and even lawnmowers. Hydrocarbons are found in many consumer products including paint, hair spray, charcoal lighter fluid, solvents and plastic “bubble” packaging. EPA sets national standards for ozone (one of the six widespread **criteria pollutants**) and the states must take action to ensure that standards are met. Areas of the country where air pollution levels persistently exceed the **national ambient air quality standards** may be designated “non-attainment.” (See reading material on “The Clean Air Act” in the Lesson Resources.)

Many of the ground-level ozone prevention efforts involve motor vehicles because virtually everyone is exposed to their emissions. Also, if an area is designated non-attainment, additional pollution controls may be required for new or existing industries. Strategies that may be required by law to reduce and control these toxic emissions include state permitting programs, changes in the composition of gasoline, use of alternative fuels (such as natural gas and electricity) and use restrictions imposed by individual communities.

Many new and innovative approaches are being taken by local governments across the country to reduce air pollution in **non-attainment areas**. Some of these approaches include:

- banning or restricting the open burning of yard trimmings such as tree branches and twigs;
- developing high-occupancy vehicle (HOV) lanes or local highways to encourage carpooling (For more information on alternative commuting, visit, www.scdhec.gov/environment/baq/YouHoldtheKeySC/);
- restricting traffic in specific areas of the city;
- providing incentives for citizens to use public transportation systems;
- expanding public transportation systems using **clean-fueled vehicles**, such as municipal buses that use compressed natural gas (CNG) or ones that are hydrogen fuel cell powered;
- eliminating payments by employers that reduce parking costs of employees who carpool;
- encouraging employers to contribute to employee mass-transit costs;
- encouraging local governments to enact local ordinances to improve air quality such as an anti-idling policy for their vehicle;
- offering opportunities for citizens to exchange small gas powered engine equipment, such as lawn mowers, for electric powered alternatives (Visit www.scdhec.gov/lawnmowerexchange to learn more.);
- requiring more stringent vapor recovery at gas stations;
- encouraging large companies to purchase fleet cars that run on clean fuel;
- buying and scrapping older cars; and
- participating in “Breath Better.” (To learn more, visit www.scdhec.gov/b2.)

On the Web ...

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment. – www.epa.gov/air/caa/

“National Ambient Air Quality Standards (NAAQS)” www.epa.gov/air/criteria.html



Learning Procedure: 1st Class Period

1. Have students role-play a situation that illustrates making difficult choices for cleaner air. For the exercise, students are to assume that there has been a proposal brought before their town council to close the downtown commercial district to automobile traffic because of the pollution level and traffic congestion. Under the proposal, only fire and police emergency vehicles and public transit buses would be allowed on downtown streets between 8 a.m. and 6 p.m.
2. Divide the class into eight teams. Explain that each team will represent one of the “players” in this drama: three town council members, two citizens, two downtown business owners and one impartial expert who has been paid to evaluate the impacts of the proposal and report to the council. You may choose to be more specific about the roles to approximate the makeup of your community. Assign a role to each team and explain that they will have to choose one team member to be the actor when the drama is played out in class. Give a specific date for the activity but allow a few days to prepare.
3. Explain that in order to act out the role they have been assigned, each team will have to define the characteristics and views of that person. Does the character live in the town, in the suburbs or in a rural area? What does the person do for a living and where does he or she work? How does the person get to and from work? Does the person have a family? Where does the person shop? The last page of this activity is a sample “Character Attributes” worksheet that each team can complete to help define the role.
4. When each team has defined its character, they should determine the character’s concerns related to the proposal. Stress to the team that these concerns should go beyond deciding whether the character would be “for” or “against” the proposal. Teams should define why this character may feel a particular way. Encourage students to talk to their parents, local town council members and business owners to help develop these perspectives.
5. Explain that for this role-playing activity, the actor from each team will have to describe the team’s character and make a statement about that person’s views on the proposal as if he/she was

addressing the council members during a town council meeting. Remind the council members that they have a broader responsibility to the community and should be prepared, if necessary, to make a choice between their individual views and what’s best for the community as a whole.

6. Give students the remainder of the class to work together and assign continued work outside of class in order to be prepared for the role-playing activity.

Learning Procedure: 2nd Class Period

1. Arrange desks or a table at the front of the room with chairs to accommodate the three town council members. Place a lectern, desk or small table somewhere else in the room from where the expert, citizens and business owners will make their statements.
2. Instruct the actor from each team to describe the team’s character based on the worksheet completed by the team. Have the expert deliver his or her impartial report to the council members and audience at the council meeting. Have the citizens and business owners state their views on the proposal. Have each council member make a similar statement.
3. Ask the council members to vote. Examine the results. How did each member vote? How did they decide how to vote? Discuss the results and the choices with the class.

NOTE: In the event that all teams take the same position on the proposal, be prepared to offer an opposing argument yourself so both sides of the issue are heard by the class.

Extension Activities

Throughout the year, have students bring in examples from the internet, newspaper or local television news of real air pollution-related decisions made by your town council, county government or major local businesses. Set aside time periodically to discuss the choices involved in these decisions and their impact on the quality of life.



Student Worksheet

Character Attributes

Name: _____

Family Members (include ages of children, if any): _____

Occupation (include type of business, if any): _____

Where do you live (in the city, suburbs, rural area)? _____

Where do you work (in the city, suburbs, rural area)? _____

How do you get to and from work? _____

What type of vehicle do you use for your commute (i.e., fuel efficient, mass transit bus)? _____

How long does your commute take? _____

Where do you shop? _____

Are there occasions when you need to be downtown during the restricted hours? _____

What do you like about the proposal? _____

What do you dislike about the proposal? _____

Are you for or against the proposal? How strongly do you feel about it? _____

Are there any modifications to the proposal that you would like to suggest to the council? _____

THE ECONOMICS OF RECYCLING

PREPARATION TIME:

MODERATE

Learning Objectives

Students will:

- research South Carolina's recycling markets;
- consider ways to encourage recycling markets; and
- examine the economics of recycling from a business' point of view.

Background

Recycling is good for the environment – and the economy.

While the environmental benefits of recycling are well known, what is less known is that recycling is an economic success story as well. By turning waste into valuable raw materials, recycling creates jobs, builds more competitive manufacturing industries and adds significantly to the U.S. economy.

Recycling is working. It's easy to say that everyone should be recycling. Recycling, after all, saves natural resources, energy and landfill space. Recycling lessens or eliminates the need to build landfills and incinerators. Recycling reduces pollution associated with the extraction and processing of natural resources. Recycling decreases greenhouse gas emissions. Recycling generates significant economic benefits including creating jobs and tax revenues. Recycling stimulates the development of green technology.

Recycling is a three-step process of collection/processing, manufacturing and buying recycled. Simple right? It's not. Recycling is a complex and fragile enterprise that has many variables that affect whether a program is successful or not.

Recycling, someone once said, is where the environment meets the economy. It's true. Recycling is market driven. Recyclables – aluminum cans, plastic bottle, glass jars, newspaper, office paper, cardboard, etc. – are **commodities** that have value and can be sold – if someone wants to buy them.



Continued on the following page

Learning Essentials

Focus: Recycling markets

Subject: Environmental Science

Materials: "The Sustainability Index" (Visit www.scdhec.gov/environment/admin/CES/cesindex.htm.)

Teaching Time: One class period plus research

Vocabulary: Commodities, recycling markets, processors, end users, Office of Solid Waste Reduction and Recycling, Center for Environmental Sustainability, S.C. Materials Exchange

Recyclables have value. Recycling allows materials that would become waste to be used as valuable resources. The recyclables that you place in your bin or take to a drop-off center end up on the market as valuable commodities that contribute significantly to the economy. The increasing supply of recyclables fuels manufacturing industries and makes them more competitive and sustainable. The value of the recyclable depends on many factors including the quality and quantity of recyclables. Plastic, for example, will be worth less if soft drink bottles are mixed with milk jugs. There is the supply and demand factor as well. The price for cardboard may drop if there is a lot of cardboard in a specific market. Markets are fickle.

Your local program may or may not collect a specific recyclable – glass or plastic, for example – if there is no demand (markets) for glass or plastic in the area. In short, a critical component of recycling is finding markets for the collected material. **Recycling markets** are companies that are willing to buy the recyclables. Generally, there are two types of recycling markets: **processors** and **end users**. Processors are companies that buy the recyclables and process them to sell – they are an intermediate market. End users are companies that use the recyclables that have been processed and manufacture recycled-content products – they are an end market. A processor, for example, may grind plastic soft drink bottles and form them into small pellets. An end user would buy the plastic pellets, melt them and make them into fiber used in clothing and carpets.

What is the recycling industry? The recycling industry is a large and diverse network of public sector institutions (e.g., local governments, state agencies, colleges and universities) and private companies. Types of recycling organizations include steel mills, iron and steel foundries, paper manufacturers, computer and electronics demanufacturers, glass container manufacturers, rubber product manufacturers, pavement producers, plastics reclaimers and converters, private and government-staffed collection centers, materials recovery facilities and recyclable materials wholesalers.

Within the industry, the economic impact of the recycling manufacturing sector far exceeds the recycling collection, processing and reuse sectors.

Four major manufacturing industries account for more than half of the industry: paper mills, steel mills, plastics converters as well as iron and steel foundries.

The S.C. Department of Health and Environmental Control's (DHEC) **Office of Solid Waste Reduction and Recycling (Office)** and **Center for Environmental Sustainability (CES)** work on recycling and market development issues in the state. Every year CES publishes the "Sustainability Index" that contains information on companies that accept recyclables and other market information. For access to the "Sustainability Index," visit <http://efismt01.dhec.sc.gov/forms/frmservlet?config=cesindex>.

In addition, the Office offers the **S.C. Materials Exchange**, a free service that seeks to reduce waste by facilitating the exchange of reusable material by businesses, non-profit institutions and government. It serves as a "matchmaking service" that provides users access to information on material available or wanted. For information on the S.C. Materials Exchange, visit www.scdhec.gov/scme.

Recycling is big business. The U.S. Recycling Economic Information (REI) Study was commissioned by the U.S. Environmental Protection Agency in partnership with numerous states to determine the economic benefits of recycling to the national economy. The study was completed in 2001.

According to the study, the recycling and reuse industry nationwide includes more than 56,000 establishments. Together the businesses employ 1.1 million people, generate an annual payroll of \$37 billion and gross \$236 billion in annual sales. The REI Study also shows that another 1.4 million jobs are "indirectly" supported by the recycling and reuse industry, resulting in an annual payroll of about \$52 billion and about \$173 billion in annual receipts.

Spending by employees of the recycling and reuse industry leads to another 1.5 million jobs with an annual payroll of \$41 billion and annual receipts of \$146 billion. In addition, the recycling and reuse industry generated about \$12.9 billion in federal, state and local taxes.

Recycling also is big business in South Carolina. The S.C. recycling industry has a \$6.5 billion impact on the state's economy according to a study conducted by the College of Charleston's Department of Economics and Finance.

"The Economic Impact of the Recycling Industry in South Carolina" study was commissioned in 2006 by DHEC. It shows that the recycling industry is directly responsible for more than 15,000 jobs, \$1.5 billion in annual personal income and \$69 million in tax revenue each year.

Overall, the nation's recycling and reuse industry compares favorably to other key industries such as automobile manufacturing and mining according to the REI study. The industry far outpaces the waste management industry because recycling adds value to materials and contributes to a growing labor force.

In addition, a large number of jobs are supported by the reuse industry according to the REI study. These type of jobs range from the more traditional thrift shops and antique dealers to computer demanufacturers and pallet rebuilders. Overall, the reuse industry employs nearly 170,000 workers in more than 26,000 establishments nationwide with an annual payroll of about \$2.7 billion and about \$14.1 billion in annual revenues.

Please visit www.epa.gov/jtr/econ/index.htm for more information about the economic benefits of recycling including the complete U.S. REI Study.

Learning Procedure

Ask your students to find out what is recycled in your community. For information about local recycling programs, call your county or city recycling coordinator or visit www.scdhec.gov/environment/lwm/recycle/counties.htm.

Divide students into groups. Have each group research a specific recyclable as far as possible from collection, to processing, to end user. Have students start by contacting their local recycling coordinator, then follow the trail to the next level. Have students try to find the answers to these questions:

1. Where does the county or city market the material – i.e., who buys or takes it?
2. How much do they get paid or how much do they pay to their market?
3. What happens to the material next? What form does it take and where does it go?
4. What is the final end use of the material? Who is the buyer for the end product? Is it a consumer or a manufacturer?

This activity may take some time. Have students plan their research and schedule phone calls, e-mails

and letters to companies well in advance. Advise them to call DHEC's Office of Solid Waste Reduction and Recycling at 1-800-768-7348 or the Center for Environmental Sustainability at (803) 896-8986.

Question for the Class

1. Why is it important to know the markets available for a recyclable before you begin collection?

Extension Activities

1. Locate recycling companies listed in the Sustainability Index. Invite a speaker to visit your classroom to discuss their recycling operations, or if possible, schedule a field trip to their facility.
2. If your local program has a recovered material processing facility (a facility that sorts and processes recyclables for end users), plan a field trip to see how the recyclables are prepared for market.
3. Have students investigate other states' recycling and environmental legislation and compare it to what's being done in South Carolina.

Recycling helps businesses, other organizations and communities avoid disposal costs associated with landfills and incinerators. More and more local communities – large and small – are demonstrating that recycling and reuse programs can be cost-competitive with disposal options. This is particularly true if communities consider the "full cost" of solid waste disposal and account for the environmental and other negative impacts of waste generation.

Recycling also stimulates the development of green technology. Recycling allows for and encourages the development of more environmentally friendly products. The vast supply of low-cost materials from local collection programs has spurred many businesses to develop cutting-edge technologies and products. Waste tires, for example, are used in many applications including rubberized asphalt for paving roads.



HOW PACKAGING & PURCHASING IMPACT THE ENVIRONMENT

PREPARATION TIME:

MODERATE

Learning Objectives

Students will:

- observe and keep a record of the materials and packaging purchased in their households for one week;
- classify the packaging purchased as recyclable, non-recyclable and/or degradable/compostable;
- calculate the percentage of recyclable, non-recyclable and degradable/compostable packaging purchased by their households;
- use calculations to estimate the percentage of recyclable, non-recyclable and compostable packaging purchased by larger groups (e.g., whole class, school, county);
- discuss the merits and pitfalls of “green” labeling and its regulations;
- identify alternatives to non-recyclable packaging; and
- look at environmental choices in packaging.

NOTE: This lesson is divided into two parts: packaging and purchasing. Either one or both sections can be taught.

Part 1: Packaging

The most basic functions of **packaging** are to contain, carry, protect and dispense materials. Containment is an essential element to packaging. Without the ability to contain products, especially liquids, distribution is difficult. Imagine how a grocery store would sell milk or juice without it. Packaging also can serve useful secondary functions such as preserving freshness and safeguarding against contamination, tampering and/or theft.

As competition for consumer attention in the retail market has grown, manufacturers have become increasingly dependent on packaging as a selling tool. The ability to display, motivate, promote and communicate has been explored to the point that they have become prime purposes of packaging. As a result, much of today’s packaging is not essential.

Packaging waste is placing heavy burdens on our nation’s waste disposal systems. A large portion of used packaging also is

Continued on the following page

Learning Essentials

Focus: Creating an awareness of packaging alternatives, understanding how buying decisions affect the amount of waste we produce

Subject: Environmental Science

Materials: Samples of recyclable, non-recyclable and degradable packaging, “Weekly Household Purchase Record” worksheet, “Picking Packages” worksheet, “A Consumer Survey” worksheet and a list of recyclable items collected in your community – visit www.scdhec.gov/environment/lwm/recycle/counties.htm

Teaching Time: Several class periods plus home assignments

Vocabulary: Packaging, reusable, recyclable, compostable



discarded as litter on roadsides and beaches as well as in cities and parks.

To minimize the environmental impacts associated with packaging, consumers need to make informed choices. For example, reducing the packaging used to sell products could greatly extend the capacity of our waste disposal systems and reduce the litter problem. At the same time, a reduction in the amount of unnecessary packaging used would conserve energy and resources. By purchasing products with minimal packaging and products packaged in **reusable**, recyclable and/or compostable materials, we can all help to reduce the impact of packaging waste.

Along with the strategy to recycle waste comes the responsibility to look for and buy products and packaging made from recycled materials. Buying recycled products is important. This is called closing the loop of recycling. Today more and more products and packaging are available and made from recycled content. Items such as recycled notebook and computer paper, recycled plastic office products and recycled paperboard cereal and food boxes are readily available. Although some individual states have packaging legislation designed to encourage recycling of beverage containers, there are no federal packaging mandates similar to those in other parts of the world that place responsibility for recycling on the manufacturer.

Nearly 30 percent of the total municipal solid waste generated in the United States is packaging according to the U.S. Environmental Protection Agency (EPA). About 49 percent of the total amount of packaging waste generated is recovered for recycling.

As consumers, we can have an impact on how much packaging goes into landfills by selecting products that have less packaging, are contained in **recyclable** or reusable containers and are packaged in recycled materials. Many consumers are not aware that more than 70 percent of the packaging they discard is recyclable and could be used again to make new items. In addition, recycling packaging saves energy and natural resources.

Recyclable packaging material include most forms of paper, wood, steel, aluminum and glass, and some forms of plastic like PET (polyethylene terephthalate) soft drink, ketchup and salad dressing bottles and HDPE (high-density polyethylene) milk, water, juice, shampoo and detergent containers. The key to successful package recycling is knowing what is recyclable in your area.

Although a great deal of packaging is degradable, this is not a waste management option. In addition, it is important to remember that these items do not degrade in a landfill. Degradable packaging material is decomposed by bacteria and fungi (biodegradable) or broken down by chemical reactions initiated by light (photodegradable). Degradable packaging material includes paper and wood.

Buying items that can be composted is only effective if there is a compost facility in your community that accepts packaging waste. In San Francisco, residents are given a green roll-cart in which to place **compostable** items including food scraps, yard trimmings and cereal boxes. The packaging material is collected along with the other organic material and taken to a commercial composting facility that produces high-grade compost that is sold to farmers, landscapers and gardeners.

Perhaps the most effective method of reducing the quantity of waste entering the waste stream is reusing. Reuse means giving an item another life and not simply discarding it once its intended use is complete. For example, a plastic margarine tub can be cleaned and reused many times to store leftovers. Reuse also means rethinking shopping habits.

Learning Procedure 1

1. Discuss how packaging contributes to the waste stream. Define and discuss the terms “reusable,” “recyclable,” “non-recyclable” and “compostable.”
2. Pass around samples of different types of packaging and discuss why it may have been chosen for the product. For example, some packaging is designed to help sell the product, to protect the product or to offer a specific amount of the product, etc. Ask students to estimate what percentage of packaging waste is recyclable, what percentage is compostable and what percentage is reusable. **NOTE:** These numbers may overlap. An item may be classified several ways. There is no single right or wrong answer.
3. Distribute copies of the “Weekly Household Purchase Record” worksheet to the class. Have students keep a record of 20 household items their family purchases in a week. Students should identify the type of packaging used for each item. For example, a six-pack of soft drink cans

would include aluminum (the cans) and plastic packaging (the ring holder for the cans) or the paperboard box. A box of cereal would include paper (the box) and plastic packaging (the box liner).

If students are unable to complete this assignment at home, ask them to list in class the last 20 products they recall using at home. Have students mentally walk through their day and list the packaged items they used. For example, their toothpaste may have included a box as packaging and a metal or plastic tube or pump. Breakfast may have included cereal packaged in a paper box with a plastic liner and milk may have been packaged in a waxed carton or plastic jug, etc.

Have students classify each type of packaging on their lists as R (recyclable), NR (non-recyclable), C (compostable) and/or RU (reusable). Again, each piece of packaging can be designated in more than one type. Also have students note if the packaging is made from recycled content (RC). Students should make these classifications based upon the recyclables collected in their community. For example, if your area recycles only certain types of plastic – such as PET and HDPE – then only these two types should be classified as recyclable.

At the end of one week or after lists are complete, have students complete Part 2 of their worksheets and calculate the percentages of packaging that are reusable, recyclable, non-recyclable, degradable/compostable and contained recycled content. Review the procedure for calculating percentages if necessary.

4. List each student's information on the board and have the class average the results to estimate the overall percentage of reusable, recyclable, non-recyclable, degradable/compostable packaging and packaging made with recycled content purchased or used by the class. Instruct students to record these values on Part 3 of their worksheets.
5. Ask students to review their lists and identify alternative products they could purchase to reduce the amount of non-recyclable packaging used. For example, if your community has plastic recycling, consider buying salad dressing in recyclable plastic bottles instead of glass jars that may not be recycled in your community.

Learning Procedure 2

In this activity, students will compete in teams to design a product package with the environment in mind and then sell the product.

1. Divide the class into groups. Select a product for students to use in designing and creating a package and sales campaign. The product should be the same for all teams such as a baseball bat, personal care item, food product, toy, tennis ball or other common item. If the package and advertising campaign work is to be done in class, collect the suitable materials for each team to use. These items may include:
 - scissors;
 - glue;
 - tape;
 - construction paper;
 - markers;
 - rulers;
 - poster board; and
 - potential packaging materials (aluminum foil, paper bags, plastic wrap, cardboard, etc.).

If students are to complete projects at home, suggest the types of materials to use.

2. Ask the class to describe what advertisers do (create marketing plans and communications to help sell things). Have the students identify the different communication media advertisers use to sell products (e.g., social media, television, radio, newspaper and magazine ads, billboards, contests, promotional flyers, packaging). Make sure students realize that an advertiser's main goal is to sell a product. Briefly discuss the different "pitches" advertisers use to sell a product (e.g., new and improved features, endorsements from famous people, status, better for the environment, cheaper). Are there any environmentally friendly methods of advertising? (Web sites, radio, television)
3. Divide the class into groups of three to five students. Tell each group to imagine they work for an advertising company that has been hired to develop an ad campaign for the product you choose. In addition to the campaign, each group is to design the product's packaging. Each group should develop packaging to help sell and protect the product while minimizing its effect on the environment.

Have each group keep a record of reasons of why they selected a specific package design and sales pitch. For example, what natural resources must be used to make the packaging? How much waste will the packing generate? Can any of the packaging be recycled? Explain that the ad campaign can consist of videos, skits, poems, jingles, posters or any other technique that could sell the product.

Briefly review the primary and secondary functions of packaging and describe the negative environmental impacts associated with packaging waste. Discuss the potential conflicts associated with packaging designed to sell a product versus packaging designed to have a low environmental impact. Ask students to determine ways to design a package that sells but doesn't create a lot of waste. Give students a week to complete their projects.

4. After completing their projects, have each group present its ad campaign and package design to the class in a 10-minute presentation.
5. Assign each product package a number and display all of the designs. Have students anonymously vote for the best package design. Tabulate the votes and announce the first-, second- and third-place winners. Ask the class the following questions:
 - What made the winning package more appealing than the others?
 - How much material was involved in the package? Was the packaging necessary? Why or why not?
 - What influence does the packaging have on the quality of the product?
 - Why was the product packaged?
 - Who pays for the packaging?
 - Should the manufacturer of the product be concerned about disposal of the packaging?
 - What impacts will manufacturing and disposing of the packaging have on the environment?
6. Ask students to identify packaging choices they can make to reduce environmental impacts. Distribute the "Picking Packages" handout and have the class rate the different types of packaging according to the disposal and recycling options in your community.

Part 2: Purchasing

Think about your shopping. Many consumers are interested in buying products that are safe for the environment. Many products claim to be "green" or "earth friendly," but can you heed what you read? How do you know it's true? Several organizations offer environmental labeling designed to substantiate these "eco-claims."

The Federal Trade Commission (FTC) tries to protect consumers from deceptive and unsubstantiated advertising. That work includes environmental or "green" advertising and marketing claims. The FTC acknowledges that consumers may misunderstand claims about the recycled content or recyclability of products and packaging. To help clear up misconceptions and provide a baseline of information, the FTC published its first "Environmental Marketing Guides" in 1992 and updated them in 1996 and 1998. The Commission currently is reviewing the "Green Guides" as they are also known. The publication defines terms including "recyclable," "recycled" and "compostable".

Here's what the FTC wants consumers to know.

- A product or package can be marketed as "recyclable" if it can be separated and collected from residential or commercial waste for reuse or to make another product or package through an established recycling program.
- Product labels that say "Please Recycle" are relevant only if your community collects the products for recycling – and meaningfully

Take it a step further – buy recycled!

There's more to buying recycled than just looking for recycled packaging. Many of the products you can buy also are made from recycled material. Many kinds of paper, like notebook paper, paper towels and tissues have been recycled from other paper products. Steel is one of the most recycled materials, and almost anything you buy that is made from steel has some recycled content. Cars, office furniture, building supplies and bicycles almost always have some recycled steel content. Where do you think your plastic soda bottles end up? Many of the soda bottles you place in your recycle bin end up as fleece jackets or wall-to-wall carpeting.

if it doesn't. Contact your city or county recycling coordinator to see what is recycled in your community or visit www.scdhec.gov/environment/lwm/recycle/counties.htm.

- Sometimes, businesses recycle products for you. For example, many grocery stores take back their plastic bags. And some manufacturers of toner cartridges have programs that allow consumers to return their empty cartridges that are remanufactured for reuse.
- Manufacturers and marketers may claim that a product or package has recycled content if it is made with materials that have been recovered or separated from the trash during the manufacturing process (pre-consumer) or after consumer use (post-consumer). Previously used newspapers, cardboard boxes, plastic bottles, glass containers and metal (aluminum and steel) cans are considered post-consumer waste. Leftover manufacturing scraps – for example, the scraps left over when envelopes are cut from paper – are considered pre-consumer waste.
- Recycled products are made from material that has been recycled. Or it may have been made from material that is used, reconditioned or remanufactured. If a product is labeled “recycled” because it contains used, reconditioned or remanufactured parts, the label also must say the product is “used,” “reconditioned” or “remanufactured” unless that fact is obvious to the buyer.
- If a label says “recycled,” it must tell the percentage of recycled content – unless it's 100 percent.
- Certain symbols placed on consumer products mean that you may be able to recycle the product or package – depending on your community's program – or that the product or package is made from recycled materials.

Environmental Marketing Claims

Today, green claims can be found in many advertisements and labels today. They're the marketing response to consumers' increasing interest in protecting the environment.

But what do green claims mean? And when are they considered misleading? The FTC, with the cooperation of the U.S. Environmental Protection Agency (EPA), is available to make sure green claims don't break the law. The FTC prohibits deceptive acts or practices including deceptive representations in advertising, labeling, product inserts, catalogs and sales presentations.

Learning Procedure

1. **Ask:** Have you ever seen product packaging or advertising that includes references to that item's impact on the environment? Encourage students to think of as many types of items as they can. You may want to bring in examples of products or have students bring these to class. Many products – from shampoos to cosmetics to anything with the chasing arrows symbol – allude to environmental benefits.

Ask: Why do companies use environmental claims on packaging? (Because of environmental awareness, many people will make changes in the brands they buy if they think one is “better for the earth” or “good for the environment.” This has become a major sales attribute for many people.)

Ask: Can a “biodegradable” plastic trash bag degrade if it is buried in a landfill? (No. Conditions in a landfill allow very little to biodegrade. There is insufficient air and sunlight for this process. Even food items and newspapers

Watch the words!

Beware of the word “recyclable,” which is not the same as “recycled,” the word it closely resembles. Many materials are technically recyclable, but what matters is what you can recycle in your local programs. A recycled product or container is actually made from materials that have been used before.

When shopping, look for the chasing arrows on the products you buy.



have been removed from landfills after years and look the same as they did the day they were buried there.) **Ask:** When you see a chasing arrows recycle symbol what does it mean? (The chasing arrows symbol does not have a standardized meaning. It may mean that the product or the package is all or partly recyclable or it may mean that some part of the contents were made from recycled material. In any case, the term recyclable is meaningless unless the person buying the product actually can and does recycle the material in his or her community recycling program.

2. **Ask:** What role do you think the U.S. government should play to establish standards for environmental product claims? What role do you think the state government should play to establish standards for environmental product claims? How should these standards be enforced? Would you be willing to pay additional taxes to have the federal or state government involved? If not, then who should set standards? Explain to the class that these are complex issues. Some people believe that it is a responsibility of the government to set standards and enforce them. Others feel that it would interfere with free enterprise and would slow down the development and use of new technologies.
3. Show several products still in its packaging to the students. Show things the students use like two types of notebooks or backpacks, one plastic and one canvas. Have the class discuss the life cycle of these products. For example, discuss the packaging waste and options to improve it as well as the materials and durability. Ask the students how they would decide which one to buy? **Ask:** Which one is a better buy for the environment?
4. Have students review the FTC's publication "Environmental Marketing Guides" on the Web at

<http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=7e0a20be10f7276a37692157bdf9d02a&rgn=div5&view=text&node=16:1.0.1.2.24&idno=16>. Have students search for products at home that may have a label that fits into one of the numbered categories outlined in the "Green Guides." Have them bring these items to school and create a display of environmental claims by companies.

Extension Activities

1. Have students select several popular products and review the packaging. Can it be improved to create less waste? Do products contain any environmental claims that are not fully explained? Have students send correspondence to companies inquiring about packaging and requesting improvements.
2. Have students visit the packaging news Web sites at www.packagingdigest.com or www.packworld.com. Find any references to recyclability in the articles.
3. Packaging can be used as advertising and for teaching. Give each group of students one packaged food item such as a box of crackers or a bag of cookies. How many different types of information can be found on the package?
4. Have students identify five common household items and describe reusable, recyclable, non-recyclable, degradable/compostable and recycled-content forms of packaging for each item. For example, margarine may be packaged in a reusable plastic tub, a recyclable plastic tub, a non-recyclable plastic tub or squeeze bottle or a degradable or compostable cardboard container with a paper liner.
5. Have the students complete the worksheet, "A Consumer Survey" included with this lesson.



Picking Packages

When you go shopping, pick a product wrapped in the least amount of packaging as possible. Use this sheet as a guide when making your packaging decisions. Use the following notations to complete the chart.

- **CHECK** (✓) means the packaging can be reused, recycled or composted.
- **ZERO** (0) means the packaging is disposed of in a landfill.
- **PLUS** (+) means there is no packaging.
- **MINUS** (–) means the packaging cannot be disposed of easily and should be avoided.

NOTE: You must research, know and understand what is and what is not recyclable in your area before you can accurately perform this exercise. Visit www.scdhec.gov/environment/lwm/recycle/counties.htm for a list of recyclables collected in your community.

KIND OF PACKAGE	GROCERY STORE ITEM	RATING
No packaging or natural package	Fruits, nuts, vegetables	
Glass bottles	Beverages, oils, sauces	
Reusable items	Cookie and cracker tins, sturdy glass jars, plastic tubs	
Uncoated paper	Bags of candy, cookies, chips and other snacks, sugar bags	
Uncoated cardboard	Cereal boxes, detergent boxes, sauce and mix boxes (without cellophane window)	
All-steel cans	Canned fruits and vegetables	
All-aluminum cans	Beverage containers	
Steel cans with aluminum tops	Some pull-top cans	
Waxed paper	Liners in cake boxes and other food boxes	
Cellophane	Windows in paper boxes, pasta bags	
Coated paper	Paper milk and juice cartons	
PET plastic (polyethylene terephthalate) bottles, jars and jugs	Soft drink, ketchup and salad dressing bottles	
HDPE plastic (high-density polyethylene) bottles, jars and jugs	Plastic milk jugs, detergent bottles, some shampoo bottles	
Other plastic (tubs, clam shells)	Plastic wraps, tubs, miscellaneous bottles, etc.	
Aluminum foil-based containers	Foil-lined boxes and bags	
Collapsible metal/plastic tubes	Toothpaste, hand cream, cake icing	
Metal and plastic pumps	Toothpaste pumps	
Aerosol cans	Toiletries, deodorants, hairsprays, pesticides, oil sprays	



A Consumer Survey

	NEVER	SOMETIMES	OFTEN
Consider whether you really need something before you purchase it.	3	2	1
Think about what will happen to a product or package after you no longer need it.	3	2	1
Try to reuse things you already have instead of disposing of them and buying new things.	3	2	1
Consider what pollution and waste were created in the manufacturing of the things you buy.	3	2	1
Take advantage of the opportunities to recycle in your area or advocate establishing recycling.	3	2	1
Purchase items with recycled content.	3	2	1
Shop at second-hand stores or garage sales.	3	2	1
Do you see "bargain" as a factor of quality and durability as well as price?	3	2	1
Donate old clothes and other items for further use.	3	2	1
Use reusable items instead of disposable products.	3	2	1
Refuse to buy products that contain too much waste packaging.	3	2	1
Use mugs or cups at work/school/parties rather than disposables.	3	2	1
Buy in bulk or buy concentrates that use smaller packages.	3	2	1
Use less toxic substitutes for cleaning and household maintenance.	3	2	1
Write to companies or governmental officials about your concern about the environment and wasteful products.	3	2	1
Read consumer articles to find out about the quality and durability of products you buy.	3	2	1
TOTAL			
GRAND TOTAL			

- **GRAND TOTAL OF 38 OR MORE** means you are contributing your fair share to the solid waste problem. Think of ways you can improve your shopping!
- **GRAND TOTAL OF 25 TO 37** means you are doing some good things to reduce waste.
- **GRAND TOTAL 24 OR LESS** means you are a super shopper. Next time you shop take someone along and show them how you do it!



OIL AND WATER

PREPARATION TIME:

MODERATE

Learning Objectives

Students will:

- see how oil pollutes water;
- test water samples for oil residue;
- perform an experiment to determine one part per 10 million; and
- survey their community to determine the level of awareness of used motor oil recycling.

Background

Have you ever heard the saying “Oil and water don’t mix?” It’s true. Improperly disposed of oil can be a major threat to the environment, particularly our water supplies.

Most of us probably think that spills from oil tankers are the No. 1 source of oil dumped improperly into the environment. That’s not the case. The U.S. Environmental Protection Agency (EPA) estimates that the largest single source of oil pollution harming our nation’s waters is from people who change their own oil – **do-it-yourselfers** (DIYers). Overall, about 200 million gallons of **used motor oil** are disposed of improperly each year – poured down storm drains or the sewer, dumped on the ground or tossed in the trash – according to the EPA.

In South Carolina, used motor oil must be recycled – it’s the law. The S.C. Solid Waste Policy and Management Act of 1991 (Act) prohibits the disposal of used motor oil in **landfills**, sewers, drainage systems, septic tanks and surface water. The Act also prohibits using used motor oil on roads as dust control, for weed abatement and other uses that can potentially harm the environment. Used motor oil must be recycled. If you have your oil changed for you (at a car dealership or quick lube), your used motor oil is recycled by that business. If you are a DIYer, you must recycle the used motor oil.

South Carolina has one of the nation’s best and most comprehensive recycling programs targeting DIYers. What began in the early 1990s to conserve resources and to stop illegal dumping of used motor oil, has grown into a one-stop program that also accepts motor oil bottles,

Continued on the following page

Learning Essentials

Focus: How Oil Pollutes Water

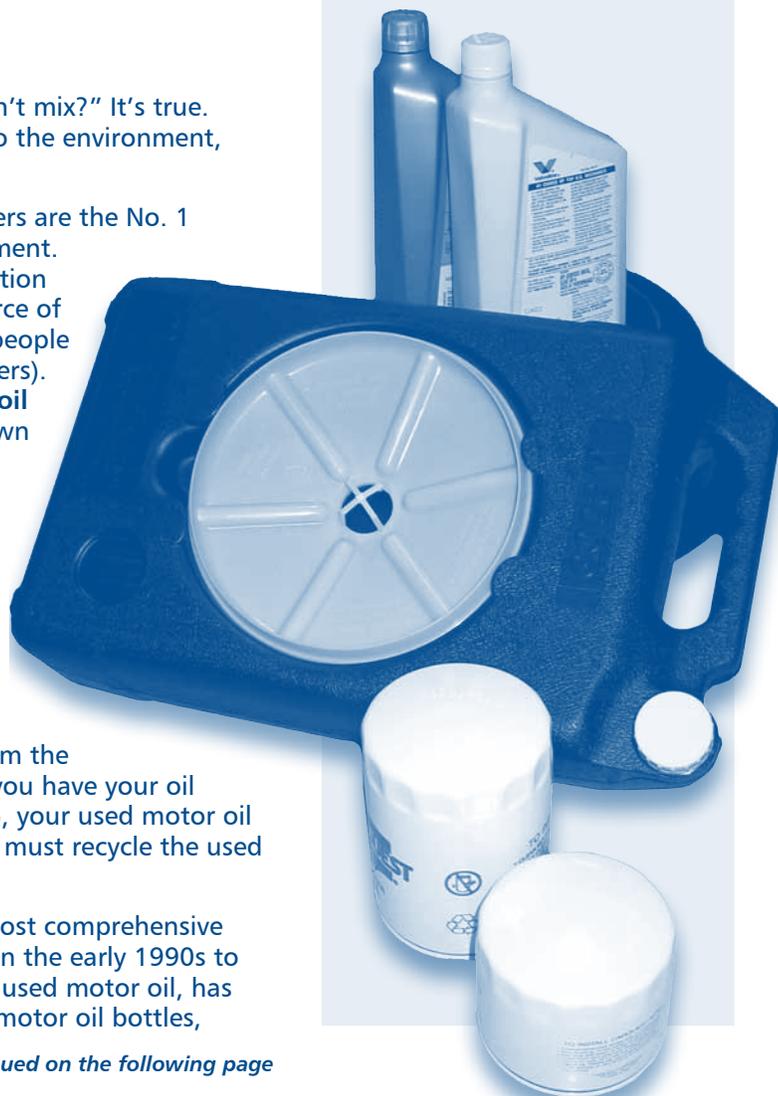
Subject: Environmental Science

Materials: See list provided

Teaching Time: Two class periods

Vocabulary: Carcinogens, do-it-yourselfers, landfills, photosynthesis, plankton, used motor oil

Lesson Resources: “Used Motor Oil Recycling”



filters and oil/gasoline mixtures from DIYers as well as used motor oil from small farming operations.

The program – primarily funded by DHEC through the Petroleum Fund – has grown to nearly 900 collection sites across the state. In addition, the program serves as a model of how convenience and participation go hand in hand. Part of this growth and subsequent success can be attributed to retail outlets, quick lubes and auto parts stores that accept used motor oil from DIYers. In calendar year 2010, DIYers recycled 984,437 gallons of used motor oil. Since 1990, DIYers in South Carolina have recycled more than 17 million gallons of used motor oil. Used motor oil generated and recycled by DIYers is counted as part of the state’s municipal solid waste (household garbage) recycling rate.

Just what does happen when oil ends up in water? When oil ends up in water, a film of oil on the surface can block **photosynthesis** and slow the production of oxygen. The reduced oxygen supply then causes stress to the point of death in aquatic organisms. Large organisms such as mammals and birds are the most familiar victims of oil pollution because of their visibility and emotional appeal to people. Feathers and fur stick together, become matted and lose the ability to insulate animals against cold. Death may result from temperature shock or from swallowing oil as the animals try to clean it from their coats.

Oil in water also can affect other organisms. Some of the components of oil may evaporate into the air or dissolve into the water. Many of them are **carcinogens**. Some of the oil spilled into an aquatic environment settles to the bottom affecting the organisms living there. Oil can clog breathing structures or be absorbed into tissues and then passed up the food chain, even to humans who eat fish or shellfish. Oil may harm bacteria or **plankton**, the basis of the food chain.

Green Driver Project

The Office also has developed the Green Driver Project. The Project targets students in high school driver education classes and provides an overview of the environmental impact of driving – lessons that will last a lifetime. Students learn the importance of used oil recycling, related air, water and energy issues regarding the proper maintenance of their vehicles, litter prevention and safety through a classroom presentation and video, “DHEC1: Behind the Oil Change.” For a copy of the video or to schedule a presentation, please call the Office at 1-800-768-7348.

One gallon of used motor oil can potentially destroy 1 million gallons of fresh water – enough to supply 50 people with drinking water for an entire year. One pint of oil can produce a slick on water about 1 acre in size and will kill floating aquatic organisms.

It’s not just the oil that poses a threat to the environment. As much as 20 percent of automotive oil is composed of substances that are added to improve performance, inhibit rust or prevent foaming – many of which are toxic. Oil also will pick up sediment and gasoline components and additives from the engine during combustion. High levels of lead – as well as other toxins including benzene, cadmium, zinc, magnesium and polychlorinated biphenyls (PCBs) – may be present in oil and may contaminate the environment if not properly handled.

Used motor oil should never be emptied into sewers or storm drains or dumped directly onto the ground to kill weeds or to suppress dust on dirt roads. Used motor oil also should never be thrown into the trash where it will end up in landfills. Improper disposal of used oil is illegal and carries penalties that include jail and fines of up to \$10,000 per day.

Why recycle oil?

It is clear that recycling used motor oil protects human health and the environment, but there are other reasons why we should recycle it.

- Recycling used motor oil also saves valuable energy. Two gallons of used motor oil can generate 36-kilowatt hours of electricity. That’s enough to run an average household for a day, cook 36 meals in a microwave, blow dry your hair 216 times, vacuum your house for 15 months or run your television for 180 hours.
- Recycling used motor oil also helps reduce dependency on foreign oil. Oil is the No. 1 source of energy for the U.S., supplying about 40 percent of the nation’s overall energy needs according to the American Petroleum Institute (API). About half of the oil we use is produced in the U.S while the rest is imported.

What happens to collected motor oil? It can be used in a variety of ways. Nationally, about 14 percent of the used motor oil collected is re-refined for use as a new generation of motor oil or as fuel oils according to the API. About 75 percent is reprocessed for use in asphalt plants, industrial and utility boilers, steel mills and other facilities. About 11 percent is used in specially designed space heaters in automotive bays and municipal garages.

The oil helps these types of facilities reduce their heating costs. This practice, however, is not recommended for home use. Most of the oil collected in South Carolina is burned for energy recovery to generate electricity.

Lesson Materials

If possible, assemble several sets of these materials so that the class can perform the experiment in small groups. Otherwise use one set of materials and perform the experiment as a class. One set of materials includes:

- seven test tubes (OPTIONAL: Seven same-sized jars, such as baby food jars);
- test tube rack;
- 10 ml graduated cylinder;
- olive oil;
- 250 ml beaker;
- brown paper bag (cut in strips);
- blue food coloring;
- wax pencil; and
- eye dropper (or calibrated straw).

Learning Procedure: Day One

1. Review the background material with the class on the impact improperly disposed of used motor oil has on the environment, especially water.
2. Have students perform the following experiment to demonstrate how small quantities of oil can pollute large amounts of water. Perform the following experiment.
 - A. Add a few drops of blue food coloring to a large bowl of water.
 - B. Measure 100 ml of blue water from your bowl and place it into the beaker.
 - C. Add 9 ml of blue water to each test tube in your test tube rack.
 - D. Calibrate the eyedropper to measure 1 ml. This can be done by adding 10 ml of this solution to your cylinder and then drawing out the water, using the eyedropper until the level in the cylinder reaches the 9 ml mark. Use the wax pencil to mark the water level in the dropper.
 - E. Pour out unused water from your cylinder and measure out 1 ml of olive oil. Add this to test tube #1.

- F. Shake the test tube thoroughly. Quickly, before the oil and water separate, remove 1 ml of this solution with your calibrated dropper and add it to the next test tube (#2).
- G. Repeat step F with each test tube until you feel that there is no oil left, checking either visually or by smell.
- H. Check for oil in your solution by dipping a strip of brown paper 5 inches long by 1/2-inch wide into each test tube. Label your strip and set it aside to dry overnight.
- I. Clean the lab area and materials. Use warm water and soap to remove all traces of oil in all the test tubes.

Learning Procedure: Day Two

1. Check the brown paper strips for oil spots.
2. Have students answer the “Questions for the Class” individually or as a group.

Questions for the Class

1. Did you find oil spots on the brown paper strips the next day? (Yes)
2. Where do you think this oil would go in nature? (It may end up in lakes, rivers and groundwater. It may be swallowed by fish, animals and by people.)
3. What are some of the contaminants found in used oil? (Used oil contaminants include heavy metals such as lead, cadmium, zinc, barium, chemical additives, dirt, iron and steel particles.)
4. Did the water dilute the oil completely? (No)
5. List items you or your family own that use motor oil and have the capability of contaminating the environment. (This list may include lawn mowers, cars, boats, gasoline-powered tools such as chain saws, string trimmers and leaf blowers.)
6. What can you do with used motor oil to prevent it from becoming a source of pollution? (Take it to a used oil collection site. Visit www.scdhec.gov/recycle and click on RECYCLING WHERE YOU LIVE or call 1-800-768-7348 for the location nearest you.)

Extension Activity

DESIGNING A SURVEY TO DETERMINE A BASELINE OF INFORMATION

1. **Ask:** What do you think people in our area do with their used motor oil, used oil filters and empty oil bottles? List student responses on the board. Encourage students to consider local influences and habits such as farmers changing oil in farm equipment and individuals collecting oil/gasoline mixtures from lawn equipment, recreational vehicles and boats.

Ask: Do you think people in our area are aware that they should be recycling their used motor oil? How can we find answers to these and other questions about the public's knowledge and perceptions of used motor oil recycling?

2. Tell the class that one way that public perceptions are measured is with surveys. Surveys ask a sample of the population questions and then take their answers and extrapolate them to make assumptions about a larger population. For example, to survey a school of 2,000 students it would not be necessary to survey everyone to produce meaningful results. Surveying a random sample of about 400 would yield results that are considered reliable. This would yield an error rate of about 4 percent. Sampling 300 would increase the error rate to about 5 percent, still an acceptable level.
3. Tell the class that they are going to design and conduct a survey to gauge local awareness of used motor oil recycling. Divide the class into teams of about five students each. Have each team design a survey to determine the level of awareness of used motor oil recycling, identify some of the perceptions of the used motor oil problem in their area and gauge the willingness of people to recycle used motor oil, used oil filters and empty oil bottles.

Share with the class examples of questions that may be asked, survey methods and ways to evaluate survey results.

- Do South Carolina class 3 landfills accept used motor oil?

- Do you change your own oil? How often?
- How important is proper disposal of motor oil? Why?
- How do you dispose of used motor oil?
- Have you seen or heard any promotions about recycling used motor oil? If yes, where did you see them?
- What do you think would be the most environmentally correct way to dispose of used motor oil?

Students should be encouraged to think of their own survey questions based on their community. Students may also want to target a certain sample population to survey such as students of driving age or students of non-driving age, or just women or just men.

Survey methods that students should consider include an online survey tool, telephone surveys or personal interviews (such as surveying people at shopping centers).

NOTE: Students will need parental permission and should be required to be prepared and rehearsed before calling or interviewing anyone. Students should clearly identify themselves and their reason for conducting the survey. They should be polite at all times and thank anyone who declines to participate.

Suggest that students limit the scope of their surveys to those questions that can be asked, answered and answers recorded in about five minutes. Have students create their survey forms in advance and test them for ease of use before conducting their official survey. Remember to target the survey to a defined demographic group.

You may want to set a minimum number of people for students to survey, such as 25. Although this number may not offer a sample size large enough to gauge public perception with any accuracy, conducting the survey will provide meaningful information.

4. Have students tabulate the results of their surveys and share their findings with the class.

TRACKING AIR QUALITY*

PREPARATION TIME:

MODERATE

NOTE: This exercise lets students graph changes in the weather that impact air quality in the community. This exercise is best conducted over a long period of time (especially in the fall) in order for students to observe significant variations in the Air Quality Index and correlate them with weather parameters.

Learning Objective

Students will:

- observe the impact of weather on air quality;
- demonstrate data gathering, analysis, graphing and presentation techniques;
- investigate six major pollutants including major sources and effects; and
- list ways to reduce air pollution.

Background

Graphing – the ability to depict information, relationships and trends – is a basic skill for communicating ideas and sharing information. It is a skill that supports endeavors in science and mathematics. It is with graphical analysis that scientists and engineers at the U.S. Environmental Protection Agency (EPA) look for relationships and processes that are not immediately apparent with single, one-time measurements.

Conceivably, this activity could be conducted throughout the year or periodically to build a data set large enough to establish seasonal trends and determine indicators of change. When the same collecting techniques are applied to air pollutants, the accuracy, frequency, location and testing protocol become critical for obtaining useful data with which to explain the movement of pollution in the environment and the extent to which we are exposed to air pollutants.

Pollutants in the air come from many sources. Natural air pollution caused by volcanoes, forest fires and other natural sources has always existed and naturally produced pollutants are present in greater

Continued on the following page

Learning Essentials

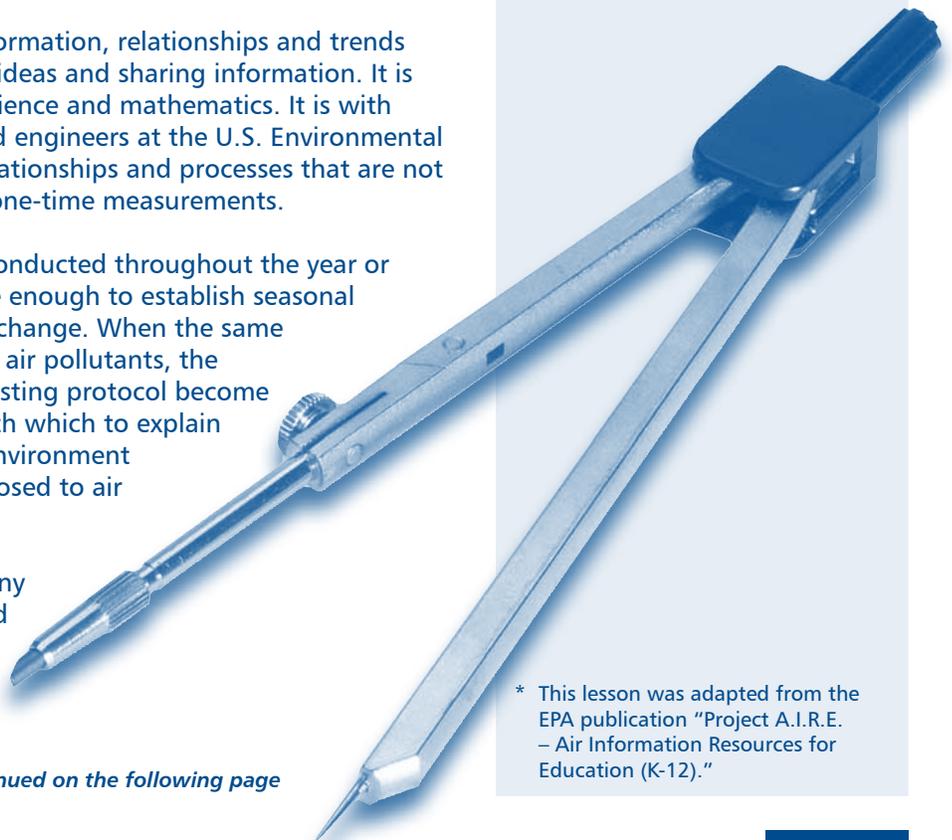
Focus: Weather, air quality

Subject: Environmental Science

Materials: Five sheets of white (or light colored) poster board or heavy construction paper each measuring 2 X 2 feet, felt-tip markers in black, green, blue, red, purple, orange (one of each color)

Teaching Time: Class #1: 15 minutes; Classes #2-#5: 5 minutes each (over 2-6 week period); Class #6: 40 minutes; Class #7: Investigation

Vocabulary: Air Quality Index, graphing, nitrogen oxides, sulfur dioxide, carbon monoxide, ozone, lead, particulate matter, criteria pollutants, precipitation, thermal inversion, pollutant



* This lesson was adapted from the EPA publication "Project A.I.R.E. – Air Information Resources for Education (K-12)."

amounts than those made by humans. They do not present as serious a problem as man-made pollutants because they are dispersed over large areas and many are less harmful.

Air pollutants from man-made sources are the result of our increasing use of internal combustion engines which use fossil fuels to produce electricity and to run everything from factories to automobiles and other vehicles. Not only are some of these pollutants very harmful, but also they tend to be concentrated in urban areas where most people live and work. Six of the major man-made pollutants – **sulfur dioxide, nitrogen oxide, carbon monoxide, ozone, lead and particulate matter** – have been designated **criteria pollutants** and are regulated by the federal government.

Daily weather conditions directly affect how much we are exposed to air pollutants. Shifting air masses (weather systems) and wind can move pollutants from one place to another. In addition, stationary air systems – like **thermal inversions** – can trap harmful pollutants over an area for days at a time. Rain, snow and other forms of precipitation can help wash pollutants from the air and onto the ground (which also can result in acid rain!). While **precipitation** cleanses the air we breathe, it also may increase pollution of the land and surface water.

The **Air Quality Index (AQI)** is used for reporting daily air quality. It tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health effects you may experience within a few hours or days after breathing polluted air. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health. Local air quality meteorologists use the Air Quality Index to forecast air quality conditions to the public.

This forecast service is provided to inform the public about the effects of ground-level ozone and helps the public make healthy decisions about outdoor activities. (**NOTE:** Currently in South Carolina, this is the only criteria pollutant forecasted.) The forecasts provide important air quality information and alert the public of ground-level ozone action days. An “ozone action day” is forecasted when conditions may be present that could generate high amounts of

ground-level ozone. In some areas of the country, a weather condition that may foster dangerous levels of ground-level ozone include thermal inversions.

Learning Procedure: Class #1

1. Divide the class into five teams and assign each team one of the following weather parameters: **TEMPERATURE, WIND DIRECTION, PRECIPITATION, AIR QUALITY INDEX** and **RELATIVE HUMIDITY**.
2. Explain that each team will record daily changes in these aspects of the weather on posted graphs over a period of time (and specify the period). At the end of this time, each team will prepare their findings and make a short presentation defining the aspect of the weather they have been tracking. Where appropriate, students should record the range of values (e.g., the high and low temperatures for the day) and a mean value.
3. Give each team a sheet of poster board. Tell them to draw a graph on their posters that will allow them to track published information about the weather aspect they have been assigned. Teams should share the black markers for this task. The X axis for all the graphs should be “date.”
4. Encourage students to visit **www.weather.gov**, call the local weather bureau or a weather reporter at a local television station for help in determining the appropriate Y axis range for the parameter they have been assigned. Suggest that the students obtain data to fill in their graphs from the internet, local weather bureau, weather reporter or newspaper.
5. Suggest that the students consult the DHEC AQI Forecast, available at **www.scdhec.gov/environment/baq/baqspare.asp** on a daily basis during ground-level ozone season (April 1 through September 30 of each year). Based on observations by the S.C. Department of Health and Environmental Control (DHEC) meteorology staff, ozone rarely forms on cool, cloudy days, even when ample concentrations of the precursor chemicals that form ozone are present. Sunny and dry conditions are more conducive to forming ozone. Students may be able to correlate their weather observations with the AQI forecasts.

6. Hang or otherwise display the posters in the classroom where students can see them and record data on them each day. The teams should be given the flexibility to organize themselves to ensure that the recording of data is accomplished every day.

Learning Procedure: Classes #2 through #5

1. Take 5 minutes during each class to call attention to the status of the graphs and give the students a few questions in preparation for the discussion at the end of the exercise. Sample questions are provided below:
 - Would you expect some aspects of the weather to have more (or less) influence on the quality of the air we breathe? If so, which ones and why?
 - The Air Quality Index is usually expressed for particular contaminants – such as ozone, sulfur dioxide and ragweed pollen. From your observations, does it appear that changes in weather have more (or less) effect on air quality for some contaminants?
 - If you have found no correlation, does that mean there is no effect?
 - Is there another, better approach for determining a correlation?
2. During one of the classes near the end of the data collection period, give the students a few additional questions to address in their presentations to the class. For example:
 - How would you describe the weather in our area?

- What causes the weather to be like it is?
- Is the weather different elsewhere? If so, what causes changes in different places?

Suggest that students brainstorm with their teammates and present the group's perspective in their presentations.

Learning Procedure: Class #6

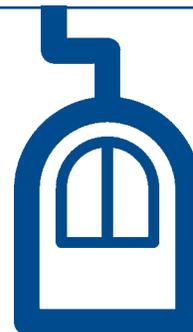
1. Before teams prepare the data for their presentation, repeat the questions you posed during the periodic status checks.
 - Would you expect some aspects of the weather to have more (or less) influence on the quality of the air we breathe? If so, which ones and why?
 - The Air Quality Index is usually expressed for particular contaminants – such as ozone, sulfur dioxide, and ragweed pollen. From your observations, does it appear that changes in weather have more (or less) effect on air quality for some contaminants?
- Encourage discussion.
2. Have each team make 5-minute presentations defining the weather parameter they have been assigned, reporting on the data collected and addressing the general questions you posed in an earlier class (see No. 2 in the previous section).
 3. Ask the teams to compare the graphs. Now that they have seen all the data, ask if they would change their answers to any of the questions discussed at the beginning of class. Ask them to explain why or why not.

On the Web ...

"What is Acid Rain?," www.epa.gov/acidrain/what/index.html

"Air Quality Index (AQI) – A Guide to Air Quality and Your Health,"
www.airnow.gov/index.cfm?action=aqibasics.aqi

"SC Green Guide," www.scdhec.gov/greenguide



4. Give each team one of the colored felt-tip markers. Encourage students to use the markers to point out similarities (or wide variances) between data on different graphs to illustrate and support their answers.
 5. Encourage students to discuss what the results of this exercise may mean. For example, if the data collection period is “typical” for this time of year, how may the weather stress people with asthma or other respiratory problems? How may it affect plants and trees in the area? Could it affect your pets? Have the students discuss possible options for making the air quality better in these kinds of weather conditions.
 6. Ask the students how they would determine whether their assumptions and conclusions are correct. End the class by recording a list of their ideas. The list should include research at www.weather.gov and talking to the local weather bureau, meteorologists, physicians and local health department personnel.
1. Tell the students that many air pollutants come from burning coal, oil, wood and other fuels. We use these fuels to run factories, cars and power plants that generate the electricity that heats, cools and lights our homes, schools and workplaces. Other pollutants come from industrial and manufacturing processes. These typically are released in much smaller quantities but are generally much more toxic. Regardless of their source, these pollutants are a by-product of today’s lifestyle – a lifestyle that we enjoy and expect. Totally eliminating these pollutants would require drastic changes in lifestyle – changes most of us would rather not make. Ask the students to name any air pollutants, natural or human-made.
 2. Present the following information on each of the six major pollutants. Remind them that these are criteria pollutants and are regulated by EPA. The following descriptions are from EPA.
 - **CARBON MONOXIDE** – a colorless, odorless gas emitted when vehicles burn fuel. It also is given off by kerosene or wood stoves used to heat homes. The effects of carbon monoxide include headaches, reduced mental alertness and heart damage. It may even cause death by reducing the oxygen-carrying capacity of red blood cells.
 - **LEAD** – formerly a problem when cars used gasoline with lead additives. When leaded gasoline is burned, lead is released into the air. Some industrial processes also result in lead air pollution. When people or animals breathe lead over a period of time, it accumulates in their bodies and can cause brain or kidney damage. Today, all cars in the United States use unleaded gasoline and the use of lead additives has been discontinued.
 - **NITROGEN OXIDE** – a light brown gas at low concentrations. In higher concentrations it becomes a major component of brown urban haze. Nitrogen dioxide is the result of burning fuels from utilities, industrial boilers, cars and trucks. It is one of the major pollutants that causes ground-level ozone and acid rain to form. In high concentrations, it can harm people and vegetation. In children, it may cause increases in respiratory illness such as chest colds and coughing. Asthmatics may suffer from more difficult breathing.

Learning Procedure: Class #7

Remind students that the atmosphere is necessary for plants, animals and humans to live. The atmosphere is only a thin layer of air, roughly comparable to the skin of an apple. Natural air pollution caused by volcanoes and forest fires has always existed. Naturally produced pollutants are present in greater amounts than pollutants from human origin. For example, the planet’s vegetation accounts for about two-thirds of the pollutants known as volatile organic compounds (VOCs) emitted globally. Because they are less concentrated and, in many cases, less toxic than pollutants resulting from human activities, natural pollutants do not present as serious a problem as man-made pollutants do.

Modern society uses large quantities of fuel to produce electricity and power vehicles and also engages in industrial activity, all of which results in air pollution. Not only are some of these pollutants very harmful, but the activities producing them often are carried out in urban areas, increasing their concentration in places where many people live and work. We have no control over natural pollutants, but we can control human-made pollutants. As humans produce even more pollutants, control and reduction of them becomes increasingly important and difficult.

- **OZONE** – a very reactive molecule made up of three oxygen atoms. Ozone can be either good or bad, depending on where it is. Ground-level ozone occurs near the Earth’s surface in the troposphere and is harmful to our lungs and to the environment. The ozone layer, 10-35 miles above the Earth’s surface in the stratosphere, protects us from the sun’s harmful rays.
- **PARTICULATE MATTER** – soot, dust, tiny droplets of liquid and other materials. It is sent into the air usually by burning coal, diesel fuel or wood. Particulates gradually settle back to the earth and can cause people to cough, get sore throats or develop more serious breathing problems. They can affect animals and plants. The smaller the particulates, the more easily they can travel deep into the lungs, causing more harm.
- **SULFUR DIOXIDE** – emitted by power plants and factories that burn coal for fuel. Sulfur dioxide is the main sulfur oxide pollutant. It can harm the lungs of humans and animals as well as all kinds of plants. Sulfur dioxide is a main contributor to acid rain. It reacts with

oxygen in the air to become sulfur trioxide and then reacts with water in the air to form sulfuric acid. Acid rain can harm aquatic life in lakes and rivers as well as trees and plants by damaging leaves and root systems. It can deteriorate metal and stone on buildings and statues. Acid-forming dry particles also can fall to Earth. The effects of acid rain are not only local. They also can occur hundreds of miles away from their source.

Extension Activities

1. Have each team member verify the validity of one of their conclusions by writing a report and presenting it to the class.
2. Research historical weather data for the same period in previous years. See if a pattern can be found between the conditions in previous years and the data collection period for this exercise. Graph the historical data in the same manner as the current data and compare it with the current graphs.



WASTE NOT, WANT NOT

PREPARATION TIME:

MODERATE

PART 1: TALKING TRASH

Learning Objective

Students will:

- visualize the amount of trash generated by each person in South Carolina each day;
- identify trash as recyclable, reusable, repairable or compostable; and
- show the principle of waste reduction.

Background

What you call **trash** or garbage, professionals call solid waste. There are different kinds of solid waste, but the most common type measured is **municipal solid waste** (MSW). What is MSW? MSW is the garbage we make in our homes, places of work and schools. In South Carolina, MSW is defined as the combined residential, commercial, institutional/non-profit and industrial packaging/office waste we make. In Fiscal Year 2011 (July 1, 2010 to June 30, 2011), South Carolinians generated about 5 pounds of MSW each day. Of that amount, about 3.6 pounds was disposed of in landfills. We recycled the rest – about 1.4 pounds per person per day.

Recycling is a smart waste management option that conserves natural resources and reduces the need to build landfills or incinerators. Other smart waste management options are to reuse or compost. When implemented, waste is removed from the MSW stream and is not disposed of in our landfills or incinerators.

Total MSW generation in 2010 (the latest data available) was 250 million tons. Organic materials continue to be the largest component of MSW. Paper and paperboard account for 29 percent and yard trimmings and food scraps account for another 27 percent. Plastic comprises 12 percent; metals make up almost 9 percent; and rubber, leather and textiles account for 8 percent. Wood follows at around 6 percent and glass at nearly 5 percent. Other miscellaneous wastes make up about 3 percent of the MSW generated in 2010.

The best way to deal with trash is to not have any! Reducing the amount of trash you have to throw out actually prevents waste from piling up in the first place. To reduce your waste, avoid unnecessary packaging and items designed to be used only once. Reduce the need for 'single use'

Continued on the following page

Learning Essentials: Part 1

Focus: Recycling

Subject: Environmental Science

Materials: A little more than 5 pounds of clean, selected trash (see the Learning Procedure), four or more clean plastic or paper bags, a kitchen or bath scale

Teaching Time: 30 to 45 minutes

Vocabulary: Municipal solid waste

Learning Essentials: Part 2

Focus: Dwindling natural resources

Subject: Environmental Science

Teaching Time: Two class periods plus outside time for research

Vocabulary: Natural resources, non-renewable resources, renewable resources, greenhouse gas, ecosystems, biodiversity, resource conservation, source reduction, reuse, recycling, buying recycled, energy conservation, sustainable development, product stewardship

plastic bags by bringing your own bags when you shop, and use a travel mug when you buy coffee. Choose durable, reusable products to make less trash. The next best option is to extend the life of items you buy by reusing them. For example, reuse containers and jars, and donate still usable household goods and clothing to charity.

Another form of waste reduction is by composting, the process of converting vegetable scraps, leaves, grass clippings and other material into a nutrient rich soil material. Finished compost can be used in your garden and around shrubs or other plants to help them grow. Composting also reduces the amount of material that needs to be landfilled. Following that is recycling your glass, cans, newspapers, milk jugs and other acceptable recyclable items. Recycling saves natural resources, energy and landfill space as well as creates jobs and saves on avoided disposal costs.

In this activity, students look into a typical bag of household trash and decide if any of the items can be repaired, reused, recycled or composted as well as what needs to be thrown away. Some items may fit into more than one category. For example, an item may be reused and recycled.

Learning Procedure

NOTE: Before beginning this lesson, it is important to know what is recycled in your community. Visit www.scdhec.gov/recycle/html/counties.html for a list of recyclables collected in your curbside program or at your local recycling center. For this activity, you will need a bag of trash to represent everyday household garbage. Include items that can be recycled, reused and/or repaired and some things that only can be disposed of at a landfill. For sanitary reasons, do not include food waste. Fill your trash bag with items that your students would use such as fast-food wrappers, Styrofoam, soft drink cans, snack food packages, old clothes, etc. Be sure to include about 5 pounds of garbage.

1. Show students the bag of trash you have prepared and ask them to **estimate** its weight. Call on several students to estimate from just looking at the bag and then from holding the bag. Weigh the bag. Using a bath scale, weigh the person with the trash bag and weigh the person without the trash bag. Then subtract to obtain the weight of the trash bag. Your answer should be about 5 pounds. Tell students that this is how much trash each one of us generates each day. Students may find this unbelievable.

Remind them that this figure includes trash from all of their meals, classroom waste, etc. It is just the MSW that we make. It does not include any of the waste from an industry's processing or manufacturing operations.

2. Make six cards marked RECYCLE, REUSE, REJECT, REPAIR, COMPOST and LANDFILL. Tape these cards onto the six bags. Discuss what these words mean. Find out and discuss with the class what is recyclable in your community. Visit www.scdhec.gov/recycle for more information.
3. Have the students open the trash bag and tell what each item is used for and why it was purchased. Discuss if the product was necessary or not. Now that the item is trash, was it worth buying the product in the first place? Remind students that we can **reduce** the amount of trash we throw out by only buying what we need.
4. Have students divide the contents of the trash bag into the proper categories – RECYCLE, REUSE, REJECT, REPAIR, COMPOST and LANDFILL.
5. After classifying, re-weigh the items in the landfill category and discuss how much trash was saved from going to the landfill.
6. As a math exercise, create a chart graphing the weight of the six bags after the 5 pounds of trash has been sorted into recycle, reuse, reject, repair, compost and landfill.
7. As another math exercise, ask the class to multiply 5 pounds by the number of students in the class and school.

Extension Activities

1. Each South Carolinian makes 5 pounds of MSW for disposal each day. Determine how much each of us make in a week, month and year. Calculate how much MSW a family of four makes in a week, month and year.
2. Each South Carolinian recycles on average 1.4 pounds of materials per person per day. Determine how much each of us recycles in a week, month and year. Calculate how much a family of four recycles in a week, month and year.
3. As a math exercise, create a chart showing the weight of the bags after the five pounds of trash have been sorted into the categories – RECYCLE, REUSE, REJECT, REPAIR, COMPOST and LANDFILL.

PART 2: DISAPPEARING NATURAL RESOURCES

Learning Objective

Students will:

- identify natural resources;
- see how natural resources are a part of the things we use each day; and
- identify ways we can protect natural resources.

Background

Natural resources are naturally occurring and useful materials such as coal, oil, natural gas, minerals, water, soil and trees. We absolutely depend on natural resources for basic survival and use them as raw materials to build and run society. Everyday we use natural resources when we take a shower (water and energy), grow our food (soil and water), to power our cars (oil), to build our homes (trees) and to make all of the products and conveniences of our lives.

It is important to note that many of the same natural resources that we use everyday are vital to plants and wildlife. In addition, population growth, a higher standard of living and technology all contribute to the increased use of natural resources. The majority of the world's consumption of natural resources comes from developed or industrialized nations.

The amount and type of natural resources – or lack thereof – plays an integral role in the development and prosperity of a nation. Nations buy and sell natural resources. Throughout history, natural resources like oil or water often have been the source of international conflicts including wars.

There are two categories of natural resources.

Non-renewable resources are those that are in limited supply that cannot be replaced or can be replaced only over extremely long periods of time. Non-renewable resources include fossil fuels such as oil and coal and mineral deposits such as iron ore and gold ore.

Renewable resources are those that can be replaced over time by natural processes such as fish populations or natural vegetation or is inexhaustible such as solar energy. The concept of renewable is sometimes blurred. Groundwater in deserts, for example, may take years to be replaced while it

may take only a few days to replace groundwater in tropical rainforest.

Some resources may be considered both renewable and non-renewable. Trees, for example, may be a renewable resource because more trees can be planted. But if an entire forest of 400-year-old trees is cleared and a new-growth forest planted, the supply of old growth trees has not been replenished. It takes hundreds of years for old-growth trees to mature and therefore old-growth trees are considered non-renewable resources. Trees are a complex resource because as a forest their environmental and economic contributions often depend on their age. For example, clearing a forest of 200-year-old Redwoods, unlike clearing a forest of new-growth pine trees, diminishes high levels of biodiversity only developed in old growth forests.

The extraction, processing and use of natural resources require a great deal of energy and may create air, water and land pollution, and create **greenhouse gas** (that is created from the burning of oil and coal). Many scientists believe that the buildup of greenhouse gas in the atmosphere may cause global climate change.

The extraction, processing and use of natural resources also can disrupt or destroy **ecosystems** and threaten biodiversity. Ecosystems are the self-regulating communities of plants and animals that interact with one another and with their non-living environment – a pond, for example. **Biodiversity** refers to the variety of organisms that live on Earth. Natural resource extraction and other human activities increase the rate at which species of plants and animals are vanishing.

Natural resources are conserved for their biological, economic and recreational values as well as their natural beauty and importance to local cultures.

Resource conservation is the sustainable use and protection of natural resources. The challenge of conservation is to understand the complex connections among natural resources and balance resource use with protection to ensure an adequate supply for future generations. In order to accomplish this goal, a variety of conservation methods are used including reducing consumption of resources, protecting them from pollution or contamination and reusing and recycling resources when possible.

Consumption of natural resources increases dramatically every year as the world's population increases and standards of living rise. The large, developed nations, however, are responsible for the

greatest consumption of natural resources because of their high standards of living. Clearly, conservation and thoughtful use of natural resources is necessary to reduce that consumption.

There is much disagreement on what or how much needs to be done to protect natural resources from pollution including reducing the pollution allowed into our air, water and land and limiting or eliminating the amount of pesticides and other toxic chemicals that we use.

It is important to note that waste is just not created when we throw things away but also can be produced by other activities including mining raw materials and manufacturing new products. **Source reduction, reuse and recycling** as well as **buying recycled** products conserves natural resources. Source reduction – also known as waste prevention – is the practice of designing, manufacturing, purchasing and using products and materials in ways that reduce waste. Source reduction also refers to the reuse of products and materials.

Here's a virtually perfect example of recycling. Recycling aluminum cans saves natural resources (bauxite ore), reduces pollution associated with the extraction of natural resources (mining bauxite ore), saves energy (making a new aluminum can out of an old aluminum cans saves about 95 percent of the energy used to make a new can out of bauxite ore as well as other natural resources). Overall, it takes about six weeks to manufacture, fill, sell, recycle and remanufacture an aluminum can.

Energy conservation is the practice of using less energy, both by using more energy-efficient products and by changing wasteful habits.

Sustainable development is an environmental protection strategy designed to protect natural resources. The goal of sustainable development is to meet the needs of the present without compromising the ability of future generations to meet their own needs.

Product stewardship calls on those in the product life cycle – manufacturers, retailers, users and disposers – to share responsibility for reducing the environmental impact of products. Manufacturers

have the greatest ability and therefore the best opportunity to do this. Reducing the use of materials and redesigning products to be reused or recycled are just a few of the opportunities that manufacturers have to make product stewardship work. Still, all of us are responsible. Consumers need to ask or demand these types of products.

Learning Procedure

1. Prepare a bag with enough items in it so each student (or groups of students) can have one of the items. Select a variety of items (soft drink can, aluminum foil, glass bottle, plastic soft drink bottle, plastic bag, newspaper, paper bag, drinking straw, comb, pencil, paper clip, ruler, etc.) OPTIONAL: Place the names of objects – such as automobile tires, CDs, etc. – on index cards and have the students choose these from the bag. In either case, select items that represent a wide variety of natural resources.
2. Have each student or group draw an object (or a card) and determine what natural resource(s) was used to make the object. Distribute the "Resource Research" worksheet (provided) and have them complete it. Students should then prepare a one- or two- page report on the natural resource and item they selected.
3. After several days for research, have students display the item and deliver an oral report on their findings to the class. As students deliver their reports, use the world map to pinpoint areas where natural resources are found.
4. How could Americans reduce their use of natural resources?

Extension Activity

Research and report on international conflicts over exploration expeditions for natural resources throughout history. Note what resource was being sought and what was its ultimate use. You may want to consider Marco Polo's travels, mineral rights arguments in the Space Race to the moon, battles in North Africa during World War II or international agreements not to mine resources in Antarctica.

Constructing a Landfill Model

This activity includes construction of a landfill model as well as conducting an experiment to see what happens to the “buried” garbage. It is not necessary to purchase new items for most of the materials listed. Enlist the support of parents and students in providing materials. This is a long-term project and could involve several class periods.

The diagram provided on page 42 and materials list below calls for a 30-gallon garbage can. Some teachers have chosen to modify this by using a 13-gallon kitchen trash can. Before you select to use the smaller can, please be aware that a larger can will provide for a greater selection of trash to be placed in your “landfill,” allowing you to collect a “better” quality leachate for your experiments. The larger trash can, however, will require a greater amount of “rain” and more percolation time for leachate collection.

- Plastic 30-gallon garbage can
 - 5 to 10 gallons of soil
 - Screw-in, plastic faucet with securing nut
 - A small piece of screened wire, ± 2 ” square
 - Caulking compound
 - Waterproof glue for plastic
 - 1 gallon of distilled water
 - Coliform bacteria test kit/lactose broth (optional)
 - Student worksheets (included)
1. **Ask:** What is waste? What does “biodegradable” mean? (The necessary elements for biodegradability – air, water and sunlight – are not available in a landfill. Without air, water or sunlight, biodegradation is not possible.)
Ask: What are the sources of waste? (Give examples.) What happens to the waste from our homes, schools and businesses? Then what happens? What happens next? (Lead the students to the conclusion that most waste is buried in a landfill in South Carolina.) Why is waste disposal an important issue?
 2. Arrange for students to visit the nearest landfill or see the video “Trashumentary” available by calling **1-800-768-7348**. Explain to the students how a landfill is constructed. Discuss the following topics: site selection; methods and operations; chemical and biological reactions occurring in completed

landfills; methane gas and leachate movement and control; and landfill design criteria and regulations.

3. Ask the students to describe what they think the properties of landfill leachate might be (in terms of pH, bacteria and suspended solids) and what the processes occurring in its formation might be. (Seeing and smelling the landfill operation or hearing a presentation by a landfill operator first will give students a better understanding of the simulation they will be undertaking.) As a less-than-complete-but-effective alternative, have the students take a trip to the school dumpster which should reveal the early formation of leachate as liquid wastes have probably started to accumulate in the bottom of the container.
4. Ask each student (with supervision of a teacher and/or custodial staff) to collect bags of waste around the school containing food (vegetable and fruit peels but NO meat or dairy products), yard trimmings or plant residue, metal, paper, plastic and cloth.
5. Have the materials and equipment gathered for constructing the landfill model. Divide the class into teams. Give the teams copies of the handout “Construction of a Landfill Model.” Begin building the landfill model.
6. Most of the state receives on average about 45 inches of precipitation per year. Given that, the average weekly precipitation is a little less than 1 inch. Measure about 1 inch of distilled water to equal the average weekly precipitation and sprinkle it over the soil in the model landfill.
7. Repeat this step weekly for at least one month until water begins to collect in the bottom of the landfill model. The liquid that collects in the bottom is the leachate.
8. After at least one month, withdraw the leachate from the model and test for pH and total suspended solids (liquid weight minus weight of solids). If possible, test for the hardness of the water, coliform bacteria and other water quality factors. Compare the results of these tests with the properties of distilled water and list the results. Discuss what is done to prevent leachate from contaminating groundwater and surface waters. Today, class 3 landfills are required to have leachate collection systems. The leachate, after being collected, is sent to a wastewater treatment facility.



Resource Research

After you have selected an object or a card, research the principal natural resource(s) that make(s) up that object and prepare a one- or two-page report on the resource(s). Use the following questions to guide your research. The questions may not have an answer, depending on your selected resource.

1. Are the natural resources renewable? _____
2. Where are the natural resources found? _____

3. How much of that natural resource is left worldwide? _____

4. How much of what is left is relatively easy to obtain? _____

5. Who (what country) uses the most of this natural resource? _____

6. Is the consumption of this resource increasing? _____
Why? _____

7. What happens to the natural resource after the product has completed its useful life? _____

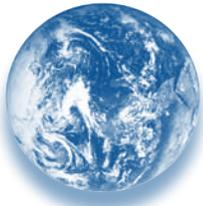
8. Can product (made from a natural resource) be recycled? _____
9. What effect does recycling of the product have on the overall quantity and availability of the natural resource?

Products Made from Natural Resources

NATURAL RESOURCE	PRODUCT/SERVICE
Trees.....	Paper, furniture, fuel
Cotton plant.....	Clothing
Oil/Petroleum	Plastic, fuel
Natural Gas	Fuel
Coal.....	Fuel
Iron ore	Steel products (cans, bridges)
Bauxite ore	Aluminum cans, car parts
Gold	Jewelry, dental material
Copper	Wire, coins, electrical equipment
Manganese	Steel, cast iron
Cobalt	Steel, jet engine parts, cutting tools
Platinum.....	Air pollution control and telecommunication, equipment, jewelry
Chromium.....	Stainless steel, green glass, gems (rubies and emeralds), leather treatment
Diamonds.....	Jewelry, mechanical equipment

Natural Resource Consumption Facts

- The United States uses about 1 million gallons of oil every 2 minutes.
- Every American uses about 47,000 pounds of newly mined minerals each year.
- There are 66 individual minerals that contribute to the typical computer.
- In the past 40 years, global consumption of wood as an industrial fuel increased by nearly 80 percent.



Lesson Resources

Environmental Timeline

This timeline lists in chronological order some of the major U.S. and South Carolina environmental laws and events. This list is not meant to be comprehensive or all-inclusive. This list does not include amendments, reauthorizations, expirations and repeals of Acts. This list is simply a brief overview.

- 1872 Yellowstone becomes the nation's first national park.
- 1899 The River and Harbor Act established the legal basis for banning pollution of navigable water.
- 1905 The U.S. National Forest Service is established to manage forest reserves.
- 1916 The National Park Service Act established the National Park Service.
- 1924 The Oil Pollution Act prohibits oil discharges into coastal waters.
- 1935 The Soil Conservation Act is signed into law.
- 1948 The Water Pollution Control Act is signed into law.
- 1950 The Water Pollution Control Authority is created within the State Board of Health.
- 1965 The Solid Waste Disposal Act is signed into law.
- 1965 In South Carolina, the Air Pollution Control Authority is created.
- 1968 The S.C. Safe Drinking Water Act is signed into law.
- 1970 The National Environmental Policy Act of 1969 is signed into law on January 1, 1970.
- 1970 The first Earth Day is held on April 22. An estimated 20 million people participated in Earth Day activities across the nation.
- 1970 The U.S. Environmental Protection Agency is established by Presidential Order.
- 1970 The Clean Air Act is signed into law.
- 1970 The Occupational Safety and Health Act is signed into law.

Continued on the following page



- 1970** The Poison Prevention Act is signed into law.
- 1970** The S.C. Pollution Control Act is signed into law. The Water Pollution Control Authority and the Air Pollution Control Authority are consolidated into the Pollution Control Authority.
- 1972** The Clean Water Act is signed into law.
- 1973** The Endangered Species Act is signed into law.
- 1973** In South Carolina, the Pollution Control Authority and the State Board of Health are merged as the S.C. Department of Health and Environmental Control (DHEC).
- 1974** The Safe Drinking Water Act is signed into law.
- 1976** The Resource Conservation and Recovery Act is signed into law.
- 1976** The Toxic Substances Control Act is signed into law.
- 1976** The Noise Control Act is signed into law.
- 1980** The Comprehensive Environmental Response, Compensation and Liability Act is signed into law.
- 1980** The S.C. Hazardous Waste Management Act is signed into law.
- 1986** The Emergency Planning and Community Right-to-Know Act is signed into law.
- 1988** In South Carolina, the State Underground Petroleum Environmental Response Bank Act is signed into law.
- 1990** The Pollution Prevention Act becomes law.
- 1990** The National Environmental Education Act is signed into law.
- 1991** The S.C. Solid Waste Policy and Management Act (Act) is signed into law.
- 1993** The S.C. Coastal Council and parts of other agencies dealing with water and land resources are merged with DHEC.
- 1997** The first America Recycles Day is held on November 15.
- 2000** The Act is amended to require additional reporting of recycling efforts by state agencies and institutions of higher learning.
- 2006** South Carolina passes legislation setting up a mercury switch removal program for end-of-life automobiles.
- 2007** South Carolina passes legislation requiring certain state-owned and state-funded construction projects to achieve LEED certification.
- 2008** S.C. landfill reclassification is finalized in a revised regulation.
- 2009** South Carolina's only municipal solid waste incinerator closes in Charleston County.
- 2010** The 40th anniversary of Earth Day is celebrated.
- 2011** Certain consumer electronics are banned from landfill disposal.





Lesson Resources

How Landfills Work

It's not a dump – so don't call it that.

It's not just some hole in the ground either – it's much too expensive to build and operate to think of it that way. It's a Class 3 landfill that accepts municipal solid waste (MSW). It's the place your household garbage calls home.

So, just what is a Class 3 landfill? A Class 3 landfill is a scientifically engineered facility built into or on the ground that is designed to hold and isolate waste from the environment. Federal and state regulations strictly govern the location, design, operation and closure of Class 3 landfills in order to protect human health and the environment.

Class 3 landfills are the most common places for waste disposal and are an important part of an integrated waste management system. Today, about 73 percent of the MSW generated in South Carolina is disposed of in the state's 24 permitted Class 3 landfills. Nationwide, about 54 percent of the MSW generated is disposed of in landfills according to the U.S. Environmental Protection Agency (EPA).

From Your Home to the Landfill

You think garbage, you think garbage truck. Depending on the Class 3 landfill's size, as many as 200 trucks may come every day. The trucks come from all over, too. Why? Well, Class 3 landfills are difficult to locate as well as expensive to build and operate. Given that, there are fewer Class 3 landfills today than in the past, but they are larger and accept MSW from greater distances.

There are, of course, different types of garbage trucks that hold different amounts of waste. The truck that comes through your neighborhood can hold anywhere from 12 to 14 tons of waste. How much is that? Well, on average, this type of garbage truck can pick up waste from about 800-850 homes.

When the truck is full, it heads to the landfill. At the landfill, the truck drives on to a scale and is weighed on its way in, on its way out, or both. The truck carefully drives to a specific area of the landfill and

dumps or "tips" its load. Then it leaves and drives to another neighborhood to repeat the process.

What Happens Every Day

The daily operation at a Class 3 landfill includes dumping of waste into a specific area of the landfill – called a working face – followed by compaction (crushing) of the waste and then covering of the waste with soil.

Waste is dumped into an open area of the landfill called a cell. Class 3 landfills almost always just have one cell open at a time to accept waste. At the same time, another cell is being built so it is ready when the current cell becomes full.

Space is money. Garbage is compacted or crushed to save space. You've seen the giant tractor with spiked wheels that goes back and forth over the garbage. Well, that's a compactor. It weighs 100,000 pounds. The compactor makes three to five passes over the garbage to crush as much garbage into the space as possible. On average, about 1,200 to 1,400 pounds of garbage can be compacted into one cubic yard of space.

At the end of the day, the working face of the cell is covered with a layer of soil or other cover material to minimize odor, pests and rodents as well as litter. This is called daily cover.

This three-step process is repeated over and over until the cell is filled.

The Sum of Its Parts

Here are some basic parts of a landfill.

1. The bottom liner system is designed to keep waste from coming in contact with the environment – particularly groundwater. From the bottom up, the system is: 1) 2 feet of clay 2) a plastic liner and 3) a protective layer 2 feet thick, usually comprised of sand.
2. Cells are specific areas where the waste is dumped and compacted (crushed).

- The storm water drainage system collects rainwater that falls on the landfill. The system may include plastic drainage pipes that collect water and move it to a retention pond at the Class 3 landfill. This water has not come into contact with the garbage.
- The leachate collection system collects liquids – called leachate – that are part of the MSW and any water (e.g., rainwater) that comes into contact with the garbage. This water works its way through the Class 3 landfill like water percolating through coffee grounds. As the water moves through the garbage, it picks up contaminants. It must be collected and treated.
- The methane collection system collects methane gas that is created during the decomposition of the garbage. Bacteria break down the garbage. The by-product is landfill gas that is about 50 percent methane and 50 percent carbon dioxide with very small amounts of nitrogen and oxygen. Methane gas presents a hazard because it can explode and/or burn. Methane is actively

collected in a series of pipes, then passively vented or burned through a flare. Currently seven Class 3 landfills in South Carolina (Anderson Regional Landfill, Lee County Landfill, Horry County Solid Waste Authority (SWA) Landfill, Palmetto Landfill, Three Rivers SWA Landfill, Greenwood County Landfill and the Richland Landfill) burn methane to produce energy (methane produces about half the energy of natural gas).

- The final covering or cap is placed on the Class 3 landfill when it is closed. The final cover has: 1) 18 inches of clay at the bottom; 2) a plastic liner in the middle; and 3) 2 feet of soil on top. The covering seals the waste from air and reduces the amount of water getting into the landfill. It also prevents pests (birds, rats, mice, flying insects and so on) from getting into the waste.

The Life Expectancy of a Landfill

The life of a landfill depends on the size of the facility, the disposal rate and the compaction rate. All Class 3 landfills are permitted by the S.C. Department of Health and Environmental Control to accept a specific amount (tons) of waste each year – this amount cannot be exceeded. As mentioned earlier, Class 3 landfill operators strive for the maximum compaction rate possible in order to save space. Given these considerations, the average life expectancy could be anywhere from 30 to 50 years. Class 3 landfills must be monitored for 30 years after closure.

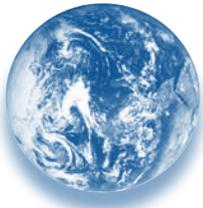
When a Class 3 Landfill Closes

When a Class 3 landfill is full, it is closed with a final cover that includes a clay layer, a plastic liner and a soil layer. Even though the facility is closed, the responsibility of the landfill operator does not end.

Class 3 landfill owners must set aside money (called financial assurance) to close the landfill and to provide post-closure care in the event of potential environmental issues. Operators must continue to pump the leachate, test the groundwater, inspect the cap, repair any erosion, fill low areas due to settlement, maintain vegetation and prevent trees from growing. Why no trees? Trees have roots and roots can tear the liner.

DISCLAIMER: The definitions in this fact sheet do not constitute DHEC's official use of terms for regulatory purposes. Specific legal definitions of some words may be found in various South Carolina laws and regulations.





Lesson Resources

The Cost of Industrial Waste

What is industrial waste? Industrial waste consists of a wide variety of non-hazardous materials that result from the production of goods and products. Industrial waste may be a liquid, sludge or solid.

It is important to know that manufacturing products uses natural resources, raw materials and energy. In addition, we often don't think of the waste that is being generated in the manufacturing of these products.

And we often don't think of the "real" price paid for products. We pay for the extraction of the natural resources when we buy the product. We pay for the development, manufacturing, shipping, marketing and packaging of a product. We also pay for the waste that is generated and managed during the manufacturing of the product.

The Bottom Line ...

It is a time-honored business maxim that increased efficiency translates into increased profits. When businesses become more efficient in their use of resources, they generate less waste. Businesses understand that reducing the amount of waste they generate, whether large or small, cannot only help protect the environment and conserve natural resources but improve their bottom line by saving money on waste disposal.

Industry, manufacturers and businesses can – depending on the type of waste – practice the same waste management options as communities such as source reduction, reuse, donate and exchange, recycling and pollution prevention.

In response, innovative companies are incorporating waste reduction principles into their daily operations. What exactly is waste reduction? Waste reduction includes all actions taken to reduce the amount and/

or toxicity of waste requiring disposal. It includes waste prevention, recycling, composting and the purchase and manufacture of goods that have recycled content or produce less waste. Some

companies are adopting simple waste reduction options

such as reducing paper consumption through

the use of e-mail. Other

businesses are reviewing

their entire operation to

identify and implement

as many opportunities

for reducing waste as

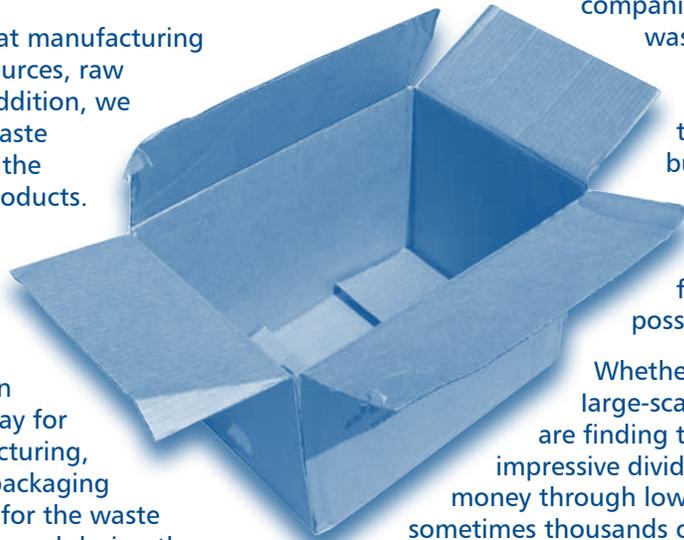
possible.

Whether simple alterations or large-scale initiatives, companies are finding that waste reduction offers impressive dividends. In addition to saving money through lower waste removal costs – sometimes thousands of dollars annually – waste reduction makes good business sense in other ways, too. Waste reduction can help reduce expenditures on raw materials, office supplies, equipment and other purchases. Streamlining operations to reduce waste often can enhance overall efficiency and productivity as well.

Furthermore, waste reduction measures can help demonstrate concern for the environment, increasing customer loyalty. For many companies, therefore, waste reduction is rapidly becoming an important component of their long-term business planning.

Reuse is another option. For example, businesses can reuse cardboard boxes internally and, if possible, reusing incoming packaging materials for outgoing shipments

Many states, including South Carolina, also have waste exchanges. A waste exchange is a clearinghouse for information regarding the availability of and demand for a waste stream – that is, waste generators may be matched with potential waste users. For more information, visit the S.C. Materials Exchange at www.scdhec.gov/scme.



Recycling: It's smart business.

Recycling not only reduces waste but also may generate significant income or cost savings for industry.

As mentioned earlier, there are many kinds of industrial waste. Industrial processes and practices are a potential source of air and water pollution. Pollution prevention is the process of identifying areas, processes and activities that create excessive waste products or pollutants in order to reduce or prevent them through alteration or eliminating a process.

DHEC has an additional program to provide assistance including the S.C. Smart Business Recycling Program that offers many services including help on pollution prevention. It is a free, non-regulatory, comprehensive technical assistance program to help businesses, industry and others reduce costs associated with waste management.

Product Stewardship

One practice that is becoming popular is product stewardship. Product stewardship, for example, is a product-centered approach to environmental protection. Also known as extended product responsibility (EPR), product stewardship calls on everyone in the life cycle of a product – manufacturers, retailers and consumers who buy, use and throw away products – to share the responsibility for reducing the environmental impacts of products.

Product stewardship recognizes that product manufacturers can and must take on new

responsibilities to reduce the environmental impact – including producing less waste – of their products. In most cases, manufacturers have the greatest ability – and therefore the greatest responsibility – to do that. By rethinking their products, their relationship with the supply chain and the consumer, manufacturers are dramatically increasing their productivity, reducing costs, developing product and market innovation and giving consumers more product with less environmental impact.

The carpet industry is a perfect example of product stewardship. In January 2002, the U.S. Environmental Protection Agency signed the National Agreement on Carpet Stewardship with state governments, carpet and fiber manufacturers, the Carpet and Rug Institute and non-profit organizations. The agreement set national goals over a 10-year period to significantly increase the amount of reuse and recycling of post-consumer carpet. Participants established a third-party organization called Carpet America Recovery Effort (CARE) to implement the agreement. The mission of CARE is to facilitate market-driven solutions to divert post-consumer carpet from landfills, in order to meet the goals of the agreement for Carpet Stewardship. In 2012, CARE will issue a final report detailing progress made toward meeting the goals of the first 10-year plan. Among its accomplishments:

- increased carpet diversion growth rate by double-digit percentages every year;
- diverted over 1 billion pounds of post-consumer carpet from landfills; and
- expanded the Carpet Reclamation Network from five in 2002 to 58 today.



Lesson Resources

Alternative Fuels

The term alternative fuel is used to describe fuels other than gasoline that can be used to power our cars. In 1992, the U.S. Congress passed a law called the “Energy Policy Act.” This Act made it a law for governments and utilities to use alternative fuels made in the United States to power some of the vehicles in their fleets. The fuels that must be used are natural gas, propane, electricity, ethanol and biodiesel.

Why are alternative fuels important?

The United States uses more oil than any other country in the world and a little less than 50 percent of that oil comes from the U.S. The rest of it is imported mostly from Middle Eastern countries. The United States’ dependence on oil from other countries makes it very vulnerable and jeopardizes national security.

In the 1970s, the Arab nations of the Organization of Petroleum Exporting Countries (OPEC) announced an embargo on exporting oil to the United States. This means that they decided to not sell oil to American companies any more. They did this because they were angry that the United States supported Israel in the Arab-Israeli War. As a result, oil prices in the United States skyrocketed because there wasn’t enough for everyone. Gasoline was rationed, meaning that people were only allowed to buy it on certain days and often after long waits. This had a severe effect on our economy and President Richard Nixon announced that the United States must attempt to use less oil. Congress passed many laws in the 1970s to achieve this goal and those laws received support from Presidents Gerald R. Ford and Jimmy Carter. Some of these included new vehicle efficiency standards, and also the 55 mile-an-hour speed limit. This was passed because vehicles operate most efficiently at this speed. All these laws had a positive effect.

Oil prices rose again in 1978 with the Iranian Revolution and in 1992 following the Gulf War. In

1992, President George Bush, championed the passage of the Energy Policy Act. This law was intended to drastically reduce our dependence on foreign oil by increasing the use of domestically-produced fuels in government and utility-provider fleets. Beginning in 1996, fleets were required to begin purchasing alternative fuel vehicles (AFVs). The percentage of AFVs was increased each year and by 2001, 75 percent of new vehicles purchased had to be capable of using alternative fuels. In spite of this law, demand for oil continues to rise. Now Americans are using roughly 19.5 million barrels of oil a day, the most ever in our history, with 54 percent of it coming from foreign countries.

Such widespread use of oil has another effect besides oil dependence. Overuse of fossil fuels has caused significant air pollution throughout the United States. When most people think of air pollution, they think of Los Angeles or Houston. Charlotte and Atlanta, our neighbors to the north and west, however, have some of the highest pollution rates in the country. Even in South Carolina, air quality is threatened by emissions from gasoline-powered cars and trucks. Fortunately, alternative fuels can help ease those problems as they burn more cleanly than gasoline and diesel fuel.

The Alternative Fuels*

Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) is domestically produced and readily available in the United States. Natural gas also is clean burning and produces less pollutants than reformulated gasoline. Natural gas can either be stored on board a vehicle in tanks as compressed natural gas (CNG) or cryogenically cooled to a liquid state – liquefied natural gas (LNG).

Natural gas is a mixture of hydrocarbons — mainly methane (CH_4) — and is produced either from gas wells or in conjunction with crude oil production. Natural gas also is used for heating and cooling homes, cooking, clothes drying and in businesses. Although one of the cleaner-burning alternative fuels, natural gas is not yet common or used very widely.

* “The Alternative Fuels” section is from the “Energy Factbook: A Resource for South Carolina” and is reprinted with permission.

The vehicles typically cost about \$3,500-\$5,000 more than a regular gas vehicle. In addition, it costs about \$3,500 for an in-home compressor that fills a vehicle overnight. Service stations that provide natural gas cost about \$400,000 and feature “fast-fill” refueling pumps that fuels each vehicle in just a few minutes.

Propane (Liquefied Propane Gas, LPG) is a popular alternative fuel choice. In fact, propane has been used widely for years in agricultural communities. Like natural gas, propane produces fewer vehicle emissions than reformulated gasoline. Propane is produced as a by-product of natural gas processing and crude oil refining. Propane is a simple mixture of hydrocarbons, mainly propane/propylene (C₃S) and butane/butylene (C₄S). Propane also is a popular choice for home heating and outdoor cooking. Propane vehicles also cost more than their gasoline counterparts. However, fueling stations are fairly inexpensive. More than 350,000 vehicles, mostly in commercial fleets, are traveling the nation’s highways under propane power.

Electricity can be used to power vehicles. Electric vehicles (EVs) store electricity in batteries. EV batteries have a limited storage capacity and must be replenished by plugging the vehicle into a recharging unit. The electricity for recharging the batteries comes from a special electrical outlet in the home or business, or from distributed renewable sources such as solar or wind energy. EVs are called “zero-emission vehicles” because they release no harmful emissions into the air. The cost of “refueling” an EV is minimal, but an EV certified to run on the highway is very expensive. Although newer battery technology shows

promising developments, most EVs have a range of only 50-100 miles before recharging is needed.

Ethanol (E-85) is a blend of 85 percent ethanol and 15 percent gasoline. Ethanol is an alcohol-based fuel produced by fermenting and distilling starch crops that have been converted into simple sugars. Typical feedstocks for this fuel include corn, barley and wheat. Ethanol also can be produced from “cellulosic biomass” such as trees and grasses. Most ethanol used in the United States today is made from corn. E-85 can be used in “flex-fuel vehicles.” These vehicles also can run on pure gasoline. Flex-fuel vehicles are very common in the United States today – many auto manufacturers now offer them and are part of their standard inventory. Unlike other AFVs, there is no additional cost for purchasing this vehicle. Because of this, and also because they can run on gasoline, they are a popular choice for fleet managers. Ethanol fuel is, however, sometimes more expensive than gasoline at the pump, although it is better for the environment. A problem in South Carolina is the lack of a supply of ethanol.

Biodiesel is manufactured from vegetable oils or recycled restaurant greases. Biodiesel is safe, biodegradable and reduces serious air pollutants such as particulates, carbon monoxide, hydrocarbons and air toxins. Blends of 20 percent biodiesel with 80 percent petroleum diesel (B20) can be used in any diesel vehicle. It also can be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems. French fry-fueled Fords may be in your future!

Alternative Fuel Use in South Carolina

S.C. government offices began purchasing AFVs in 1996, as required by law. But while the Energy Policy Act required that governments buy AFVs, it did not demand that they use any alternative fuel. Since some AFVs can run on either an alternative fuel or regular gasoline, we have many AFVs but few alternative fueling sites. This is partly because of the high cost of installing the alternative fueling equipment. But this situation is changing. Since 2000, the state has developed three new AFV refueling sites with plans to develop more.



What kind of fuel do we use?

The S.C. Office of Fleet Management has surveyed all government groups in the state to determine how many and what kind of AFVs they had. They also surveyed fuel providers to find out where our AFVs could go to refuel as state employees drive these vehicles to go about the state's business.

This survey helped us discover that while we have about 2,500 AFVs operating in government fleets in South Carolina, we don't have much alternative fuel to put in them. This survey also helped us plan where to put alternative fuel stations in the future.

- **ETHANOL:** Ninety-three percent of the AFVs operating in S.C. government fleets (about 2,300) are flex-fuel vehicles. Since these vehicles can run on either gasoline or E-85, most continue to be operated on gasoline. Since 2001, two stations that dispense ethanol opened in South Carolina. United Energy Distributors, Inc., a private fuel supplier in Aiken opened the first public multi-alternative fuel station in the country in 2001. It sells E-85, in addition to propane and biodiesel. Anyone can buy fuel at this facility, making it the only publicly-accessible AFV refueling site in the state. The S.C. Department of Health and Environmental Control opened an E-85 refueling site in Columbia in 2002. This facility serves only vehicles owned by federal, state or local governments, not the public. There are more than 600 flex-fuel vehicles in government fleets in Columbia and this was their first access to E-85. More ethanol facilities will open soon across the state. Many private citizens own flex-fuel vehicles and they will be able to take advantage of using this alternative fuel as well.
- **BIODIESEL:** It's hard to count the number of vehicles using biodiesel because any diesel vehicle can use it. It is known, however, that the state fleet and some federal fleets in South Carolina have purchased biodiesel in bulk to use in their vehicles. In addition, the S.C. Soybean Board is studying possibilities for building a biodiesel production facility in South Carolina. The state currently purchases biodiesel from Kentucky – making it more expensive to use.

- **CNG:** In 2000, the Clean Cities Coalition worked closely with the Central Midlands Regional Transit Authority (RTA) as they made decisions regarding the fate of the City of Columbia's bus fleet. Thanks in part to their efforts, RTA decided to purchase seven new CNG transit buses when they replaced the aging fleet in 2002. These buses are expected to reduce nitrogen dioxide and hydrocarbon emissions by 6,296 pounds per year over a 10-year period – resulting in a cleaner

'French Fry One'

Dorchester County owned a Chevrolet Suburban known as "French Fry One" because it was converted to run on biodiesel – a blend of used cooking oil and diesel fuel.

The county collected used cooking oil from the local correctional facility as well as community fairs and festivals. Once collected, the used cooking oil was filtered and stored in a tank at the county's fleet maintenance shop until it was pumped into the Suburban.

The Suburban ran on diesel fuel until the cooking oil was heated to 190 degrees Fahrenheit. The Suburban's performance was about the same using either fuel (about 12 miles per gallon), but used cooking oil does not emit sulfur, benzene and other pollutants that come from diesel fuel.

"French Fry One" was not only good for the environment, it also served as a teaching tool for the county's Department of Public Works. The department retired the vehicle in 2010.



City of Columbia. The Coalition and the S.C. Energy Office also worked to expand the capacity of Columbia's only CNG refueling station and to encourage other agencies to purchase CNG vehicles. Several city buses are fueled by natural gas as a result of this effort. In addition to the buses, the state fleet owns 70 CNG vehicles. Local governments and utility companies in South Carolina own some CNG vehicles as well. In addition to fast-fill CNG stations in Columbia and York County, there are slow-fill stations in Rock Hill, Clemson and Greenville County.

- **PROPANE:** There is more propane refueling infrastructure in the state than any of the other fuels because many propane companies use the fuel in their vehicles. But there are only 54 propane vehicles in the state fleet and only one station in South Carolina – the United Energy facility in Aiken – accepts the state's credit card.

Where do we go from here?

Alternative fuel use is very important for South Carolina and our country, because of dependence on imported oil and national air quality problems. There are many organizations in South Carolina that want to help increase the types and amount of alternative fuel used. The Palmetto State Clean Fuels Coalition is trying to organize all the groups and their efforts. This local group is part of a national effort called "Clean Cities" – coordinated by the U.S. Department of Energy. The Palmetto State Clean Fuels Coalition is committed to developing stronger networks of alternative fuel users in the state. It is reaching out to all existing organizations and programs that show a similar interest in improving the nation's energy security by lessening dependence on foreign oil and reducing emissions of carbon monoxide and nitrogen oxides (both help create ozone) as well as particulate matter from motor vehicle usage.

On the Web ...

Biodiesel: Technical Highlights – www.epa.gov/otaq/renewablefuels/420f10009.htm

Electric Vehicles – www.epa.gov/otaq/consumer/fuels/altfuels/420f00034.htm

Flex-fuel Vehicles – www.epa.gov/otaq/renewablefuels/420f10010a.htm

Renewable/Alternative Fuels – www.epa.gov/otaq/fuels/alternative-renewablefuels





Lesson Resources

Environmental Careers

There has been a renewed interest and understanding about environmental issues and how our actions affect the Earth. People are beginning to understand that everything they do will have an effect on the environment whether positive or negative.

This renewed interest is becoming apparent with increasing awareness about issues such as waste management, cleaning up hazardous waste sites, concerns about having clean air and water, global warming and rain forest destruction. This renewed awareness and concern for the environment has brought with it an increase in the number of jobs available in the area of environmental protection. It has been estimated that about 3 million Americans are currently employed in the environmental field.

Not too long ago, the only environmental careers available were limited to science research as well as non-profit and advocate organizations. Now the field has expanded and jobs vary from science and law to

insurance and public information. Listed below are several career categories.

- **PLANNING:** Planners are needed for all areas that affect the environment. If planning is done well, many environmental problems can be avoided. Persons in environmental planning work to reduce air and water pollution, conserve wetlands, forests and vegetation and plan for solid waste management and land-use.
- **ENVIRONMENTAL EDUCATION AND INFORMATION:** It is important for people to be aware of correct environmental facts and issues. There is a need for general education in every area of environmental concern and a need to teach people how they can help. Teachers are, of course, one of the main sources of environmental education. There also is a need for public information about environmental issues especially through media outlets. Many

DHEC Career Opportunities

The mission of the S.C. Department of Health and Environmental Control (DHEC) is to protect public health and the environment.

That's why DHEC has a combination of health and environmental careers. The quality of the environment impacts the quality of your health. You cannot be healthy if you do not have clean air, water and land. DHEC has many different kinds of jobs and in many ways is like a city. DHEC has attorneys, doctors, nurses, engineers, geologists, hydrologists, accountants, meteorologists, graphic artists and law enforcement officers.

DHEC has epidemiologists who investigate disease outbreaks. DHEC staff inspect restaurants, school cafeterias, dairies, soft drink plants, hospitals, nursing homes as well as waste management and treatment facilities. DHEC staff patrol shellfish beds for illegal harvesting, responds to environmental emergencies and tracks underground storage tanks

for possible pollution. DHEC has staff that develop and offer environmental education programs for schools and the public. DHEC even has drug agents who investigate illegal use of prescription drugs – and all of them are pharmacists.

DHEC has staff that travel frequently and make inspections around the state and people who work in the laboratory every day. Some of the jobs have direct contact with health and environmental issues. Some of the jobs – such as the people who buy supplies, keep track of funding and handle personnel issues – provide the necessary support for the jobs that have direct contact with health and environmental issues.

DHEC also has health and environmental regional offices throughout the state. That means you can work in lots of different places – not just Columbia. Like the coast? You could work in Charleston or Myrtle Beach. If the Upstate sounds better, you could, for example, work in Greenville.

government agencies, private corporations and non-profit organizations have public information staff. These staff members are responsible for promoting environmental issues and communicating with the media in case of emergencies.

- **WASTE MANAGEMENT:** Solid and hazardous waste management is one of the largest fields in environmental protection. It includes the proper management of solid and hazardous waste, recycling, waste reduction and garbage pick-up. Careers in this field include engineers, public information officers, economists, equipment operators, geologists and hydrologists.
- **AIR QUALITY MANAGEMENT:** Ensuring that the quality of our air is healthy is a difficult task because once pollutants are released into the air they disperse very quickly. Many of the jobs in the area of air quality deal with regulations. Some of these jobs include, but are not limited to, engineers, analytical chemists, meteorologists, toxicologists and risk assessment specialists.
- **WATER QUALITY MANAGEMENT:** There are many careers in water quality, some of which include drinking water protection and treatment, groundwater protection, surface water management, wetland protection, estuary management and wastewater treatment. Some specific job titles include aquatic ecologist, environmental engineer, hydrogeologist, biologist and regulatory specialist.
- **ENERGY:** Wise energy use can provide many environmental benefits. Some of the jobs available working with energy include various engineers, public information officers, energy auditors and various utility jobs.
- **LAND AND WATER CONSERVATION:** Land and water conservation involves the protection of wild lands and water bodies. There are many opinions as to whether land and water should be protected in pristine condition or whether it should be protected so that it is able to sustain diverse wildlife. Some areas of concentration include planning, natural resource assessment and management, habitat protection and restoration as well as preserving open spaces and natural habitats. Some specific jobs may include ecologist, biologist, ecotourism, environmental educator, resource engineering and forestry, soil conservation specialist, geographical information

systems (GIS) specialist, land acquisition professional and attorney.

- **FISHERY AND WILDLIFE MANAGEMENT:** The primary goal of this career field is to maintain adequate populations of fish and wildlife and to protect species against extinction. Some specific job titles in this field can include naturalist, environmental educator, biologist, ecologist, marine biologist, endangered species biologist, botanist, aquaculturist, data manager and GIS specialist.
- **PARKS AND OUTDOOR RECREATION:** Parks and outdoor recreation jobs are most concentrated in the public sector. The primary goal of this career field is to protect and maintain the public parks in this country and to guide the public through these areas making it possible for everyone to enjoy the beauty of these public lands. Some of the jobs in this field include historian, biologist, botanist, archeologist, landscape architect, ranger, planner and forest pathologist.

Other environmental management and protection professions include:

- attorneys;
- city/county planners;
- city/county recycling education coordinators;
- environmental consultants;
- environmental educators;
- environmental lobbyists;
- environmental planners;
- environmental technicians;
- environmental researchers;
- resource geographers; and
- technical writers.

Any job can be environmental. You don't have to be in an environmentally oriented field to make a positive impact on the environment. Think about all the things you can do at home, school or work to conserve natural resources. If your school or workplace doesn't have a waste reduction or recycling program, ask to set up one. Donate old computers and other items to schools or other organizations. Look for ways to save energy, too. Spread the word and set an example of good environmental stewardship.



Lesson Resources

The Clean Air Act

What is the Clean Air Act?

The original Clean Air Act was passed in 1963, but our national air pollution control program is actually based on the 1970 version of the law. The 1990 Clean Air Act Amendments revised the 1970 law.

The overall goal of the 1990 Amendments was to reduce pollutants in our air by 56 billion pounds a year – 224 pounds for every person in the country – by the time the law was fully implemented in 2005. The current law builds on the strengths of the Clean Air Act of 1970 and the environmental lessons learned over the years. As the goals of the law are met, we will breathe cleaner air every year.

Before the 1990 Clean Air Act Amendments, the U.S. Environmental Protection Agency (EPA) regulated air toxics one chemical at a time. This approach did not work well. Between 1970 and 1990, EPA established regulations for only seven pollutants. The amendments took a completely different approach to reducing toxic air pollutants. They required EPA to identify categories of industrial sources for 187 listed toxic air pollutants and to take steps to reduce pollution by requiring sources to install controls or change production processes.

For more information about the Clean Air Act, visit www.epa.gov/air/caa/peg/index.html.

What does the Clean Air Act cover?

Two kinds of pollutants are regulated under the Clean Air Act. There are six in the first group called “criteria” pollutants. These pollutants – carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, lead and particulate matter – are discharged in relatively large quantities by a variety of sources, and they threaten human health and welfare across broad regions of the country. EPA sets national standards for each of the criteria pollutants, and the states must take action to ensure the standards are met. Failure to meet the standards is called “non-attainment.” Many urban areas are classified as “non-attainment areas” for at least one criteria air pollutant.

The other kind of pollutants – and there are hundreds in this group – are the ones that are immediately hazardous to human health and are associated with specific sources. Some of these air toxics are cancer-causing; some produce other health and environmental problems. The threat is highest for people living near large industrial facilities or in heavily polluted urban corridors. The list of toxics emitted into the air is a long one, and it includes some familiar names. Benzene, for example, is a potent cancer-causing substance. Gasoline sold in the United States is, on average, 1.6 percent benzene. Eighty-five percent of human exposure to benzene comes from gasoline.

A second example is mercury. Mercury is a metal found in trace amounts in coal and is released into the air when the coal is burned. Mercury also is released by incinerators burning garbage. It is used in latex paints to prevent mildew, and as the paint weathers, substantial amounts of mercury may be released into the air.

What are the requirements of the Clean Air Act?

Areas of non-attainment for criteria pollutants have been classified according to the extent of pollution. The five classes range from marginal (relatively easy to clean up quickly) to extreme (will take a lot of work and a long time to clean up).

The 1990 Clean Air Act uses these classes to tailor cleanup requirements to the severity of the pollution and set realistic deadlines for reaching cleanup goals. If deadlines are missed, the law allows more time to clean up, but usually a non-attainment area that has missed a cleanup deadline must meet the stricter requirements set for more polluted areas.

States do most of the planning for cleaning up criteria air pollutants using a system of permits to make sure power plants, factories and other pollution sources meet their cleanup goals. A variety of cleanup methods are required in non-attainment areas, many of which involve motor vehicles. Cleaner fuels, cleaner new vehicles, better maintenance programs

for vehicles on the road, and mass transportation may be required. Also, as the pollution gets worse, pollution controls will be required for smaller sources of pollution.

The regulatory program for air toxics in the 1990 amendments reflects an entirely new approach. This law names 189 toxic air pollutants. Typically, they are carcinogens, mutagens (substances that can cause gene mutations) or reproductive toxins, and their sources usually are specific industries.

EPA identified categories of the major sources of these chemicals and then developed “maximum achievable control technology” (MACT) standards for each category. These standards were based on the best control technologies that were demonstrated in these industrial categories. State and local air pollution agencies have primary responsibility to make sure industrial plants meet the standards.

In setting the MACT standards, EPA looked only at pollution control equipment and pollution prevention methods, such as substituting non-toxic chemicals for the toxic ones currently in use. The law sets standards that industry must achieve, rather than dictating equipment that industry must install. This flexibility allows industry to develop its own cost-effective means of reducing air toxics emissions and meeting the goals of the act.

The law includes unique incentives for industries to reduce their emissions early, rather than waiting for federal standards. Sources that reduce emissions by 90 percent or more before the MACT standards go

into effect will have six additional years to comply with them. This “early reduction program” should lead to significant reductions in air toxics both immediately and into the future.

Other parts of the Clean Air Act establish a program for the prevention of accidental releases of air toxics from industrial plants and create a Chemical Safety Board to investigate accidental releases of air toxics from industrial plants.

What happens if you don't comply?

The Clean Air Act establishes “enforcement” methods that can be used to make polluters obey the laws and regulations. Enforcement methods include citations (like traffic tickets) for violators of the law, fines and even jail terms. The knowing violation of almost every requirement is now a felony offense.

EPA and state and local governments are responsible for enforcement of the Clean Air Act, but if they do not enforce the law, members of the public can sue EPA or the states to get action. Citizens also can sue violators apart from any action taken by EPA or state or local governments.

Before the 1990 Clean Air Act, all enforcement actions had to be handled through the courts. Now, in some cases, EPA has the authority to fine violators without going to court first. The purpose of this new authority is to speed up compliance with the law and reduce court time and cost.

On the Web ...

For more information about the Clean Air Act and reducing emissions from vehicles, visit this link www.epa.gov/air/caa/peg/carstrucks.html.





Lesson Resources

Automobiles and Air Pollution

Each of today's cars produces 60 to 80 percent less pollution than cars in the 1960s. More people are using mass transit. Per the Clean Air Act, leaded gasoline was phased out completely as of January 1995, resulting in dramatic declines in air levels of lead, a very toxic chemical. Despite this progress, many types of air pollution that arise in part from mobile sources have not improved significantly. At present in the United States:

- motor vehicles are responsible for at least half of the smog-forming volatile organic carbon (VOC) and nitrogen oxide pollutants in the air;
- nearly 100 cities exceed the U.S. Environmental Protection Agency's (EPA) National Ambient Air Quality Standard for ozone;
- motor vehicles release more than 50 percent of the hazardous, cancer-causing air pollutants in the air; and
- motor vehicles release about 90 percent of the carbon monoxide found in urban air.

What went wrong?

Although there has been significant progress since 1970 in reducing emissions per mile traveled, the number of cars on the road and the miles they travel almost doubled in the same time frame. As lead was being phased out, gasoline refiners changed gasoline formulas to make up for octane loss, and the changes made gasoline more likely to release smog-forming vapors into the air.

Another reason that pollution levels remain high is that emission control systems do not always perform as designed over the full useful life of the vehicle. Routine aging and deterioration, poor vehicle maintenance and emission control tampering can increase vehicle emissions. In fact, a major portion of auto-related hydrocarbons can be attributed to a relatively small number of "super-dirty" cars whose emission control systems are not working properly.

What are the most dangerous pollutants from vehicles?

Air toxics are pollutants that cause adverse health effects. The EPA has focused a large part of its air toxics efforts to date on carcinogens, compounds that cause cancer. Motor vehicles emit several pollutants that EPA classifies as probable or definite carcinogens, including benzene, formaldehyde, acetaldehyde, 1-3-butadiene, and particulates (soot and smoke, especially from diesel vehicles). Ozone is a form of molecular oxygen that consists of three oxygen atoms linked together. Ozone in the upper atmosphere (the "ozone layer") occurs naturally and protects life on earth by filtering out ultraviolet radiation from the sun. But ozone at ground level is the major component of smog and presents this country's most intractable urban air quality problem.

What are the effects on public health?

Vehicles are such an integral part of our society that virtually everyone is exposed to their emissions. EPA estimates that mobile source (car, truck and bus) air toxics may cause up to 1,500 cases of cancer each year, about half of the cancers caused by all outdoor sources of air toxics.

Ozone is responsible for the choking, coughing and stinging eyes associated with smog. Ozone damages lung tissue, aggravates respiratory disease and makes people more susceptible to respiratory infections. Adults with existing diseases and children are especially vulnerable to ozone's harmful effects. Elevated ozone levels also inhibit plant growth and can cause widespread damage to crops and forests.

How are pollutants from vehicles formed?

Some air toxics are components of gasoline, such as benzene, that is added to gasoline to increase octane. Cars emit benzene as unburned fuel or as fuel vapors

that evaporate during refueling. Formaldehyde, particulates and 1-3-butadiene are not present in fuel but are by-products of incomplete combustion.

Ozone is not in fuels and is not a by-product of combustion, but is formed in the atmosphere through a complex set of chemical reactions involving hydrocarbons, oxides of nitrogen and sunlight. In typical urban areas, at least half of those pollutants come from cars, buses, trucks and boats. The rate at which the reactions proceed is related to both temperature and intensity of the sunlight. Because of this, high ozone levels occur most frequently on hot summer afternoons.

What has been done to control vehicle emissions?

The Clean Air Act of 1970 gave EPA the primary responsibility for regulating “mobile sources,” which include cars, trucks and buses. The EPA vehicle emission control program has achieved considerable success in reducing both nitrogen oxide and hydrocarbon emissions. Cars coming off today’s production lines typically emit 70 percent less nitrogen oxides and 80 to 90 percent less hydrocarbons over their lifetimes than their uncontrolled counterparts of the 1960s.

Older vehicles without catalytic converters or simple catalysts emitted far more pollutants than the ones on the road today. Air toxics have decreased since many of these older cars have been replaced

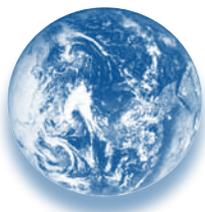
with newer models with better exhaust systems. In addition, popular hybrid vehicles also release fewer emissions.

What else can be done?

Control of hydrocarbon and nitrogen oxide emissions is the most promising strategy for reducing pollution levels in most urban areas. EPA has established more stringent limits on gasoline volatility, tightened tailpipe emission standards, required improvements in inspection and maintenance programs as well as required long-lasting catalytic converters. In the most polluted cities, however, these measures will not be sufficient. Further exhaust emission controls for vehicles are approaching the limit of technology. The only way to ensure healthy air is to markedly reduce our use of cars or to switch to cleaner fuels.

Some fuels are inherently cleaner than gasoline because they emit less nitrogen oxides or hydrocarbons that are less likely to react in the atmosphere to form ozone. These fuels include alcohols, electricity, natural gas and liquid petroleum (propane). Changes in the composition of gasoline itself (such as reducing fuel volatility or reducing benzene content) also can reduce emissions of most air toxics.

Unless we dramatically reduce the amount of pollution vehicles emit in actual use or drastically cut back on the amount we drive, smog-free air will continue to elude many cities.



Lesson Resources

Hazardous Waste

Hazardous waste is a by-product of many manufacturing processes. Hazardous waste can be a solid, liquid or gas. Hazardous waste has certain characteristics that make it potentially harmful. It may be toxic, corrosive, ignitable or explosive.

Medicines, televisions, computers, even tennis shoes – almost anything that you can think of that has been manufactured, may contain hazardous material of some kind or produced a hazardous by-product when it was manufactured. Of course, this does not mean that the item itself is hazardous. For example, putting the colors in paints and fabrics may generate hazardous waste. So does the manufacture of many metal, plastic and even wood products. Deinking newspapers before they can be recycled also may produce a hazardous waste by-product.

Hazardous waste must be handled carefully. There are laws to regulate how factories and businesses handle and dispose of their hazardous waste. The most important law concerning hazardous waste is the Resource Conservation and Recovery Act (RCRA). Passed in 1976, it has been amended to tighten regulation of hazardous substances. RCRA:

- determines which waste is hazardous;
- creates rules for handling and disposing of this waste;
- makes sure waste is transported safely if it leaves the generation site;
- makes sure any spilled or mismanaged waste is cleaned up; and
- keeps track of all the hazardous waste created in this country.

Since its passage in 1976, several amendments have been made. Visit <http://epw.senate.gov/rcra.pdf> to view a copy of the legislation.

When we think of hazardous waste and material, we may think of chemicals and thick fumes. In reality, hazardous waste is generated every day by industries, agriculture, the military, small businesses, public agencies, institutions and homeowners. Originally RCRA was written to regulate hazardous waste produced by the large quantity generators:

industries, agriculture and the military. Large quantity generators generate more than 1,000 kilograms of hazardous waste per month.

RCRA has since been amended to regulate the previously exempted small quantity generators including small businesses, public agencies and institutions such as schools, hospitals and maintenance crews. Small quantity generators are those which generate less than 1,000 kilograms of hazardous waste in a calendar month. Some large and small quantity generators, as a result of ongoing educational awareness, can reduce the amount of hazardous waste from their processes, thereby allowing their generator status to change to become conditionally exempt. The small amount of hazardous wastes typically found in homes – also known as household hazardous material – have remained exempt from federal regulations.

Small businesses that are likely to produce hazardous waste includes those that: repair and maintain motor vehicles, electroplate materials, operate printing and copying equipment, perform dry cleaning and laundering services, process photographs, operate laboratories, construct buildings and roads, spray lawns and/or homes for pest control, preserve wood, make or refinish furniture, paint and clean buildings, clean and maintain swimming pools, repair air conditioners and make and glaze ceramic pottery. The actual amount of hazardous waste generated by a single, small business or school may seem insignificant, but the amount from all of these sources adds up to a profound threat to the environment if not properly handled. In fact, improper management can adversely affect drinking water.

To identify and properly manage hazardous waste, South Carolina requires quarterly reporting by large quantity generators (companies generating greater than 2200 pounds of hazardous waste in any month). In addition, an annual declaration by small quantity companies (generating between 220 and 2200 pounds per month) is required. A conditionally exempt small quantity generator (CESQG) is a company that generates less than 220 pounds in any month. There are no reporting requirements for a CESQG. In the most recent data available, the S.C.

Department of Health and Environmental Control (DHEC) has records of notifications from 305 large quantity generators, 680 small quantity generators and 2,889 conditionally exempt small quantity generators. Although the majority of small quantity generators and conditionally exempt small quantity generator are small business companies, many schools also generate varying amounts of hazardous waste.

Sometimes, this waste is improperly disposed by unknowing school staff who pour hazardous waste down sink drains, dump them on the ground or in storm drains, bury them in containers which can leak over time or put them in garbage cans or dumpsters for disposal in landfills.

Improperly managed hazardous waste, regardless of the source, can pollute ground water, contaminate rivers and lakes, kill fish and other wildlife, pollute the air with toxic vapors, cause explosions or fires and poison humans from direct contact or consumption of contaminated plants and animals.

Many hazardous waste generators – especially large quantity generators – treat, store or dispose of wastes on site under federal and state regulations. The technology and equipment for this activity is expensive and usually too costly for small quantity generators. The most economical way for small quantity generators to manage their hazardous waste is to have it shipped to approved facilities.

Like any other kind of waste, the less hazardous waste a generator produces, the easier it is to manage. Small quantity generators can reduce the amount of hazardous waste they produce by recycling waste materials, participating in waste exchanges with other small quantity generators, and using alternative non-hazardous substitutes for potentially hazardous products. Hazardous waste that can be recycled for further use includes lead in car batteries and silver from used photographic fixer. In many cases, one generator's hazardous waste can be another industry's raw material.

Hazardous Waste in South Carolina

In March 1978, the General Assembly of South Carolina approved a regulatory program for the management of hazardous waste. This legislation, known as the S.C. Hazardous Waste Management

Act, (Act 436) established the statutory framework necessary for DHEC to regulate hazardous waste activities within the state.

There are five major elements in the state's approach to hazardous waste management:

1. classification of hazardous waste;
2. cradle-to-grave tracking (manifest system);
3. quarterly reporting;
4. standards to be followed by generators, transporters and facilities which treat, store or dispose of hazardous waste; and
5. enforcement of standards for facilities through a compliance monitoring, enforcement and permitting process.

A method of establishing waste as hazardous involves the listing of specified industrial activities or substances presumed to be hazardous.

These categories are:

- WASTE FROM NON-SPECIFIC SOURCES of the same genetic type used universally as multi-purpose chemicals, for example halogenated solvents;
- WASTE FROM SPECIFIC INDUSTRIAL PROCESSES are generated by a specific industry (e.g., distillation bottoms from the production of acetaldehyde from ethylene); and
- OFF-SPECIFICATION COMMERCIAL CHEMICALS (from off-specification materials, discarded commercial chemical products, container residues and spill residues) include:
 - about 200 chemicals considered "acutely hazardous" and regulated if more than 1 kilogram per month is generated; and
 - about 400 chemicals subject to regulations.

The state also includes a listing of hazardous waste which is not properly identified by any existing or valid waste number.

Once waste is identified as hazardous, its generation, transportation, treatment and storage or disposal is managed. Minimum standards are specified in DHEC's regulations for each of these management categories. These standards include record keeping; facility design, construction and operational requirements; permitting procedures; financial

responsibility and compliance self monitoring where applicable.

DHEC's staff responsible for implementing this program consists of engineers, hydrologists, chemists, geologists and other technical and administrative employees. These personnel are responsible for hazardous waste activities including program administration; permitting; public participation compliance and surveillance; enforcement; field inspections and investigations; emergency response to spills and releases; and cleanup activities at uncontrolled sites.

Volume of Hazardous Waste in South Carolina

According to "Hazardous Waste Activities Reported for South Carolina for 2010," published by DHEC, 153,625 tons of hazardous waste were generated. Also in 2010, South Carolina generators shipped 81,506 tons of hazardous waste out-of-state. A total of 93,389 tons of hazardous waste was received from out-of-state sources.

Hazardous Household Waste

According to experts, products may not be hazardous while they are being used, but they can become hazardous when they are burned, poured down the drain or disposed of improperly. There is a difference between hazardous products and those that can become hazardous and are dangerous.

While businesses and manufacturers are carefully monitored, there are no laws to regulate how households handle their hazardous waste. This is why it is so important that people understand the potential risks to health and the environment of the household hazardous products they may purchase, use and store.

Household hazardous material may contain the same hazardous components of industrial hazardous waste, but because of the small volumes, it is difficult to account for in state statistics.

When used safely for their intended purpose, the vast majority of these products present few concerns. But when used improperly or when containers pile up in basements, garages and barns, they are dangerous. And if they get poured down the drain or put into the household trash, they can become a dangerous source of pollution.

DHEC offers technical assistance for communities wanting to setup outlets for problem wastes.

Hazardous Household Material

The average American stores three to 10 gallons of household hazardous products at any given time. Examples of household products which contain toxic or polluting chemicals include paints, septic tank cleaners, fingernail polish, drain cleaners, disinfectants, pool chemicals, pesticides, hobby supplies and laundry bleach.

People are generally unaware of the potential dangers of using, storing and disposing of common household substances. Some potentially severe consequences of careless disposal of these products include:

- pollution of drinking water, ponds, harbors and rivers;
- injury to trash collectors (chemicals when mixed together can cause fires, acid burns and the release of toxic fumes);
- smog and other air pollution is caused by evaporation of solvents contained in products such as household paints, varnish strippers and even fingernail polish;
- injury to firefighters battling fires involving large amounts of flammable substances such as gasoline, paint thinner and pesticides; and
- destruction of important bacteria necessary to break down waste in sewer and septic tank systems.

If people follow label instruction and wear appropriate protection, household hazardous products can be safely used for intended purposes. Use Internet search engines to obtain detailed label instructions for the different products in your home.

Alternatives to Hazardous Household Material

The best way to handle household hazardous material is to avoid them altogether; that is, use less toxic substitutes that will still get the job done. Here are a few alternative suggestions.

- **ALL-PURPOSE CLEANER:** Mix 1/2 cup of borax with one gallon of water.
- **FABRIC SOFTENERS:** Add 1/4 cup of baking soda or white vinegar to the rinse cycle.
- **FURNITURE POLISH:** Mix 2 parts vegetable oil and 1 part lemon juice.

- **SILVER POLISH:** Soak silver in 1 quart of warm water with 1 teaspoon of baking soda, 1 teaspoon of salt and a small piece of aluminum foil.
- **CHROME AND STAINLESS STEEL CLEANER:** Dip dry cloth into flour and rub the surface.
- **WOOD FLOOR CLEANER:** Dampen cloth with a solution of water and mild soap. Wring cloth almost dry and wipe section by section, so that no section stays wet.
- **BRASS CLEANER:** Mix equal parts lemon juice and baking soda to make a paste. Cover brass surface with paste and allow to dry, then wipe off quickly.
- **COPPER CLEANER:** Mix equal parts of salt and flour. Heat an equal part of vinegar and add to mixture to create a paste. Rub on copper surface.
- **CERAMIC TILE CLEANER:** Mix equal parts of white vinegar and borax to paste consistency. Rinse and wipe dry.
- **GLASS CLEANER:** Mix 3 tablespoons of white vinegar in 2 cups of warm water.

Web Resources

Additional Web sites that offer alternatives include:

- Maryland Cooperative Extension, <http://extension.umd.edu/publications/pdfs/hw1.pdf>;
- New York State Department of Environmental Conservation's Division of Solid and Hazardous Materials, www.dec.ny.gov/docs/materials_minerals_pdf/hhwcht.pdf; and
- Alameda County, <http://stopwaste.org/home/index.asp?page=585>.



Hazardous Waste Classifications

- **IGNITABILITY** – Ignitable wastes are liquids with a flash point less than 140°F for flammable gases, strong oxidizers or substances which burn vigorously under spontaneous circumstances. Besides potential hazards from fire, heat and toxic smoke, they can spread harmful particles over a large area. Examples include solvents such as toluene, xylene and benzene; oils; plasticizers as well as paint and varnish removers.
- **CORROSIVITY** – Corrosive wastes are substances which can, upon contact, cause destruction of living tissues and materials by chemical action. They are generally water-based wastes with a pH less than or equal to 2 (acids) or greater than or equal to 12.5 (bases). Because they may corrode standard materials, such as steel, corrosive wastes require special containers. Examples include alkaline cleaners and battery waste.
- **REACTIVITY** – These are wastes that are normally unstable, may spontaneously and vigorously react with air or water, be unstable to shock or heat, generate toxic gases when mixed with water and/or explode. Examples include obsolete munitions, cyanide- and sulfide-bearing wastes and wastes from the explosives and chemical industries.
- **TOXICITY** – Toxicity is measured by the potential for a waste to release substances in sufficient quantities to pose a substantial hazard to human health, domestic livestock and/or wildlife through ingestion, inhalation or absorption. The U.S. Environmental Protection Agency (EPA) has identified maximum concentrations of heavy metals, pesticides and herbicides over which significant risk to human health may occur. These concentration limits are set at a level 10 times the EPA/Primary Drinking Water Standard.