INTRODUCTION TO WASTE MANAGEMENT

Municipal Solid Waste Management
Waste Management in Alabama is as diverse as the state's natural resources. Municipal solid wastes are generated in homes, commercial establishments, institutions, and industries. Municipal solid waste varies from yard waste to food scraps and from construction and demolition debris to office and classroom paper. In the United States, each individual produces 2,555 pounds of garbage each year. In Alabama, each individual produces approximately 4.5 pounds of municipal solid waste a day. Local governments, waste management companies, and consumers have established methods of disposing of waste in an environmentally friendly manner.

Recycling is the process by which used items are reconditioned and are adapted to a new use or function. Recycling is a waste management method that can be a responsible, cost-effective way to help solve some of Alabama's waste disposal problems. Recycling helps preserve natural resources, reduce pollution, and save energy.

Composting is a low-cost disposal method whereby organic material is accumulated in mounds or containers to bring about decomposition by microorganisms such as bacteria or fungi. Composted items can be used as a soil conditioner in landscaping and gardening.

Incineration is a disposal method involving the burning of solid waste to reduce volume, with or without the recovery of energy.

Landfilling is the major disposal method of solid waste in Alabama. A landfill is a system of trash and garbage disposal in which waste is buried between layers of earth in such a manner that minimizes environmental hazards. New EPA regulations called subtitle D make landfilling more environmentally friendly than before, but much more expensive.

Hazardous Waste Management
In addition to municipal waste management, Alabama also must manage hazardous wastes produced in the state. *Hazardous waste* is any solid, liquid, or gaseous material that is no longer of use in its present form and would cause injury or death to living organisms and would pollute land, air, or water if improperly disposed. Some examples of hazardous wastes include oil, batteries, pesticides, and oil paints. Hazardous wastes may be managed through minimization, resource recovery such as recycling or reuse, treatment, or disposal.

The *Resource Conservation and Recovery Act* (RCRA) classifies hazardous waste into two categories: characteristic hazardous waste and listed hazardous waste. *Characteristic hazardous wastes* exhibit one or more of the following traits: ignitability, corrosivity, reactivity, or toxicity. *Listed hazardous wastes* are incorporated into lists from the RCRA rules. They exhibit one of the previously listed characteristics or contain any number of toxic constituents that have been shown to be harmful to health and the environment.

Household hazardous waste, unlike hazardous waste generated by industry, is not regulated in Alabama by the Alabama Department of Environmental Management or the U.S. Environmental Protection Agency. The best way to manage household hazardous waste is to avoid generating hazardous products.

Disposal may be reduced or eliminated by giving leftover products away, recycling materials when possible, using less hazardous alternatives when possible, and buying only the amounts of products needed.

Classroom Compost

Grades:
9 - 12

Subjects:
Biology, Ecology, Environmental Science, Earth Science

Time Needed:
Two class periods (21 days apart), plus 5 to 10 minutes per day for days 2 through 20

Materials:
wire or screen compost container for outside compost or large glass container for indoor compost
organic yard and food waste (leaves, grass clippings, wood ash, sawdust, eggshells, fruit and vegetable food waste)
lawn fertilizer that contains nitrogen, dirt, or non-sterile potting soil
thermometer
trowels or large kitchen spoons

OBJECTIVES:

Students will be able to:

1. Identify the components of an active compost pile.
2. Explain the composting process.
3. Identify current and potential markets and uses for finished compost products.
4. Describe the benefits of composting as a waste management technique.

BACKGROUND:

Composting of materials is one of the oldest forms of recycling. When dead leaves fall to the ground in wooded areas, they are broken down and decomposed over time by a combination of physical (nonliving) and biological (living) factors. Eventually the elements and compounds that were once part of the living leaves are released into the air and soil where they can be used to form new plants or other organisms in the endless cycle of life. Given proper conditions, many of the organic wastes we throw away every day also can be composted and used as a soil amendment.

Organic materials are carbon-based substances that are or were parts of living organisms. Composting is a process whereby organic material is broken down and decomposed by microscopic bacteria, or fungi, and other decomposers such as earthworms. When organic wastes, such as grass clippings, leaves, sewage sludge, and food waste, are combined and receive sufficient air and water, microorganisms, especially bacteria, proliferate. If a compost pile is constructed and operated properly, the resulting bacteriological activity significantly increases the temperature in the pile destroying unwanted pathogens and quickly breaking down the organic materials. The finished product called compost is an important source of nutrients, such as nitrogen, for plants.

The large-scale use of composting as a waste management tool could significantly reduce the volume of solid waste that communities send to landfills. At present, few Alabama communities include large-scale composting in their waste management programs. A major deterrent in developing large-scale use of composting is a lack of demand or market for the finished compost product. Several large Alabama cities have “compostin” programs for yard wastes (leaves, brush, and other plant materials). They make those composted mterials available to the general public for mulch or other re-use.

Currently, composted yard waste and sewage sludge are used for soil enhancement; for landfill cover; and as a top dressing for grassy areas, vegetable gardens, and flower beds. Current major purchasers of compost are road and park departments, landscapers, golf courses, campgrounds, airports, and hay and corn farmers. Other potential purchasers include cemeteries, state and U.S. forests, homeowners, citrus growers, horse farms, topsoil and bark companies, retail farm and garden suppliers, phosphate miners, building contractors, and the fertilizer industry.

In addition to encouraging the development of additional large-scale composting facilities, homeowners are encouraged to use yard and food waste to make their own compost for use as fertilizer and/or mulch.

VOCABULARY:

decompose, organic, compost, humus, aerate, soil amendment

PROCEDURE:

Setting the Stage

1. A few days before the activity is scheduled, ask students to bring in samples of yard and food waste from home. Instruct students not to bring in meat scraps, fats, or oils. Pre-consumer food waste also could be obtained from school cafeterias. It may be beneficial to find an outside location for storing the compostable materials. There are many ways to build a compost pile. This lesson gives you several options. If you have a suitable site outdoors, you may dig a hole to use instead of building the pile in a container.
2. Prior to class, make copies of "Striking It Rich With Compost" and "Classroom Compost."

Activity

<u>Day 1</u>

1. Introduce and define the term "compost." Ask students to identify the "ingredients" they think are essential to a good compost pile and to explain why these ingredients are necessary.
2. Distribute the "Striking It Rich With Compost" information sheet and review the nine components of an active compost pile. Next, explain the composting process and ask students what they think finished compost looks like. Explain that finished compost looks and smells like dark, nutrient-rich soil, or humus, when properly prepared.
3. As a class, design and build a mini-compost pile in the schoolyard. A suggested procedure includes the following steps:
   • Chop the food and yard waste into small pieces.
   • Alternate layers of soil (one inch), organic waste (two inches), a sprinkle of fertilizer, and a sprinkle of water.
   • Place a top layer of one inch of soil on the completed pile.
   • Add additional water as needed to make the pile moist but not soggy. (It should feel like a damp sponge.)
   • Place a thermometer into the middle of the pile.
   • DO NOT SEAL THE COMPOST PILE—AIR CIRCULATION IS CRITICAL.
4. Explain that, if accelerated decomposition is not needed, the soil, fertilizer, and water additives are not necessary.
5. Place the completed compost pile in an appropriate area in the schoolyard and post the "Classroom Compost" data sheet nearby. Have one student record the initial temperature, odor, and texture of the compost and list the organic waste materials added to the compost pile in the appropriate boxes next to START on the data sheet.

<u>Days 2-20</u>

1. Keep the compost pile away from extreme temperatures and direct sunlight. Assign a different student to examine the compost pile and use the data sheet to record data regarding the temperature, odor, texture, and changes observed in the compost pile each day. Once each week (Days 6, 11, and 16) use a trowel or large kitchen spoon to gently turn and aerate the compost. On these days, have students make and record their observations BEFORE the compost is turned and aerated. Remind students to record the temperature of the compost pile from the same location and depth and at the same time each day.
2. Check the moisture level of the compost pile every few days and add water as needed to keep it moist.

Day 21
1. Record the final temperature, odor, and texture of the finished compost product and allow each student to feel, smell, and look at a sample of the finished compost.
2. Have students help you construct a graph of the temperature of the compost pile over time and reproduce the completed "Classroom Compost" data sheet on the board or overhead.
3. Ask students what they think happens to organic food and yard wastes 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. Now, all new landfills must include systems for collection and release of methane gas. Review the benefits of composting in reducing the volume of waste sent to landfills and recycling the elements and components necessary to sustain life. Tell students that according to U.S. EPA figures, currently 10.9 percent of the solid waste generated is food waste and 12.1 percent is yard waste. This is a total of 23 percent.
4. Composting needs to continue for 2 more weeks to get finished products.
5. Have the students find places and ways to use their composted material around the school grounds.

EVALUATION:
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/uses for finished compost products.
4. Explain the benefits of large-scale and home composting.
5. Why was it important to record the temperature of the compost pile from the same location and depth and at the same 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 wastes added to the compost pile? Which materials were broken down and decomposed the fastest? Slowest? Why?
11. Explain that finished compost is a natural fertilizer and 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. Review the current and potential purchasers and uses of composted sewage sludge and plant and yard waste compost in Alabama.

EXTENSIONS:
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 peel, one without earthworms). Compare the rates and effectiveness of decomposition among the piles.
2. Prepare one compost pile containing large pieces of organic waste and another containing small pieces of the same types of organic waste. Have students investigate the effect of material size on the rate and effectiveness of decomposition.
3. Collect samples of natural humus from a wooded area. Have students observe and compare the texture, odor, and color of natural humus and prepared compost and examine the humus for evidence of decomposers (fungi, earthworms, insects).
4. If the community has a municipal composting center, take a field trip to observe its operation.
5. Have students design and maintain a school or home compost pile using food and/or yard waste.

6. Have students prepare a Composting Fact Sheet and distribute it to classmates, family members, and perhaps city council members.
7. Perform soil tests on natural humus, commercially obtained humus, and compost to determine how they compare. Grow seedlings in each, under identical conditions, to see if there are any differences. If differences occur, to what could you attribute the differences?

ORIGINAL DEVELOPMENT RESOURCES:

Roest, M. (1995). *Animal tracks.* Washington, DC: National Wildlife Federation.

www.epa.gov

"*Home Composting"*. The Composting Council. www.compostingcouncil.org

Alabama Department of Economic and Community Affairs - Science, Technology and Energy Division: Waste Utility and Reuse Technology publications, www.adeca.state.al.us

Questions About Composting

Will everything in the wastestream compost?
No. About 66 percent of the typical waste stream is compostable. This includes yard and food waste, paper, and wood.

What is the best method of composting?
There are several methods of composting. Choose the method based upon the materials you want to compost and the time you have to devote to composting.

Is composting considered recycling?
Yes. The United States Environmental Protection Agency includes composting in its definition of recycling.

What's the advantage in having a community composting facility?
Composting can reduce the dependence on landfilling and/or incineration.

How does compost benefit the soil?
A high-quality compost properly applied to the soil improves soil structure and aeration as well as increases its water-holding capacity. Compost improves the permeability of clay soils and the water retention of sandy soils.

Is compost considered a fertilizer?
No. While compost can contain varying amounts of nitrogen, phosphorus, and potassium, it is considered a soil amendment, not a fertilizer.

What are typical uses for compost?
High-quality compost can be used in horticulture, landscaping, and golf courses.

Striking It Rich With Compost

Key Component	Function
1. Soil	Contains microoganisms (bacteria) that help decompose organic materials.
2. Organic wastes (leaves, fruit and vegetable scraps, egg shells, and grass clippings) containing both carbon and nitrogen	Alternating layers of high-carbon and high-nitrogen wastes create good environmental conditions for decomposition to occur. Meat scraps, fats, and oils inhibit decompositions; and their strong odors can attract dogs, rats, raccoons, and other animals. They should not be used in compost piles.
3. Fertilizer containing nitrogen (or manure) or green grass clippings containing nitrogen	Many of the organisms responsible for decomposition need extra nitrogen for rapid and thorough decomposition.
4. Water	Essential component of the decomposition process; too much water can make the compost pile soggy and can 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; stirring the compost pile every few days can speed up the decomposition.
7. Heat	Heat is a byproduct of the chemical reactions occurring during decomposition. A properly functioning compost pile can reach a temperature of 65 degrees Celsius. The 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

Age of Compost Pile	Temp. (C)	Odor of Compost	Texture of Compost	Changes in Organic Waste Materials (size, color)
Day 1 (Start)				
Day 2				
Day 3				
Day 4				
Day 5				
Day 6 (Stir)				
Day 7				
Day 8				
Day 9				
Day 10				
Day 11 (Stir)				
Day 12				
Day 13				
Day 14				
Day 15				
Day 16 (Stir)				
Day 17				
Day 18				
Day 19				
Day 20				
Day 21 (Finished Compost)				

Notes

Closing The Waste Loop

Grades:
9-12

Subjects:
Social Studies, Chemistry, Marketing, Consumer Education

Time Needed:
Two hours

Material:
worksheets

OBJECTIVES:

Students will be able to:

1. Explain the processes in both a one-way flow system of waste (open loop) and a cyclic system (closed loop).
2. Research local industries and report on their recycling efforts.

BACKGROUND:

Every product has a life-use cycle. The cycle begins with the design and then the manufacturing of the product. The product is then used as intended and discarded after use. The above process, common in many products, is a straight line or open loop process contributing to filling up landfills.

A preferable alternative is to close the loop and bring the discarded product into the manufacturing process again to create a new product. Another way that this concept can be explained is the 4 R's (reduce, reuse, recycle, and rebuy).

Both manufacturers and consumers can help in *reducing* the amount of waste that is generated. *Reusing* products and containers directly increases the life of products and resources, thus decreasing the rate of waste generation. Products that are *recycled* for remanufacture are removed entirely from the waste stream. The last R depends upon the consumer. When we buy recycled products, we are *rebuying* products that meet all specifications for new products. We, as consumers, get the quality of new products and, at the same time, keep waste out of landfills when we buy recycled, remanufactured products. When we purchase recycled products (re-buy), we help not only ourselves but our environment.

VOCABULARY:

one-way flow waste system (open loop), cyclic waste system (closed loop), by-product, reduce, reuse, recycle, rebuy, raw material, second generation use, networking, economic growth

PROCEDURE:

Setting the Stage

1. Show the diagrams of open loop and closed loop systems on the worksheets. Discuss examples of closed loop and open loop systems. Discuss the economic and environmental advantages of a closed loop system.
2. Discuss the process of networking with other industries to aid in the disposal of waste products by using one plant's waste as another plant's raw material. Examples are given in the following chart.

Company	By-Product Waste	2nd Generation Use
Steel Manufacturing	Naphthalene Ferric Sulfate	Mothballs Clarifying agent for drinking water
Trucking Company	Used Tires Used Oil Used Oil Filters	Asphalt blending Fuel oOl Recycled into steel products
Poultry Production	Poultry Litter	Natural Fertilizer

Activity

1. Research project: choose businesses in the local community and assign to individual students or student teams.
2. Survey company to determine what waste products it produces; how they are disposed of; and whether or not any of these are reused, recycled, or sold to other manufacturers.
3. Chart waste on either an open or closed loop diagram. (Use the appropriate one.)
4. Evaluate whether a company's waste management system is environmentally efficient or economically efficient. If both, explain.
5. Prepare a 5-minute presentation for the class to share findings of individual students.

EXTENSION:

1. Ask businesses for a cost estimate of their waste management program. Compare with other businesses.

Waste Management Survey

Company Name:

Company Address:

Contact Person:

Phone Number:

Type of Business:

List Major Waste Product	How Waste Products Are Disposed	Why This Method Of Disposal Is Used

Questions To Ask A Contact Person

1. What is it about your waste management practices that makes your company environmentally responsible?

2. How might the company become more environmentally responsible?

3. What factors prevent your company from becoming more environmentally responsible?

4. Have your waste management practices affected the economics of your business?

   Negative effects:

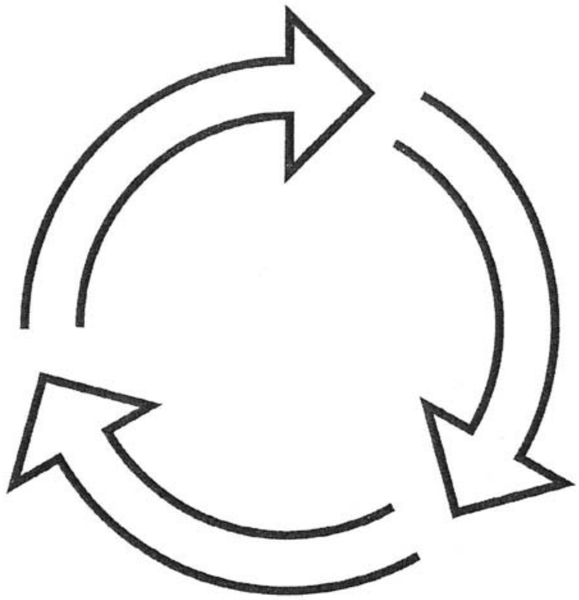
   Positive effects:

5. What are your predictions for future developments of waste management in your industry?

Closing The Waste Loop - Student Worksheet

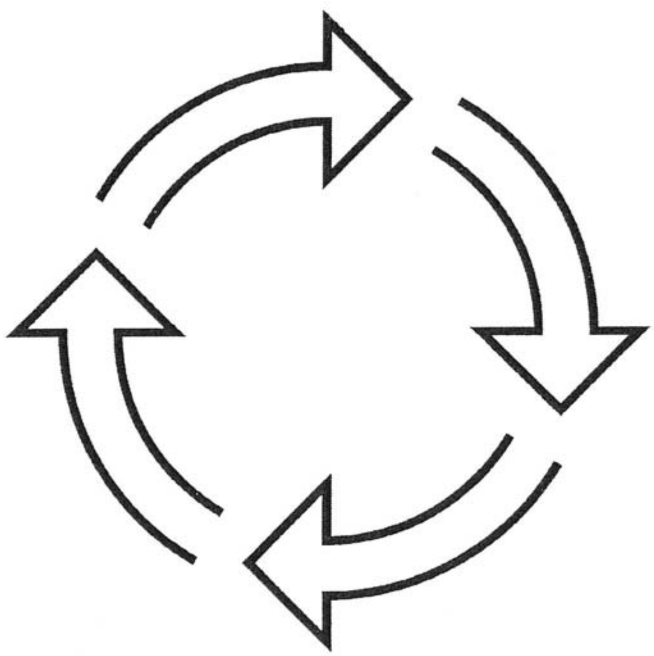
Open loop system has at least one component missing.

Closed Loop



3 arrows

or

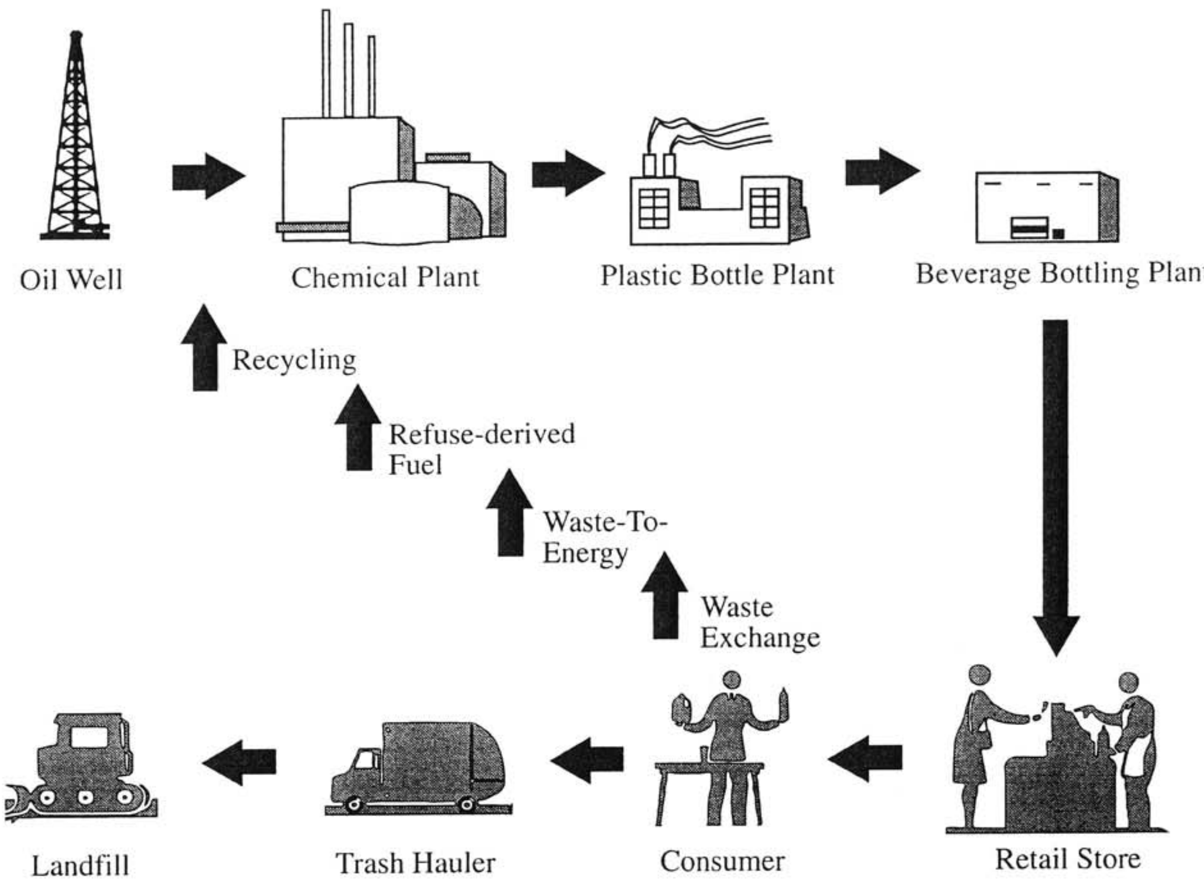


4 arrows

Industrial and Ecological Flow Systems

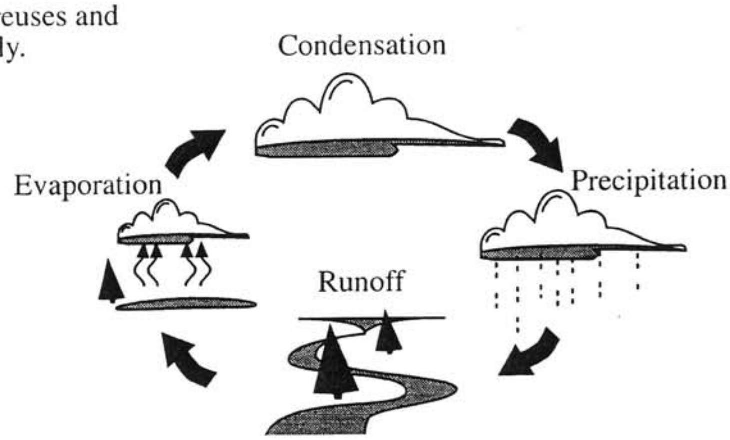
Industrial Cycle Flow Using Solid Waste Options

A cyclic system involves the potential of using materials over again at each step of the process or after final use with the intent to reuse or recover the resource or energy.



Ecological Cycle Flow

Nature provides a cyclic system that reuses and recycles natural resources continuously.



Notes

Deciding What To Do

OBJECTIVES:

Students will be able to:

1. Restate the complexities of managing solid waste.
2. Explain various agencies and legislation related to solid waste management.
3. Participate in a debate on solid waste legislation.

Grades:
9-12

Subjects:
Social Studies, Government, Environmental Science, Drama

Time Needed:
Several class periods, plus research over several weeks

Materials:
copies of the Scenario and role descriptions for students involved
sample hearing agenda
copies of the "Garbage Dictionary" for each student in the class
newspaper and magazine articles from your local area on problems in the management of solid waste

BACKGROUND:

Regulations for environmental quality usually lag behind the factors that contribute to environmental problems. Prior to World War II, there were few environmental regulatory programs. States directed their efforts to land use, not land quality. State and federal officials assumed the roles of advisors and persuaders. Only recently has government assumed a more active environmental role.

The 1970 amendments to the Federal Solid Waste Disposal Act of 1965 were an important step toward addressing current issues in waste disposal methods. Emphasis began to shift from waste disposal to waste management and resource recovery.

The Resource Conservation and Recovery Act (RCRA) of 1976 (amended in 1984) replaced the Solid Waste Disposal Act. This law regulates the disposal of solid waste and gives strict requirements for the construction of municipal solid waste landfills (Subtitle D) and incinerators. Subtitle D landfill requirements went into effect October 1993.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) reflected changing attitudes and increasing efforts to protect the quality of the land. The Superfund legislation created a system of assessments (taxes) and provided federal funds to clean up major sites of pollution such as abandoned dumping sites.

VOCABULARY:

Solid Waste Disposal Act, RCRA, CERCLA, Superfund, NIMBY, solid waste

PROCEDURE:

Setting the Stage

To supplement these materials and to prepare students on the issues, have students collect information from newspapers, television news shows, and magazines related to citing landfills or incinerators. Review these as a class.

1. Have students research and report on the regulation of solid waste and related issues.
2. Divide the class into eight groups and explain to the students that each group is to research one of the following state and federal government agencies involved in the enforcement of solid waste legislation:
   - Environmental Protection Agency
   - Department of Energy
   - Army Corps of Engineers
   - Department of Labor

• Department of Transporation
• Department of Health and Human Services
• Interstate Commerce Commission
• Alabama Departments of Health and Environmental Management

3. Each group is to research, write, and present to the class a one- or two-page report that includes the name of the agency, its responsibilities, and the government legislation for which the agency is responsible. This will serve as a review of how government must work together to provide answers to complex solid waste situations.

   NOTE: This lesson requires students to think about the many issues surrounding solid waste disposal. For this lesson to be effective, students should have a basic understanding of solid waste, landfills, incinerators, and solid waste regulations. Management of solid waste and citing a garbage disposal facility are complex and controversial public decisions. In the decision-making process, a wide range of perspectives and values come into play.

Activity

1. The class will conduct a simulated refuse disposal citing/solid waste management hearing with class members taking the roles of various participants in the waste management decision-making process. The disposal facility under consideration includes options for an incinerator only, landfill(s) only, or both. For this exercise, students will be looking at the citing of a municipal solid waste facility. Other pertinent issues not explicitly on the hearing agenda but having direct or indirect bearing on the waste management problem as a whole are:
   • Waste prevention and reduction and what can be done to encourage it, especially in industry.
   • Recycling and the role it should play in the overall waste management plan.
   • Reducing industrial waste through the establishment of waste exchanges or treatment facilities.These issues and others are a few of the many problems facing communities and government agencies the world over as they grapple with the cumulative effects that result from our 'throwaway' culture.
2. Distribute copies of the scenario and a role description to each participating class member. For best results, use one role description for each group. Tell the students that the problem closely parallels the actual situation in a number of communities. The job of the class is to understand and discuss the solid waste problem and to come up with solutions. The emphasis should be on possible alternative solutions and not just a single answer to the problem.
3. Choose a student to serve as County Commissioner/Hearing Examiner. Then choose other students to fill the roles (see descriptions included). You may wish to assign some roles to more than one student. For example, have two journalists, one from a large newspaper and one from a smaller weekly publication, or one from the daily paper and one from a magazine. If the class is large enough, let some of the roles be assigned to two or three students who will each study and research a particular aspect of their roles' concerns about the county's disposal strategies. Not all the roles are necessary, but the 'hearing' will work best if at least the first six or seven parts are included.
4. An alternative approach is to assign the more technical and science-oriented roles, such as Scientist Expert, Toxicologist, Incinerator Vendor, to a chemistry and /or biology class while giving the other roles to a social studies class. The final hearing could be held in two sessions, one for each class.
5. Explain to the students that this simulation is not meant to represent any actual public hearing or governmental hearing process, but that many public bodies are required by law to solicit input and comment on complex projects that can affect human health and environmental quality.
6. Have students prepare to play their roles realistically and convincingly by having them contact their real counterparts in your county. Encourage students to add substance and appropriate detail to their roles. You'll notice that in the roles given, various positions and opinions are expressed. People use different terminology to describe what they agree with versus what they oppose. For example, people who oppose an incinerator may call it an incinerator while those who are for it may call it a waste-to-energy facility. This is not to say that all incinerators are waste-to-energy facilities, but it points to the fact that people's

opinions color their descriptions. Also, this example is for the siting of a municipal solid waste facility, that is, a facility to take only household and business garbage, not hazardous waste. This does not mean, however, that people won't mix issues and won't bring in their fears about dangerous wastes.

7. Hand out the sample hearing agenda or prepare a similar one of your own. Assign a specific date or dates for conducting the hearing. Encourage all the participants to come prepared with either questions or a brief presentation as indicated on the agenda. When the hearing takes place, have that part of the class not playing specific roles serve as the County Council, both questioning the hearing participants and, in the end, reaching a decision about what to do with all the solid waste.

EXTENSIONS:

1. Invite recyclers, environmental activists, solid waste engineers, garbage haulers, reporters, county commissioners to your class to describe the role each plays in dealing with your county's solid waste.
2. Invite these representatives to view your hearing and then to critique the student's arguments. How would they have handled their role in the hearing?
3. Share with the class the acronyms in the Garbage Dictionary. Have them think of others.

ORIGINAL DEVELOPMENT RESOURCES:

Adapted from the South Carolina Department of Health and Environmental Control and used with permission.

Schematic X-Section of A Solid Uaste Landfill

Deciding What TO DO
The Scenario

County population is growing rapidly. The volume of solid waste produced in the county is growing even more quickly. Federal and state regulations have outlawed open dumping, so all the old dumps have been closed. New U. S. Environmental Protection Agency guidelines for RCRA Subtitle D approved landfills are strict. In building a new landfill, Subtitle D regulations are not an option; they are the law.

To protect human health and the environment, Subtitle D landfills must have safeguards built into them, but this makes it very expensive to construct. In addition, a Subtitle D landfill must be monitored throughout its use and for many years after.

Incinerators and waste-to-energy facilities are controversial. A brief federal moratorium on these facilities puts them in the spotlight. Federal regulations on emissions are designed to safeguard the environment. These are strict and construction is expensive. People have been attracted to living in the county because of its beautiful semi-rural character and thus are very sensitive about environmental degradation or property devaluation that may possibly result from a landfill or large-volume incinerator being built nearby.

The county public work department, which has responsibility for proper disposal of all municipal waste generated within the county, is increasingly concerned about the growing amount of waste and is considering both an incinerator and/or a new landfill. The existing landfill is filling up fast; and, given the long lead time needed to site and build a replacement, a decision about what to do with the county's waste must be made soon.

ROLES

Activist
You oppose any new waste facilities. You feel strongly that more recycling could be done in the county. You think the county should require home source separation of recyclable materials such as aluminum, glass, plastic, and newspapers. Private or public garbage haulers should be required to provide separate pickup for recyclables. You'd like the county to institute a county-wide, per-can garbage collection fee schedule that allows as little as one pickup a month. You want the county to fund public education programs in recycling: programs both for citizens' groups and schools.

You oppose the construction of an incineration plant. You are concerned about the effects of incinerator emissions on air quality. You understand that an incinerator will require huge amounts of refuse to operate efficiently and thus may discourage recycling efforts, while at the same time presenting problems in disposing of the ash generated. You believe that a landfill could cause considerable environmental damage to the land, air, and water.

Garbage Hauler
You own a garbage collection company. Your company is licensed by the state and franchised by the county. Your prime concerns are providing good service to a rapidly growing number of customers and keeping costs down. You also are concerned about county and state regulations of your business.

In recent years, more of the task of running your business has been taken up with government forms and "red tape." You are concerned about the prospect of the county telling you how to set your collection fees, how the garbage itself must be picked up, and where you have to take it once it has been collected.

Commercial Recycler
You became involved in recycling a long time before concerns about environmental degradation were first voiced. Profits have never been large, and the markets for recyclables have never been particularly stable or reliable. Nevertheless, the satisfaction of knowing that your job is part of the solution and not part of the problem has always made the hard work and long hours necessary to survive more than worth it. After 20 years, you have carved out a secure market for your business, and you are looking forward to relaxing a little while letting the younger generation carry on the day-to-day work.

You are worried that an incinerator will cut the bottom out of the recycling market. Although you would like to see the city institute mandatory recycling and source separation, you recognize that your own business is probably too small to compete with the large waste management firms that the city would most likely end up contracting with for such a mandatory program. You are gratified that, at last, recycling has become a "big business" and thus respectable; but you are angry and a little bit frightened that you and your hard-earned business will get lost in the shuffle.

Spokesperson, Homeowners' Group
You are worried that the county/city may be planning to build a landfill or an incinerator near your home. You are worried about the roadway litter that may result. You also are concerned about the increase in the rat, crow, sea gull, and wild dog population that a landfill may bring, You are worried that household hazardous wastes dumped into the landfill will generate toxic leachate that could contaminate your drinking water. You are angry when you think that a landfill or incinerator may decrease the value of the house and land you've worked so hard to own.

As the co-founder of a civic organization against incinerators/landfills, you have been asked by the organization to present the group's concerns at the upcoming hearing. You realize, however, that it is not enough to protest a specific site and that appealing and feasible alternatives must be presented. For this reason, your organization has come out in favor of increased recycling.

County Public Works Engineer
Your county department has responsibility for disposing of all wastes generated in the county. You also have responsibility for meeting federal and state regulations governing the disposal of waste. Part of your job is to design and build waste facilities such as landfills and incinerators. At the same time, you are required to ensure that these disposal facilities do not create hazards for the environment or human health. A great deal of your energy goes into selecting and evaluating possible disposal sites and advising county commissioners/council members on technical aspects of solid waste management. You are becoming alarmed at the rate of growth of the county's volume of solid waste and, probably most acutely, realize the enormity of the county's solid waste problem. You ask yourself, "Where is all this stuff going to go?"

Lately, however, much more of your time has been taken up with public relations dealing with the concerns and sometimes the anger of citizens who question or challenge county solid waste policy or decisions. You believe that citizens need to be better informed about some of the scientific and technical issues that are part of deciding what's the best option. You are especially concerned that the press is playing up some of the more sensational but remote dangers associated with incinerators and landfills. It seems that no matter how well you document the safety of a waste-to-energy incinerator or a landfill site, the papers always play up the negative aspects.

County Commissioner/Council Member
Your job is to make the final decision about how to deal with the county's growing volume of solid waste, while taking into account the needs and interests of a broad range of county citizens and businesses. You have to understand both the technical information provided you by the public works director and the anxiety of homeowners who feel threatened by the possibility of a landfill or incinerator in their area. You try to be pragmatic and fair. You also want to get re-elected to office.

Your role in the hearing is to conduct a landfill citing/solid waste management discussion by calling on and questioning the citizens who have a position or an opinion to express. It is also your responsibility to seek the input of other county commissioners/council members and interested citizens. It is your responsibility to conduct an orderly and productive meeting. This means that all participants should be treated equally and that all viewpoints are given a fair hearing.

County Citizen
You lead a busy life. You like the convenience that some packaged and processed foods give you, although you are sometimes bothered by the amount of packaging left over.

You know your county is growing rapidly; but you have been more concerned about other consequences of growth, such as crime and crowded highways, than you have been about an increase in garbage. Frankly, you'd like to throw your trash in the garbage can and forget about it, even though you know in the long run that your children or grandchildren may end up paying for it with a less healthy environment.

You're paying the garbage hauler and the county taxes to take care of trash for you. You don't feel you have enough time in your day to fool around with the trash by separating it for recycling. And you don't want anything to do with higher taxes.

Journalist
Time and time again you've been assured by elected officials that the city has its garbage problem under control only to learn later, after careful digging, that the plans made have proved to be inadequate for the mounting garbage generated daily through expanded growth. When you ask about safeguards for environmental and human health, the engineers and planners present seemingly endless numbers and graphs, all purporting to establish the safety of the sites being proposed for the disposal facility.

Your job is to ask hard questions, understand the important issues, and report accurately the decision-making process.

Incinerator Plant Vendor
You believe that incineration is the best solid waste management method available. As an engineer with many years of experience in waste management and chemical processes, you know that the

technology for safe incineration is already available; and you don't understand why some citizens are fearful and unwilling to trust your professional judgment.

If asked, you would have no qualms about having an incinerator site next to your property. You want your company to be selected for this county's contract. Your boss has promised you an especially attractive bonus if you can "land" this one. You also know that waste incinerators, under the right conditions, are good opportunities for investors.

Regulatory Agency Official
You have been assigned by your agency to carry out state law as mandated by the state legislature. Your responsibility is to write about enforcing regulations that will protect public health and the environment, yet still provide practical and economically feasible waste management facilities.

You are sensitive to the public's view of you, yet you know that there is no perfect set of regulations that will please all the parties. From your experience as a field inspector, you know that strict enforcement of the law doesn't always lead to the desired result of a safer environment. You are sometimes as frustrated as the public by the legal requirements built into the regulations as safeguards against unjust government actions but which are all too often exploited by a few "bad eggs" at the expense of the many.

It is sometimes hard to remember that most individuals and businesses are honest and want to comply with the law, especially as it relates to the environment. You have been asked to attend this hearing to explain the current state and federal regulations and to show how they affect the county's proposal for siting a disposal facility. You expect to be questioned closely by both citizen and industry groups.

Scientist Expert
You are a professor of geology at a nearby university specializing in hydrology, the study of water movement in the Earth. Your research has focused on groundwater flow and the scientific study of the problems associated with groundwater contamination from human activities.

Your publications have appeared in numerous journals, and your scholarly expertise has been acknowledged by many professional organizations throughout the world. As your reputation as an expert has grown, you have been called on to speak at a growing number of public hearings and workshops throughout the state including testimony at legal trials on the safety of various disposal options with respect to potential and actual groundwater contamination. You know as a scientist that there is no such thing as certainty, especially in a field like geology where most events are measured in millions of years, and actual experimental verification is possible only on a limited basis. Nevertheless you find yourself being asked to give "yes" or "no" answers to questions that scientific and technical knowledge can never provide. The county commissioner has asked you (for a fee) to examine the county's plans for disposal and to provide a brief report discussing the impacts that each option might have on the water supply now and in the future. At present, the data available and current scientific models can only suggest in a most sketchy fashion what these impacts might be. You are worried that, because of this, each faction will seize upon those parts of your presentation that most closely support its position and then point to you as proof of the "truth" of its claims.

Private Consultant
The county hired the firm you work for to study the various options for a garbage disposal facility. You have been part of the team that carried out the necessary research, and your particular expertise is in the area of stack emissions in incinerators and the safeguards of the new Subtitle D landfill design.

Your supervisor is out of town this week, and you have been tapped to represent the firm if any questions arise concerning the recommendations that were made to the county as part of your firm's final report. Since a landfill and/or incinerator were included as part of the recommendation, you expect to be questioned sharply on these aspects of the overall strategy your company proposed.

County Attorney
The district attorney's office reviews all the county plans to ensure that the county does not violate any of the many governmental regulations that inevitably cover any large-scale plan.

Projects with the potential for environmental harm and/or human health effects are especially complex, involving as they do both technical and political issues. You have been assigned the job of monitoring the legal aspects of the county's waste management plans. A top-notch lawyer, you welcome this assignment as the first step in your career as a public official. You have political ambitions, and you know how crucial it is to perform well on this assignment.

Your boss, the district attorney, is particularly concerned about the threat of lawsuits and other legal actions from various special interest-groups such as nearby homeowners, industry organizations, and environmental activists.

Toxicologist
You work at a federal government laboratory studying the effects of chemicals on mice and rats. Most of your research is directed toward determining whether certain chemicals can cause cancer in humans and animals. The main research tool for doing this is to expose special strains of rats and mice to substances and observe whether, or at what dosages, tumors develop. You know that many people are doubtful about relating results from mice to humans. Skeptics point out that experimental animals are exposed to high doses of substances at levels not commonly found in a normal environment. You, however, know that to extrapolate to the low dose exposures that are typical of human environments, the 50 to 100 rats and mice must ingest enough toxin to produce a statistically significant number of cancers. Estimates of cancer-causing potency are based on the extrapolation of the experimental animal results to low doses.

Several environmental organizations have expressed concern about production of dioxins by the incinerator, either as smokestack emissions in the air or as part of the flying ash that must be disposed of. Dioxins are a class of chlorinated organic compounds produced as byproducts in the production of herbicides and other products. At least one dioxin, TCDD, is the most potent carcinogen known in mice and rats. The evidence for its cancer production in humans is not established, however; and scientists disagree as to what exposure levels are safe.

Farmer/Agriculture Representative
Your family has roots in the area that stretch back to the early pioneer days more than 100 years ago. You have watched the county seat grow from a small town to a medium-sized city. You are

concerned about the rapid growth and its effects on prime agricultural land. In your view, building an incinerator or new landfill will encourage more growth, and you know that your family farm ultimately may be threatened by this growth.

Taxes continue to increase, and you have farmer colleagues who have been forced to sell their acreage due in part to rising property taxes. You feel strongly about the stewardship of the land and are worried that your family's longtime ties to the land may be broken. When it comes to new people and waste disposal, you say, "Not in my backyard."

Real Estate Developer
You believe that progress must necessarily include some environmental disruption, but that the economic growth for the area far outweighs the short-term pollution of a "few" streams or the conversion of some prime agricultural land for suburban housing and shopping centers.

If most environmentalists had their way, the county would soon stagnate from the many regulations and restrictions that stifle growth. You are convinced that the expansion now underway must not be interrupted and that desirable "high tech" industries can be attracted to the area only if they can be assured that there are adequate waste disposal facilities.

You believe that growth is inevitable and that, even if there are some minor problems now, scientists and engineers will come up with the necessary technology in the future to solve them. Sure, in the past some mistakes were made, but there are plenty of safeguards built into the law now. Besides, it's always been necessary to "break a few eggs to make an omelet." You believe that an incinerator, especially a waste-to-energy incinerator designed to produce energy while it burns trash, is necessary for the continued economic health of the county. You think that all the people who oppose progress have the NIMBY (not in my backyard) syndrome and should wake up.

Chamber of Commerce Representative/Local Businessperson
You have been a member of the local business community for 20 years. Your business has been slowly growing after a struggle to make ends meet for the first 10 years. However, the national economic situation has caused you great concern. Will you be able to meet the costs of a college education for your two teen-aged children?

A waste-to-energy incinerator would bring cheaper electrical power rates and would build an economic base in the county. Recycling efforts could bring in a few jobs, but larger companies outside the area already are prepared to initiate large-scale recycling efforts. A new landfill might cause a reduction in business opportunities, tourism, and residential growth. However, when it comes to where a facility should be located, you say, "Anywhere except my side of town."

Public Hearing On Proposed Municipal Refuse Disposal Facilities

Agenda

I. Opening Statement - County Commissioner

II. County Proposals - Public Works Engineer
   A. Combination Incinerator and Sanitary Landfill
   B. Waste Reduction/Recycling with Smaller Landfill and Incinerator
   C. Long Distance Hauling to Another Part of the State
   D. Question Period

III. Expert Reports

IV. Citizen Testimony
   A. Citizen Environmental Group
   B. Organizations

V. Industry/Business Testimony

VI. Final Summarization and Questions

VII. Conclusion and Vote - Commission Members

VIII. Report of Proceedings by the Journalists

Garbage Dictionary

excerpts from *Garbage* magazine

NIMBY— This acronym for Not In My Backyard sums up some peoples' reaction when plans for the new landfIll or incinerator are unveiled

GUMBY— Gotta Use Many Backyards. The divide-and-conquer methods of siting hazardous waste facilities and the like: You've got six sites, and you only need to use one. You try to get people to fight it out. The town offering the weakest opposition gets the facility.

YIMBY (FAP)— Yes In My Backyard (For A Price). A new siting tactic: Waste-handling firms pay fat inducements including road improvements, free disposal, and a piece of the dumping fee (which can total in the millions of dollars) to any community willing to "host" a large regional landfill or incinerator.

NIMTOF— Not In My Term Of Office. A waste-industry tag for politicians who give in to community opposition thereby leaving their successors to deal with the problem.

NIMIC—Not In My Insurance Company. When a community rises up to fight a waste site, they're branded hysterical housewives, but when an insurance executive refuses to underwrite a pollution liability policy for the same site, he's credited with sharp business acumen.

NOPE— Not On Planet Earth. When the NIMBY syndrome gets them down, this term is muttered by waste handlers convinced the "NIMBY-ites" don't want disposal facilities sited anywhere.

PICESP— Put It In Corporate Executives' Swimming Pools. In fevered moments, this term is used by radicals who think waste management executives should just keep the wastes.

NIMFY— Not In My Front Yard. If "NIMBY-ism" is taken to extreme and there are no more garbage pickups because no one will accept new recycling facilities, landfills, or waste-to-energy plants, NIMFY is what people will be crying as they watch their waste pile up.

Notes

Generating Methane From Waste

OBJECTIVES:

Students will be able to:
1. Describe the energy-producing potential of some solid wastes.
2. Examine some systems of generating methane from waste.
3. Construct a model methane generator.

Grades:
9-12

Subjects:
Chemistry, Environmental Science

Time Needed:
One class period to set up the experiment (Time needed for generating gas will depend upon the procedure used.)

Materials:
safety glasses
fume hood (if using heat source)
three Erlenmeyer flasks (one 500 mL, two 125 mL
a lubricant petroleum jelly
organic slurry of manure or ground grass clippings, etc. (from a compost pile)
balloon (blown up several times, making it easier to inflate)
three rubber stoppers (these may be pre-drilled)
one foot of glass tubing
3 feet of surgical tubing (or any flexible tubing that can be attached to glass tubing)
the nozzle from a medicine dropper
one pinch clamp
a drill to bore a hole in rubber stoppers (not needed if stoppers are pre-drilled)

BACKGROUND:

Methane gas is created naturally as a waste product of anaerobic bacteria living in water-logged soils and wetlands and also in human-produced environments such as rice paddies and landfills. The digestive systems of some animals, such as cattle and sheep, contain these bacteria and produce methane gas. A single cow produces 100 gallons of methane each day. The microbes in the intestines of termites, which digest wood, also produce methane. Methane is produced for fuel in some parts of the world and is burned in methane digesters. Methane gas is a greenhouse gas and contributes to global warming. Some scientists believe about 18 percent of global warming may be attributed to increases in methane in the environment.

The top ten sources of methane in the atmosphere are:

1.	wetlands	20.2%
2.	rice fields	19.4%
3.	cud-chewing animals	14.0%
4.	biomass fires such as burning forests	9.7%
5.	oil & natural gas pipeline leaks	7.9%
6.	termites	7.0%
7.	coal mining	6.2%
8.	landfills	6.2%
9.	animal wastes	5.0%
10.	sewage	4.4%

Once buried, organic wastes (food wastes, plant and animal materials) decompose anaerobically, which means that they decompose without oxygen. The speed of decomposition is highly variable and depends upon moisture, the amount of compaction, and other factors. Carbon dioxide, methane, ammonia, and hydrogen sulfide gases all are produced as microorganisms break down wastes. Note this distinction: this activity deals with organic wastes. Inorganic wastes and very stable anthropogenic organic materials, such as plastics, *may* decompose eventually if given enough oxygen, light, and time. However, they decompose only very slowly in a landfill where they are sealed off from oxygen and light.

Trapped beneath the landfill surface, the gas by-products of organic waste decomposition become potential health and safety threats if not properly vented. To avoid explosions or lateral migration of methane beneath the surface of a landfill, vents are installed to reduce pressure build-up of the gases.

Methane is the largest component of natural gas. If the landfill volume is great enough (at least one million tons), the methane produced can be captured, purified by removing carbon dioxide and water, and sold to gas utility suppliers. Capturing methane from landfills may not result in a profit, but it can help to defray the landfill's operating costs. There are many methane recovery systems operating or under construction in the United States, and there are a great many more landfills large enough to justify a methane recovery system.

In Birmingham, Alabama, the New Georgia landfill recovers methane gas that is used for fuel.

According to an article in *The Waste Age* magazine entitled "The Clean Air Act," November 1993, the United States EPA has proposed new performance standards for new municipal solid waste landfills and emission guidelines for existing facilities under Section 111(b) of the Clean Air Act. This was in response to EPA's findings that municipal solid waste landfills can be a major source of air pollution that contributes to ozone problems, air toxin concerns, global warming, and potential explosion hazards.

The EPA conducted a study of landfills to determine the methane generation rate constant and the potential methane generation capacity of the refuse. Based on these data and other assumptions, the EPA estimated that the baseline (1987) emissions from the 7,124 existing landfills in the U.S. was 15 million gallons/year of methane and 300 million gallons/year of other non-organic compounds that occur in landfill gas including trichlorofluoromethane, trichloroethylene, benzene, vinyl chloride, toluene, and perchloroethylene. The predictions do not include emissions from the 32,000 landfills closed prior to 1987.

Due to these concerns, EPA is considering more comprehensive regulation of 'municipal landfill gas emissions' in total.

VOCABULARY:

organic waste, methane, slurry, anaerobic, pyrolysis, methane digester

PROCEDURE:

Setting the Stage

1. Prior to class, make an overhead transparency of the *Methane Digester Model* or copies for each student group.
2. Review with the class the background material included with this lesson. Explain to students that they are going to create a methane generator.

Activity

1. Refer to the illustration to help with setting up the methane generation/collection apparatus. **Wear safety goggles**. This experiment must be properly constructed. Your system must be well sealed. Any leaks will result in a lack of gas pressure. (You may want to practice this experiment and have students assist you in demonstrating the experiment for the class. If enough equipment is available, you may have students set up several stations.)
2. Bore two holes in each rubber stopper, or use stoppers with two holes already in place.
3. Run a tube from the flask representing the landfill to the flask representing a gas storage container. (***Note:*** Make sure all connections are tight. Use petroleum jelly or Amogel on stopper holes. Keep tubing to a minimum. Use large diameter tubing.) The gas storage container's stopper should have two holes, one for the tube coming from the landfill flask (the large flask) and one for a nozzle and clamp. This is your flare.
4. Run a tube from the large flask representing the landfill to the third flask. This is the pressure relief system. Attach a second tube to the third flask and connect a balloon that's been blown up several times to stretch it. Make sure the tube from the landfill flask extends down into the water (see illustration; fill your pressure relief and gas storage flasks to near capacity with water). This arrangement will prevent an excess of gas from feeding back into the landfill flask.

5. Fill the large flask about three-fourths full with an organic slurry (for example, manure and ground grass clippings mixed with water until a thick, but pourable, consistency is reached). This flask will represent the landfill. Keep it warm. In the classroom, keep it away from any air conditioning. Warmth from a sunny window will help. It may be advisable to keep this set up under a fume hood.
6. It will take days or maybe even weeks before gas is produced. Keeping the slurry warm speeds production. As gas is produced, the balloon is inflated.

Optional Procedure to Speed Up Gas Production

1. Set up as before but *without* the gas storage flask.
2. Let the slurry (compost and manure) set overnight and then apply continuous heat and stirring. (Use a hot plate set to about 350 degrees C.) This should produce gas in about 20 minutes. You should see the balloon inflate.

EVALUATION:

1. What is methane?
2. How is methane produced?
3. List materials that can be used to generate methane.
4. Describe another means of using solid waste to produce fuel.

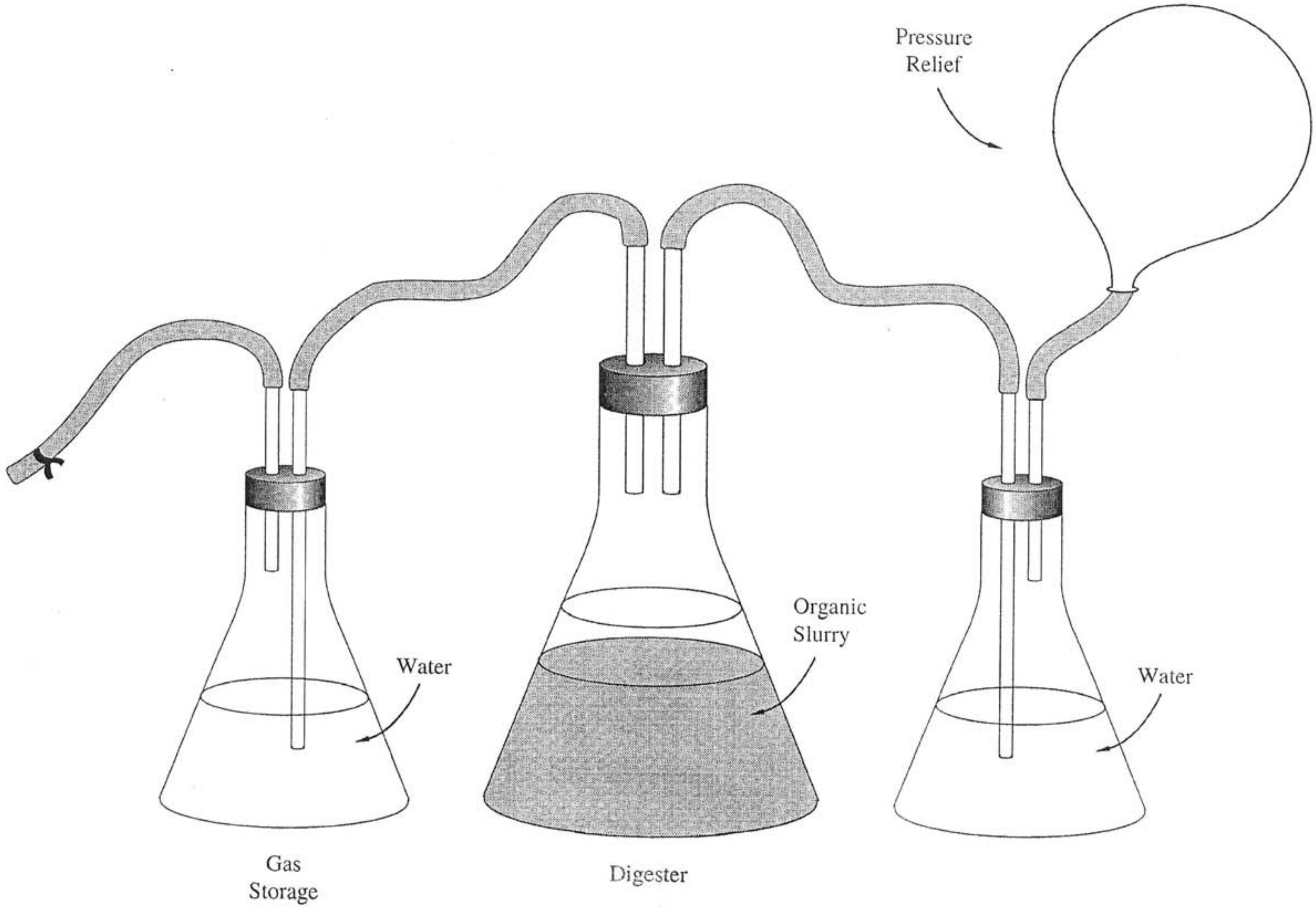
EXTENSIONS:

1. Have students research the historical uses of methane gas digesters. For example, in Holland a tarp was placed over a portion of a swamp with a hose running from under the tarp to a house to produce methane for light and heat.
2. Have students work in teams to build four or five of the three-flask methane generation/capture apparatuses. Have students test different organic wastes. Which produces the most gas the fastest? Which waste produces the best fuel?
3. Research modern methane technology.
4. Study resource recovery technology to learn how industrial fuel is created from solid waste by pyrolysis.

ORIGINAL DEVELOPMENT RESOURCES:

Environmental Literacy, the A to Z Guide. Adapted from South Carolina Department of Health and Environmental Control. Used with permission.

Methane Digester Model



Making Landfill Models

OBJECTIVES:

Students will be able to:

1. Define waste and leachate.
2. Describe a sanitary landfill in terms of its construction and function.
3. Identify some common chemical and physical properties of leachate.
4. Describe the effects of leachate on soil and groundwater.

BACKGROUND:

Landfills bury waste. An important factor in how landfills are built is how well they retain waste and prevent waste from contaminating nearby soil and water resources. The possibility of leachate contaminating soil and groundwater exists wherever wastes are buried. Leachate is formed in landfills when disposed wastes mix with water (either present at disposal or from precipitation). This water percolates through the waste, picking up a variety of suspended and dissolved materials from the waste. It collects at the bottom of a landfill.

In unlined landfills, the leachate continues to percolate through the soil. Some landfills have a simple clay liner used for containing leachate. In these landfills, which are being closed, leachate is not collected for treatment. In landfills with more sophisticated liner systems (Subtitle D landfills), leachate is collected and treated.

In this lesson, the landfill model represents the construction of a Subtitle D sanitary landfill to hold municipal solid waste.

VOCABULARY:

percolation, residue, leachate, aquifer, groundwater, leach, pH, hardness

PROCEDURE:

Setting the Stage

1. Prior to class, make copies of “Construction of a Sanitary Landfill Model” and “Student Work Sheet--How Leachate Affects Plants.”
2. Discuss with the students the following questions:
   - What is waste?
   - What does the term ‘biodegradable’ mean? (*Note that all the elements for biodegradability (air, water, and sunlight) are not available in a landfill. Without air, water, or sunlight, there is limited or longer-term degradation.)*
   - What are the sources of waste in a landfill? Give examples.
   - What happens to the waste from our homes, schools, and businesses?
   - Why is waste disposal an important issue?

Grades:

9-12

Subjects:

Chemistry, Math, Environmental Science

Time Needed:

Three to four class periods per procedure (not consecutive), homework, one month (minimum) for leachate collection

Materials:

30-gallon plastic garbage can
5 to 10 gallons of soil (clay, loam, and sand)
screw-in plastic faucet with securing nut
two-inch square piece of screen wire
caulking compound or silicon sealer
waterproof glue for plastic
plexiglass (4” x 30”)
one gallon of distilled water
(optional) Coliform bacteria test/lactose broth
laboratory thermometer
test kit for pH and hardness
egg cartons and egg shell halves
For extenstions: Daphnia (10to 20)
4 petri dishes
4 steel nails
soap
rubbing alcohol
paper towels
ammonia
vinegar
safety goggles
radish seeds
soil test kit

3. If possible, make arrangements for students to visit a landfill site, or arrange a presentation by a local waste management or public health expert. Explain to the students how a landfill is constructed. Discuss:
   • Site selection.
   Methods and operations.
   • Chemical and biological reactions occurring in completed landfills.
   • Methane gas and leachate movement and control.
   • Landfill design criteria and regulations.
4. Ask 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.

Activity

1. Ask each student to bring to class a small plastic bag containing household wastes including foodstuffs (vegetable and fruit peels, NO meat or dairy products), yard trimmings or plant residue, metal, paper, plastic, and cloth. As they bring the small bags of waste, have them deposit the bags in a larger bag in the large container.
2. Have the materials and equipment gathered for constructing the landfill model. Divide the class into teams. Give the teams copies of the student sheet "Construction of a Sanitary Landfill Model" and proceed with the construction of the model and waste preparation.
3. To prepare for the simulated rainfall, determine the average annual precipitation for your geographic area. Information is available from a meteorologist or local extension agent.
4. Divide the average annual precipitation by 52 to calculate the average weekly precipitation.
5. Measure distilled water to equal the amount of the calculated average weekly precipitation and sprinkle it over the soil in the model landfill.
6. Repeat the addition of 'average weekly precipitation,' keeping a record of the number of "weeks" until water begins to collect in the bottom of the model landfill. (*The liquid that collects in the bottom is the leachate*.) Be prepared to allow several weeks of adding precipitation to obtain enough leachate to perform this activity.
7. Monitor the temperature by inserting a thermometer as far as possible into the center of the landfill model. Keep a daily record of temperature readings. This can be an excellent graphing exercise.
8. One month after the addition of the water, withdraw all of the leachate from the model and test for pH, total suspended solids (liquid weight minus the weight of solids), hardness, and coliform bacteria (optional). Then:
   • Compare qualitatively color differences in leachate.
   • Compare the results of these tests with the properties of distilled water and graph the results.
   • Discuss what we can do to prevent leachate from contaminating groundwater and surface waters.

EVALUATION:

1. Ask the students to discuss the need for monitoring streams, wells, and springs located below the elevation of landfill sites.
2. Discuss the importance of reporting unusual odors in drinking water and knowing to whom such information should be reported.

EXTENSIONS:

1. Conduct the following experiment to determine how leachate, once it has reached an aquifer, contaminates groundwater.

Materials needed:

4 petri dishes, 4 steel nails, soap, rubbing alcohol, paper towels, pH test kit, a sample of the leachate, household ammonia, household vinegar, tap water, safety goggles

a. Measure the acidity of the leachate with a test kit. Compare it with tap water, household ammonia, and household vinegar.

b. Clean the nails with soap and water, rinse with alcohol, and dry with paper towels. Be careful not to touch the nails with bare hands after rinsing.

c. Fill each of four petri dishes about half full. Place tap water in one, leachate in another, household ammonia in the third, and vinegar in a fourth. Place one nail in each dish.

d. After a few days, when the liquid has evaporated, observe the nails. Record the observations. Have the nails changed in appearance?

e. Discuss results in relationship to landfill management. Why do we need to try to control liquid in a landfill? Under what conditions do metals leach? What other materials leach under the conditions found in a landfill?

2. Conduct the following experiment to determine how leachate can affect plants. To perform the experiment with the leachate sample, ask the students to bring to class an egg carton containing nine eggshell halves.

Materials needed:

3 different types of soil (clay, loam, sand), radish seeds, soil testing kit, copies of "Student Work Sheet--How Leachate Affects Plants"

a. Discuss soil structure and compare soils with three different structure types: heavy (clay), medium (loam), and light (sand).

b. Have the students prepare three seed beds from each of the three soil types using the eggshell halves as containers. (Have the students make tiny drainage holes in the bottoms of the eggshell halves.)

c. Have the students sow several radish seeds in each shell half and keep them moist during germination. (A plastic wrap laid on top will hold moisture in the soil.)

d. When the radish plants are one or two inches high, water one bed of each soil type with distilled water (control group), one bed of each soil type with leachate drawn directly from the landfill model, and the other bed of each type with leachate that has been passed through a column of soil. To simulate the leachate passing through a column of soik, add 99mL distilled water to 1 mL of leachate. (Discuss the movement and dilution of leachate, including how continued movement changes the degrees of dilution.) Use the same measured volume of liquid on each plant. (Be sure not to overwater.)

e. Have the students record the condition of the plants after one hour, 24 hours, and 48 hours. Observe for signs of beneficial and detrimental effects. Record the observations on the student sheet "How Leachate Affects Plants."

3. HOW LEACHATE AFFECTS LIVING THINGS

Materials needed:

1 mL of leachate, 99mL of distilled waterk 10 to 20 Daphnia-

a. Measure 1 mL of leachate in a container and add 99 mL of distilled water (to simulate the dilution of leachate due to normal movement through soil).

b. Place 10 to 20 living *Daphnia* in the container. (*Daphnia* are any of a variety of small fresh water crustaceans of the genus *Daphnia*, some species of which are commonly used as food for aquarium fish.)

c. Record any change of activity or obvious death after 1 minute, 2 minutes, and 5 minute

4. HAZARDOUS WASTES IN LANDFILLS

CAUTION: MAKE SURE STUDENTS TAKE PROPER PRECAUTIONS, SUCH AS WEARING PROTECTIVE CLOTHING, GLOVES, AND GOGGLES, BEFORE PARTICIPATING IN THE FOLLOWING SEGMENT OF THE EXPERIMENT.

Add hazardous wastes—household chemicals such as hazardous pesticides, nail polish remover, cleaning fluids—in your landfill model. Have leachate samples analyzed at a laboratory. How might this leachate affect groundwater? Should household hazardous wastes be land filled in municipal solid waste landfills? If not, what should we do with them?

Student Worksheet

Control Soil Samples

Soil Type #1 pH________________ P________________
K ________________ NO_3 ________________

Soil Type #2 pH________________ P________________
K ________________ NO_3 ________________

Soil Type #3 pH________________ P________________
K ________________ NO_3 ________________

Pure Leachate on Soil Samples

Soil Type #1 pH________________ P________________
K ________________ NO_3 ________________

Soil Type #2 pH________________ P________________
K ________________ NO_3 ________________

Soil Type #3 pH________________ P________________
K ________________ NO_3 ________________

Leachate Through Soil on Soil Samples

Soil Type #1 pH________________ P________________
K ________________ NO_3 ________________

Soil Type #2 pH________________ P________________
K ________________ NO_3 ________________

Soil Type #3 pH________________ P________________
K ________________ NO_3 ________________

Student Worksheet
How Leacheate Affects Plants Experiment

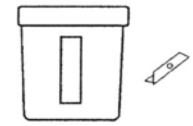
Control Soil Samples	**Plant Condition After:** 1 hour	24 hours	48 hours
Soil Type #1			
Soil Type #2			
Soil Type #3			

Pure Leachate on Soil Samples	**Plant Condition After:** 1 hour	24 hours	48 hours
Soil Type #1			
Soil Type #2			
Soil Type #3			

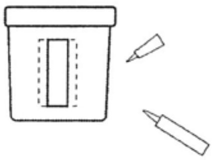
Leachate through Soil on Soil Samples	**Plant Condition After:** 1 hour	24 hours	48 hours
Soil Type #1			
Soil Type #2			
Soil Type #3			

Construction Of A Sanitary Landfill Model

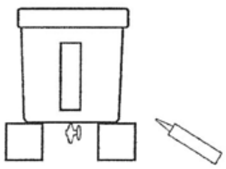
(using a 30-gallon garbage container)

1 

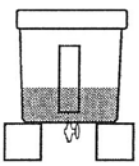
1. Cut a 2" x 30" vertical strip from a 30-gallon (or larger) garbage container, leaving the container intact for at least 3 inches of the bottom.

2 

2. Glue a 4" x 30" piece of Plexiglas to the inside of the container and over the cutout. This will allow you to view the contents of the model landfill. This window will show the strata of waste and soil. (The window may be marked in increments of inches to help with layering of the soil and waste.)

3 

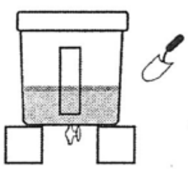
3. Before inserting a screw-in faucet on the side or at the bottom of the elevated model, cover the back of the faucet (the opening inside the tub) with the screened wire. This will help keep waste material from flowing out with the leachate. Seal around the faucet with caulking compound.

4 

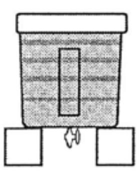
Preparation of Waste

In a sanitary landfill, the accepted ratio of soil cover to waste is 1:12 (6" of soil : 72" of waste). In this model, 1" of soil cover will be used for 12" of waste. *(If you use a smaller trash can, try to stick as close to this ratio as you can.)*

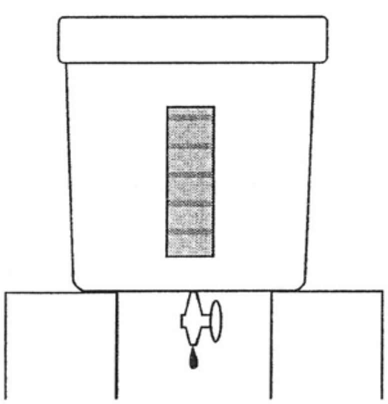
4. Place one layer of waste in the landfill model.

5 

5. Cover the first layer of waste with 1" to 2" of damp soil. Tightly pack the soil cover by pounding it firmly to simulate a real landfill situation.

6 

6. Continue the layering and compacting until the landfill model is full. The final layer should be 4" of soil.



Myths Of Soild Waste Crisis- Facts Or Opinions

OBJECTIVES:

Students will be able to:
1. Explore the scientific ways to determine what people think about solid waste issues.
2. Conduct a survey of opinions on solid waste issues.

Grades:
9-12

Subjects:
Science, Health, Biology, Physics

Time Needed:
Two 50-minute class periods

Materials:
clipboards (optional)

BACKGROUND:

What people commonly call “garbage” is actually solid waste that must be disposed of properly to assure the safety of the environment. Recycling and/or burning garbage to produce energy are ways we can make use of garbage.

America’s solid waste disposal problem continues to increase at an alarming rate. Approximately 222 million tons of municipal solid waste (MSW) was generated in the United States in 2000. This is more than 4.4 pounds per person each day or 1,300 pounds per person per year.

In the last 10 years, 12,000 landfills (or two-thirds) have been closed because they are full or environmentally unsafe. Most of these closed because they could not meet new regulatory standards designed to provide better environmental protection. Thirty landfills have closed in Alabama during this time. Only 1,000 new landfills have opened.

In the next six years, 40 percent of existing landfills will be filled. Eastern states with high density populations are suffering the most. While the average disposal fee in the United States is $27 per ton, for some large metropolitan areas it exceeds $100. Many of Canada’s cities face similar problems.

MUNICIPAL SOLID WASTE COMPONENTS

Material	% By Weight
Paper and paperboard	37.4
Rubber, Leather and Textiles	6.7
Glass	12
Metals	11.2
Plastics	10.7
Wood	5.5
Food wastes	11.2
Yard wastes	12
Other	3.2

The attached pie charts clarify the rate of solid waste materials generated in the U.S. by volume, weight, and management done.

VOCABULARY:
pollution, solid wastes, disposal, landfills, recycle, sanitary landfills, open dumping, controlled incineration

PROCEDURE:
1. Ask students to survey adult students, and faculty using the "Solid Waste Fact or Opinion" survey.
2. Obtain responses from the survey questions and keep a record. Compare the responses with the answer key.

EVALUATION:
1. Have the students analyze the survey responses with the answer key and discuss whether the answers surprise them.
2. Contact local recycling services in the county and make a joint effort to have an advertisement on radio, TV, newspaper, or other media sources to educate people about " recycle, reduce, reuse, and <u>rethink</u> solid waste management."
3. Apply solid waste ideas locally and globally. Discuss.
4. Review "Solid Waste Fact or Opinion" responses with students. See Answer Key for answers and explanations.

ORIGINAL DEVELOPMENT RESOURCES:
Rathje, W. and Murphy, C. (1992, July). *Smithsonian Magazine*. "Five major myths about garbage, and why they're wrong."

www.epa.gov

SOLID WASTE
Fact Or Opinion

Read the following sentences. Place a check mark in the correct column indicating whether it is a fact or an opinion. Discuss the statements with your classmates; then check the answers.

Statements	Fact	Opinion
1. In one year, each person throws away 1900 pounds of trash.	☐	☐
2. All recycled paper towels are made from 100 percent recycled paper.	☐	☐
3. Leftover food (like green beans you didn't eat last night) makes up the bulk of most landfills.	☐	☐
4. All glass products can be recycled.	☐	☐
5. The comics you read last Sunday could have been last year's sport news.	☐	☐
6. Making a surfboard out of recycled peanut butter jars is a "nutty" idea.	☐	☐
7. Only a few brands of bathroom tissue are 100 percent recycled paper.	☐	☐
8. The aluminum soda can could have been a pie plate 20 years ago.	☐	☐
9. Plastic packaging makes up only a small portion of America's trash.	☐	☐
10. Some of the best recyclers are worms.	☐	☐
11. With the energy saved from recycling one soft drink can, you could power a TV for three hours.	☐	☐
12. No one knows how to recycle tires, colored paper, video cassettes cases, or corrugated cardboard.	☐	☐
13. Fast-food packaging, polystyrene foam, and disposable diapers are major constituents of American garbage.	☐	☐
14. America is running out of safe places to put landfills.	☐	☐

Fact Or Opinion (Answer Key)

1. *In one year, each person throws away 1,900 pounds of trash.*
   Fact: The average person living in an industrialized nation may produce as much as 1,900 pounds of domestic waste in one year.
2. *All recycled paper towels are made from 100 percent recycled paper.*
   Opinion: Brawny® paper towels was the first brand of 100 percent recycled paper towels. In addition, Georgia Pacific–the makers of Brawny® paper towels–produces more than 700,000 tons of paper with recycled content each year.
3. *Leftover food (like the green beans you didn't eat last night) makes up the bulk of most landfills.*
   Opinion: Paper makes up the bulk of most landfills at 35 to 45 percent by weight.
4. *All glass products can be recycled.*
   Opinion: Although bottles, jars, and many other forms of glass are recyclable, a few products, such as television screens, are not.
5. *The comics that you read last Sunday could have been last year's sport news.*
   Fact: Newspapers are recyclable. The U.S. paper industry is committed to recovering and recycling. Almost 69 percent of all old newspapers in the U.S. were recovered and recycled in 1998.
6. *Making a surfboard out of recycled peanut butter jars is a "nutty" idea.*
   Opinion: Plastic products are 100 percent recyclable if there is an infrastructure to collect, sort, and reuse the materials.
7. *Only a few brands of bathroom tissue, like Quilted Northern ®, are 100 percent recycled paper.*
   Fact: Georgia Pacific produces a number of products, such as bathroom tissue and paper towels, that are made with a range of 40 percent to 100 percent recycled paper.
8. *The aluminum soda can you drink out of today could have been a pie plate 20 years ago.*
   Fact: The number of times that aluminum can be melted down and reused is limitless.
9. *Plastic packaging makes up only a small portion of America's trash.*
   Opinion: About one-third of all plastics by weight in our landfills is from packaging. Students can help reduce this amount by buying foods and other products not packaged in plastic.
10. So*me of the best recyclers are worms.*
    Fact: Every year each of us tosses out about 1200 pounds of organic garbage. Worms placed in a compost heap can eat the organic matter and "recycle" it into fertile soil.
11. *With the energy saved from recycling one soft-drink can, you could power a TV for three hours.*
    Fact: Recycling aluminum is cheaper, and it consumes less energy than making products from new materials.
12. *No one knows how to recycle tires, colored paper, videocassette cases, or corrugated cardboard.*
    Opinion: All of these products can be recycled. Tires, for example, can be burned to make steam, electricity, or industrial process heat. They also can be ground up and used in asphalt for roads. Corrugated cardboard is recycled into more corrugated cardboard that is used in making big boxes, like the one your computer may have come in.
13. *Fast food packaging, polystyrene foam, and disposable diapers are major constituents of American garbage.*
    Opinion: Contrary to popular perceptions, fast-food packages make up far less that 1 percent of most landfills. The same is true for polystyrene foam and disposable diapers. When combined, they actually take up only about 3 percent of landfill space.
14. *America is running out of safe places to put landfills.*
    Fact: For the time being: yes. Scientists, however, are looking for better ways to reduce waste.

Figure 1. Materials Generated in MSW by Weight, 2000 (Total Weight - 232 Million Tons)

Source: EPA

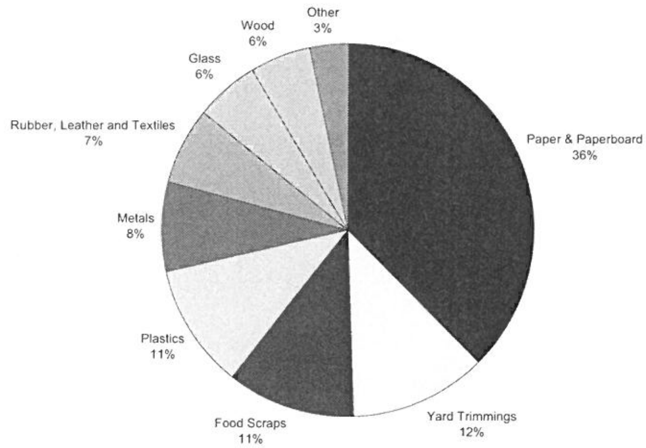
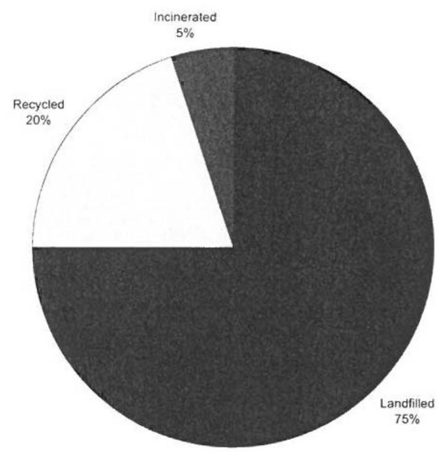


Figure 2. Management of MSW in Alabama, 1997

Source: EPA



Notes

OBJECTIVES:

Students will be able to:
1. Discuss both beneficial and negative aspects of nuclear power.
2. Observe different aspects of nuclear energy.

Grades:
9-12

Subject:
Physics, Physical Science, Chemistry

Time Needed:
Three to five class periods

Materials:
some of the following materials:
- dominoes
- ping pong or Styrofoam balls
- mousetraps
- playing cards (need 2 decks with different designs on the backs)
- sugar cubes
- flashlight

BACKGROUND:

The energy that lies within the nucleus of the atom is tremendous (one pound of nuclear fuel can produce about three million times as much energy as can be obtained from one pound of coal). There are two nuclear power plants in Alabama: the Farley Nuclear Power Plant in Dothan near the Chattahoochee River and the Browns Ferry Nuclear Power Plant in Athens near the Tennessee River. These nuclear power plants are expensive and require highly skilled operators who conform to rigid safety procedures because of the toxic nature of the nuclear fuel and associated materials. Fossil fuel resources are finite, and both fossil fuel energy generation and nuclear energy generation impact the environment.

Nuclear energy has a number of benefits for the environment. The operation of a nuclear power plant does not produce the carbon dioxide emissions that are a growing concern due to changes in the climate. Nuclear plants also do not emit pollutants that contribute to acid rain. On the negative side, nuclear power plants use a tremendous amount of water for cooling, and they generate extremely dangerous wastes for which there is still no permanent management system. In addition, they raise the water temperature downstream. The extremely long half-lives of many of the radioactive substances generated by nuclear power reactors require containment of wastes for lengths of time approaching tens of thousands of years.

In order for fission to take place and to be sustained in a controlled chain reaction, a large number of nuclear collisions must take place in a small area. The concept of how energy, and thus the number of nuclear reactions, decreases with increasing distance from the source (the inverse square law) is illustrated using a flashlight beam at different distances. A chain reaction, or a reaction that, in turn, results in a series of even larger reactions, is illustrated using dominoes or playing cards. Finally, the concept of half-life, a very important aspect of nuclear waste management, is illustrated using playing cards.

VOCABULARY:

chain reaction, deuterium, fusion, fission, inverse square law, half-life, fossil fuels, nuclear energy

PROCEDURE:

1. Demonstrate the inverse square law by intercepting at right angles the ray from a flashlight at two or three points with a piece of cardboard. Calculate and compare the areas illuminated. Show that the brightness of the illumination on the cardboard gets dimmer the farther the cardboard is from the light source: the illuminated area gets larger as the distance increases, but the illumination (lumens per square foot) decreases.
2. Demonstrate the chain reaction by one of the following techniques: (a) set up dominoes so that one, when tipped over, knocks down two others and so on; (b) longitudinally bend an old deck of cards and stand

these individually so that one, when tipped over, knocks down two others and so on; (c) set up an array of triggered mouse traps that are “baited” with a Styrofoam or ping pong ball. Throw a single ball into the array, thus setting off a “chain reaction.”

3. Demonstrate half-life by one of the following techniques: (a) Flip a deck of cards into the air and replace each one that falls face down with one card with a different decorated back. Keep a log showing “Trial #” and the number of cards replaced. Continue until all the cards with the original decorated back are replaced. Assume the half-life to correspond to the Trial # when half the cards were replaced. (b) Put a black dot on one face of 100 sugar cubes. Throw these as if they were dice and replace all the cubes falling dot-side up with unmarked cubes. Keep a log showing “Trial #” and number of cubes replaced. Continue until all the dotted cubes are replaced. Assume the half-life to correspond to the Trial # when half of the cubes were replaced. Graph this data.
4. Fusion is the fusing together of light nuclei to form a heavier nucleus. The mass of the resultant nucleus is less than the sum of the masses of the original nuclei because some mass is converted to energy in the reaction. It has been suggested that, from the amount of deuterium in a gallon of ordinary water, one might obtain the energy available in 300 gallons of gasoline! Have the students consider the energy resources represented by the deuterium in the oceans. (Optional: If time permits, discuss how deuterium comes from fusion. Explain to the students how the nuclear reactor replaces the boiler in conventional electricity generation.)
5. Ask students to identify peaceful uses of nuclear energy (power generation, quality control, medicine) and discuss them in class.
6. Have students compare fusion energy versus fission energy.
7. Write some of the entries from the following table on the board and discuss with the students.

Use of Energy Resources In Selected Countries

Country	Energy Sources as Percent of Total Use				
	Coal	Oil	Natural Gas	Nuclear	Hydro
Australia	43	40	12	0	6
Austria	19	42	13	0	27
Belgium	25	47	19	7	1
Canada	12	37	21	4	27
Denmark	31	66	0	0	0
Finland	25	45	2	14	13
France	17	50	11	13	9
Germany	33	44	16	5	2
Greece	25	69	0	0	6
Iceland	2	44	0	0	54
Ireland	23	60	13	0	3
Italy	10	65	16	2	7
Japan	19	63	6	6	6
Luxemburg	46	32	10	0	5
Netherlands	7	43	48	1	0
New Zealand	17	37	8	0	41
Norway	6	36	3	0	57
Portugal	4	82	0	0	12
Spain	27	60	3	3	7
Sweden	11	44	0	18	28
Switzerland	3	48	4	14	34
Turkey	46	45	0	0	9
United Kingdom	35	38	21	5	1
United States	23	41	27	4	4

EVALUATION:

1. Students' charts/graphs will be evaluated for accuracy, content, and creativity.

EXTENSIONS:

1. Have a student read an account of the first chain reaction, which occurred beneath the stands of the University of Chicago football field. (See books about the Manhattan Project or the atomic bomb.)
2. Gather information on different kinds of reactors.
3. Gather information about nuclear accidents that have occurred (Three Mile Island, Chernobyl) and identify any loss of life.
4. Obtain a free copy of *Nuclear Experiments You Can Do...from Edison* . (See Resources.) Also obtain the *Alabama Power Classroom Teachers' Service* publication (Catalog #AA45L). (See Resources.) Perform as many of these as you choose. A list of the eight experiments provided is as follows:
   - An Oil-Drop Model of a Splitting Atom
   - A Domino Model of a Chain Reaction
   - Observing Radioactivity with an Electroscope
   - Observing Radioactivity by Radiography
   - Observing Radioactivity with a Cloud Chamber
   - A Model Nuclear Power Plant Steam Turbine
   - Demonstrate How Radioactivity Can Be Shielded
   - Build a Geiger Counter–A Class Project

   Note: Information is given in this book about where you can obtain low level radiation sources for classroom experiments.
5. Have brief presentations in class (20 minutes each) by a local utility representative and someone from an anti-nuclear power group.

ORIGINAL DEVELOPMENT RESOURCES:

Faughn. J. S. and Kuhn, K. F. (1976). *Physics for people who think they don't like physics.* Philadelphia, PA: W. B. Saunders Co.

K.F. Kuhn. (1996) *Basic physics*. John Wiley & Sons. ISBN: 0471134473.

Cunningham, J. & Herr, N. (19940. *Hands-on physics activities with real-life applications: easy-to-use labs and demonstrations for grades 8-12*. Jossey-Bass: ISBN: 087628845X.

Power for life: educational resources for teachers. Alabama Power Company., Educational Services, P. O. Box 2641, Birmingham, AL 35282-9984. (available on-line: www.southernco.com/alpower)

Free and inexpensive science materials available from Tennessee Department of Economics and Community Development. www.state.tn.us/ecd/energy.

ADECA - Science Technology & Energy Division, 401 Adams Avenue, P.O. Box 5690, Montgomery, AL 36103-3690, 1-800-392-8098, www.adeca.state.al.us

Notes

Oil Spills

OBJECTIVE:

Students will be able to:

1. Investigate the effect and effectiveness of techniques (sinking, absorption, and disposal) used to get rid of oil floating on seawater.

BACKGROUND:

Every year millions of gallons of oil are released into the environment, either accidentally or intentionally. This oil comes from tanker accidents, blowouts or spills at offshore drilling rigs, and runoff and dumping of waste oil from cities and industries.

The type and amount of damage from an oil spill depends on a number of factors such as type of oil, weather conditions, kinds of organisms in the area, accessibility of the location to clean-up crews, and the season.

The effects of an oil spill are many and varied. The most obvious effect is the waste of an increasingly rare and valuable resource, the oil itself. Even though attempts are made to recover the spilled oil, much is lost; and much of what is recovered is not usable because of contamination from the clean-up process or the environment.

Crude (unrefined) oil is actually a mixture of hundreds of different substances. Some are very toxic; some are relatively innocuous. Some evaporate into the air, some dissolve in water, some float, and some sink. Some are very sticky and tend to coat whatever they contact.

Some of the components of crude oil, such as benzene and toluene, are extremely toxic (poisonous). Sticky oil coatings smother many organisms. Oil destroys the insulation and buoyancy of marine birds and animals, so that many drown or die of exposure to cold water and air. Fish gills are clogged. Animals that ingest the oil or eat other organisms contaminated by the oil may be poisoned or may have their digestive systems clogged.

Oil companies, governmental agencies, and people who are concerned about the environment have tried a number of ways to clean up spilled oil. It is always a difficult, expensive effort. Even as recently as the 1989 Exxon *Valdez* spill, many of the methods used were still in the experimental stage; and some of the experiments didn't work well. Sometimes people's efforts to clean up after a spill may do more damage than good.

Two approaches remain paramount in any response to marine oil spills: the enhancement of natural dispersion of the oil by using dispersant chemicals and mechanical recovery using booms and skimmers. Attempts to deal with oil at sea are seldom very successful, and it is almost inevitable in a major spill that oil will threaten

Grades:
9-12

Subjects:
Physical Science, Biology

Time Needed:
45 minutes to conduct the initial experiment; 24 hours for experiment to be left; 10 minutes to observe the beakers after 24 hours

Materials:
tap water
table salt
scale
empty 1-liter bottle with cap
beaker containing heavy-grade motor oil (gear oil 80W)
four 250-mL beakers
two 10-mL measuring cylinders
teaspoons
small dish of sawdust
small dish of 10 g Styrofoam granules (made by breaking up a Styrofoam cup)
small dish of plaster of Paris
detergent (dishwashing liquid)
stopwatch
waterproof felt-tip marker

sensitive coastal resources. Protective strategies seldom are employed to the fullest extent possible, and it usually necessary to mount a shoreline response operation. Priorities for protection and clean-up need to be agreed on and care must be taken to ensure that the techniques selected do not do more damage than the oil alone.

Despite continuing research, there has been little change in the fundamental technology for dealing with oil spills. New techniques are constantly being sought and old techniques are being reassessed. Two techniques currently receiving fresh attention are in-situ burning and the enhancement of the natural biodegradation of oil through the application of micro-organisms and/or nutrients.

VOCABULARY:

blowouts, runoff, supertanker, crude oil, benzene, toluene

PROCEDURE:

SAFETY PRECAUTIONS: Oil is flammable! BE CAREFUL! Be sure to extinguish all flames before carrying out this experiment.

1. Make artificial seawater by weighing out 5 g of table salt and adding it to the 1-liter bottle. Half fill the bottle with warm water from the faucet, put on the cap, and shake the bottle until the salt has dissolved. Fill the bottle to the top with water to produce “seawater” of the correct concentration.
2. Label four beakers “A,” “B,” “C,” and “D.” Half fill each of the beakers with the seawater.
3. Measure out 5 mL of oil in the measuring cylinder and pour into beaker A. Repeat this step with beakers B, C, and D.
4. Look at the four beakers and record in the Data Table what you see in each one.
5. Sprinkle one heaping teaspoonful of sawdust into beaker A.
6. Sprinkle one heaping teaspoonful of Styrofoam granules into beaker B.
7. Sprinkle one heaping teaspoonful of plaster of Paris into beaker C.
8. Measure out 10 mL of detergent in a measuring cylinder and pour into beaker D.
9. After 5 minutes, look at the four beakers and record in the Data Table what you see in each one.
10. Leave the beakers for 24 hours. After 24 hours, look at the four beakers and record in the Data Table what you see in each one.

DATA TABLE

Appearance of oily water

	Start/Before Additions	**After 5 Minutes**	**After 24 Hours**
A			
B			
C			
D			

EVALUATION:

1. Have students write a report comparing what happened to the oil in each beaker after 5 minutes and after 24 hours.
2. Have students answer the following questions:
   - Which treatment was most effective in making the oil sink?
   - Which treatment was most effective in soaking up the oil on the surface?
   - Did any treatments have no effect on the oil?
   - Which treatment do you think would be most effective at dispersing an oil slick at sea?
   - Would it be practical to use this method in the ocean? If not, why not?
3. Discuss the proper disposal of the oil after the experiment. How could the oil affect the environment if improperly disposed?

EXTENSION:

1. Experiment with other varieties of oil (cooking, crude, baby) and compare the effects. Add food coloring to clear oils to facilitate observation of effects.

ORIGINAL DEVELOPMENT RESOURCES:

Roe, M. L. (1993). *Environment science activities kit* . West Nijack, New York: The Center for Applied Research in Education.

http://www.itopf.com/clean-up.html

Beamish, T.D. (2002) *Silent spill: the organization of an industrial crisis*. MIT Press: ISBN: 0262025124.

Brabbia. C.A. (ed) (2001) *Oil spill modeling and process*. WIT Press: ISBN: 1853126721.

Keeble, J. & Fobes, N. (1999) Out of the channel: the exxon valdez oil spill in prince william sound. University of Washington Press: ISBN: 0910055534.

Notes

Packaging Alternatives (Waste Reduction)

OBJECTIVES:

Students will be able to:

1. Discuss product packaging and advertising.
2. Create a package design and advertising campaign.
3. Look at environmental choices in packaging.

Grades:
9-12

Subjects:
Environmental Science, Economics, Art

Time Needed:
One class period to introduce assignment, then time to complete the project at home or school

Materials:
scissors
glue
tape
construction paper
markers
rulers
poster board
foil
plastic wrap
cardboard

BACKGROUND:

Each person in the United States generates about 660 pounds of packaging per year just through regular buying, and using, habits. In Alabama this packaging waste accounts for a significant portion of the waste going into Alabama's landfills and incinerators. The Alabama Solid Waste Management Act of 1989 set a goal that the volume of solid waste would be reduced by 25 percent by 1999. As an on-going process, Alabamians should take a look at the products they buy and the packaging wastes they throw away.

To reduce the negative environmental impacts associated with the disposal of packaging waste, consumers need to be aware of their packaging choices. For example, 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.**

Recyclable packaging materials include most forms of paper, wood, steel, aluminum, glass, and some forms of plastic like PET (polyethylene tetraphthalate) soft drink bottles and HDPE (high-density polyethylene) milk, water, juice, and detergent containers. Other forms of packaging, like wax-coated paper containers, are often nonrecyclable and should be avoided if possible. In addition to purchasing recyclable packaging, consumers also can help to reduce the negative environmental impacts of packaging wastes by purchasing degradable packaging. Degradable packaging materials include paper and wood. (***Note:*** *The issue of degradability is controversial. Consider giving an assignment to review recent literature on the topic to share with the class.)*

In looking at packaging that is degradable, it is important to remember that these items do not degrade in a landfill and would need to be handled in a system such as a compost pile. In regarding a material as degradable, students must evaluate how, and where, this process will take place.

Buying items that can be degraded in a compost pile is only effective if there is a compost pile available and if the action is taken to get the item there. As it is with recycling, an item is only considered degradable if there is a system available to process it. A recyclable or degradable item that ends up in a landfill or incinerator has not achieved its purpose. Perhaps the most effective method of reducing the quantity of waste entering the waste stream is reusing. For example, a plastic margarine tub can be cleaned and reused many times to store leftovers. Reuse means rethinking shopping habits.

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: 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 exploited to the point that these have become prime purposes of packaging. As a result, much of today's packaging is not fundamentally essential.

Packaging waste is placing a heavy burden on our nation's waste disposal systems. A large portion of used packaging also is discarded as litter on roadsides and beaches and 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 waste disposal systems and could reduce the litter problem. At the same time, a reduction in the amount of unnecessary packaging used would conserve energy and resources. Through the purchasing of products with minimal packaging and products packaged in reusable, recyclable, and/or degradable/compostable materials, we all can help to reduce the impacts 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.

VOCABULARY:

recyclable, nonrecyclable, reusable, degradable, compost

PROCEDURE:

Setting the Stage

1. Begin this activity by telling students to imagine that they have just gotten a job as an advertising agent for a company that sells _________________ (*the product you select.)*
2. Explain that each group's assignment is to develop an advertisement campaign and packaging design to sell their product. These campaigns should consider effective packaging to sell the product balanced by environmental concerns.
3. Instruct students to keep a record of reasons they choose particular package designs and sales pitches. Explain that the ad campaign can consist of skits, poems, jingles, posters, or any other technique that could "sell" their product.
4. 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.

Activity

1. Divide the class into groups. Select a product for students to use in creating a package and sales campaign. The product should be the same for each team such as a baseball bat, personal care item, 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. If students are to complete projects at home, a list of possible materials will need to be provided.
2. In a class discussion, ask students to describe what advertisers do (create marketing plans and communications to help sell things*)* and ask them to identify the different means of communications advertisers use to sell products (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 (new and improved features, endorsements from famous people, status, convenience, "keeping up with the Joneses," sex-appeal, better for the environment, cheaper).
3. Have each group create a package and ad campaign for the product they have been assigned.
4. After groups have completed their projects, have each group present its ad campaign and package design to the rest of the class in a 10-minute presentation.

Follow-Up

1. Assign each product package a number, and display all package designs. Have students anonymously vote for the best package design and turn in their votes. Tally the scores and identify the first, second, and third place packages.
2. Conduct a whole class discussion addressing the following questions:
   • What made the winning package more appealing than the others?
   • How much packaging 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?
   • Who should pay for the disposal of packaging that isn't recyclable or reusable?
   • 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?
   • If the manufacturer is primarily interested in selling the product, is it more important to package the item to sell than to package it to have low environmental impact?
3. Ask students to identify packaging choices they can make to reduce environmental impacts. Show the "Picking Packages" transparency and rate the different types of packaging according to the disposal and recycling options in your area.

EVALUATION:

1. The projects should be evaluated on creativity, content, and presentation.

EXTENSIONS:

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?
2. Have students write letters to companies inquiring about packaging and requesting improvements.
3. Invite a public relations firm representative into the classroom to discuss his/her company's mission and goals.

ORIGINAL DEVELOPMENT RESOURCES:

American Plastics Council: www.plasticsresource.com

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. Place an “X” in the rating column for packaging that can be reused, recycled, or composted; a zero(0) for packaging that must be incinerated or landfilled; and a minus (-) for packaging that 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.

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, heavy duty plastic plates from microwave dinners, sturdy glass jars, plastic tubs	☐
Uncoated paper	Bags of candy, cookies, chips	☐
Uncoated cardboard	Cereal boxes, detergent boxes	☐
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	☐
Coated paper	Paper milk and juice cartons	☐
PVC (polyvinylchloride)	Some plastic bottles and plastic wraps	☐
HDPE (high density polyethylene) and PET (polyethylene terephthalate)	Plastic milk jugs, juice and soda bottles, shampoo bottles	☐
Aerosol cans	Toiletries, deodorants, hairsprays, pesticides	☐

Rural Water

OBJECTIVES:

Students will be able to:
1. Differentiate between black water and gray water waste.
2 Explain how a septic tank drainage field system is constructed and functions.
3. List ways of abusing a septic tank system.
4. Describe symptoms of a failing septic system.

Grades:

9-12

Subjects:

Biology, Chemistry

Time Needed:

Two class periods

Materials:

2 sets of the following:
- funnel
- rubber tubing
- glass bend
- pneumatic trough
- 3 "T" connectors
- 250-mL side-arm flask
- 1-hole stopper
- wire gauze

coarse gravel
fine gravel
soil
water test kit (available through a biological supply catalog)
manure
detergent

BACKGROUND:

Many rural areas are not served by centralized wastewater systems, and household wastewater must be disposed of on site. The septic tank, along with a soil absorption system, is the most common and effective method of wastewater treatment used in rural settings. Cesspools, which are no longer approved for new installations in most areas, and pit privies are the other most widely known methods.

Other alternatives include the following: aerobic (requiring oxygen) treatment tanks, off-lot systems where wastewater from several households is conveyed to a common disposal and treatment site (such as a soil absorption field), and evapotranspiration systems. Evapotranspiration is a process used for shallow soil depths. Grass or other plants are used to cover the field that receives the wastewater. The plants take up the water and selected minerals but leave the rest of the waste for organic decomposition. The water leaves the plants by normal transpiration processes.

Some of the more recent alternatives include biofilters, constructed wetlands, composting toilets, low-flush toilets, incinerating toilets, or recycling toilets and dual treatment systems that separate "black water" (human body wastes) from "gray water" (other domestic wastewater).

On-site disposal systems, such as septic tanks, discharge wastewater to the subsurface. A septic tank is simply a tank buried in the ground for the purpose of treating the sewage from an individual home or business. Wastewater flows into the tank where the design of the tank facilitates settling of the solids. Sewage bacteria then break down the organic matter, allowing partially treated water to flow out of the tank into the ground through a subsurface drainage system. The soils around the drainage field also are a part of the treatment system where additional bacterial action further breaks down the organic waste. Periodically, sludge or solid matter in the bottom of the tank must be removed and disposed of. Failing septic tanks and cesspools are frequent sources of groundwater contamination.

VOCABULARY:

sewage, sludge, evapotranspiration, black water, gray water, effluent

PROCEDURE:

1. Discuss with the students the following concepts and terminology:

Sources of household wastewater:
- “black water” - water containing human body wastes
- “gray water” - water containing other domestic wastes

Disposing of wastewater:
- “black water” - septic tank
- “gray water” - deposit in stone-lined, deep well; used to irrigate lawns and gardens

Septic tank system:
- construction - see the student sheet “septic tank model”
- drainage field - subsurface area for dispersing water flowing out of septic tank
- maintenance - sludge removal

Practices that abuse septic tank systems:
- using excessive amounts of water
- allowing strong chemicals to enter tank
- driving vehicles over the tank and drainage field

Symptoms of a failing system:
- damp or wet ground in drainage field
- oily film in drainage field area
- noticeable sewer odor
- wastewater backing up into the house

2. Have students make working septic tank models. (See the student sheet “septic tank model” for suggestions.)
3. Run “wastewater” into the septic tank (flask) until it rises to the outlet. Do not allow wastewater to flow into the “drainage field” at this time. Allow at least 24 hours (or a weekend) at room temperature. One group runs “black water” through the system, and one runs “gray water” through the system.

Note: **Prepare** “black water” by adding to containers of tap water such materials as barnyard/ animal manure or animal manure purchased from a garden shop. Prepare “gray water” by adding to containers of tap water such materials as raw peanut hulls, ashes from burned peanuts, crushed peanuts, detergent, or grease.

4. Add an equal amount of the same type of “wastewater” to the septic tank (flask) and catch any effluent coming from the drain tubing. (A pinch clamp should be used on the tubing.)
5. Test final effluent for pH, odor, mineral content, hardness, color, and turbidity.
6. Have students compare effluents of the wastewater types.

EVALUATION:
1. Define “black water” and “gray water.”
2. Explain how a septic tank is constructed.
3. Explain how to install a drainage field system.
4. List ways of abusing a septic tank system.
5. Describe several symptoms that indicate the septic tank system is failing.

EXTENSIONS:
1. Conduct research, and construct diagrams and specifications of systems for wastewater treatment making use of an aerobic treatment tank and evapotranspiration. After doing so, have students discuss such questions as the following:
   - What factors limit the volume of wastewater that can be processed?
   - Is each system equally effective in swampy and hilly terrain?
   - How does each system treat wastewater to avoid offensive odors?
   - Which system would work best in rural areas?
   - What type of system is used by the school?
   - Where are the system and drainage field for the school located if the school is on a septic tank system?

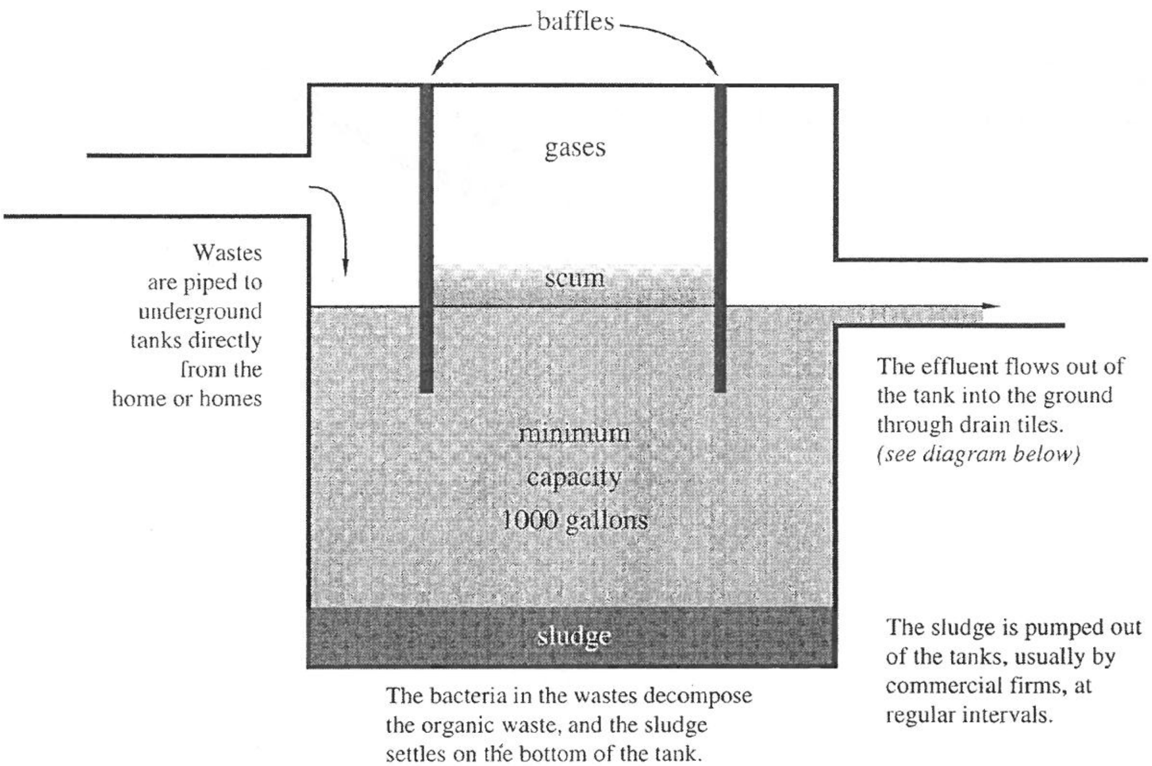
2. Have the students do a "perk" test on the soil in the area of a drainage field. (See your local health department for instructions to perform this activity.)
3. Have rural students check the site of effluent discharge from the systems at their homes in relation to the drinking water source. Is it adequate? What are the regulations for location of waste treatment systems?
4. Have students explore problems created by concentrated housing (mobile home/trailer parks) when only a septic tank system is used.

ORIGINAL DEVELOPMENT RESOURCES:

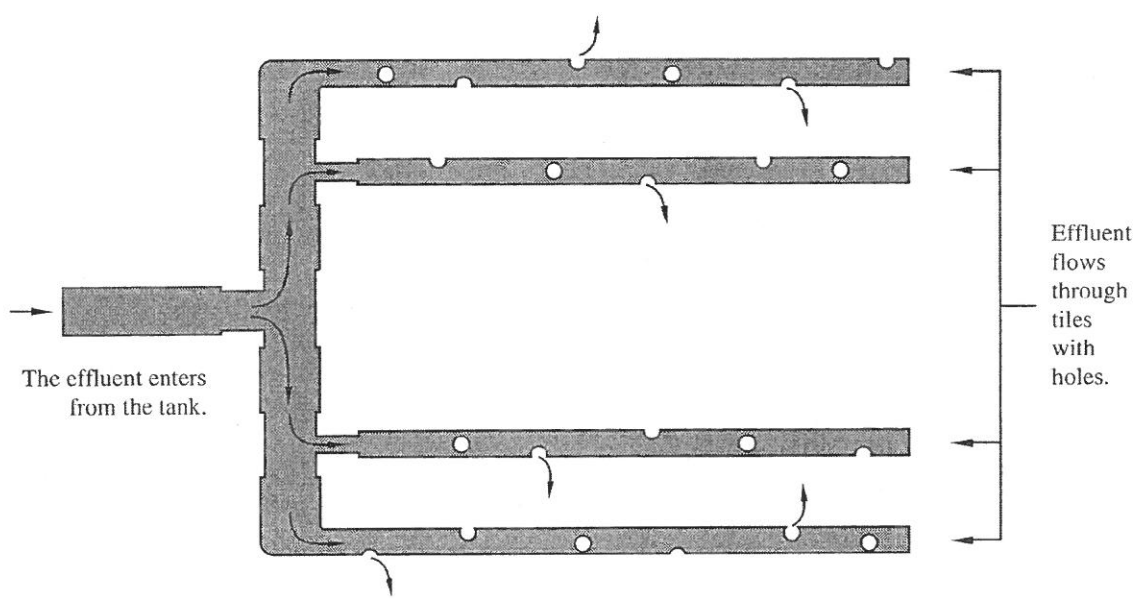
Alabama Department of Public Health: www.adph.org

Septic Tanks

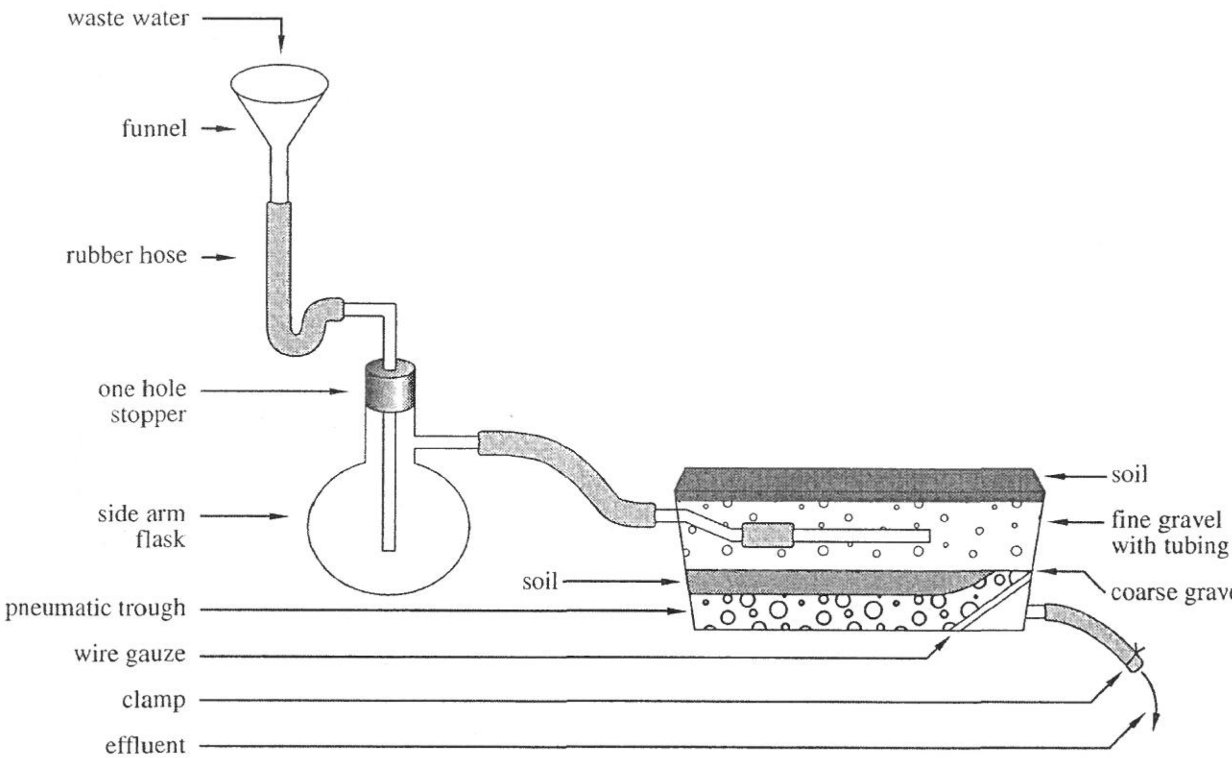
Septic tanks are used for domestic wastes when a sewer line is not available to carry them to a treatment plant.



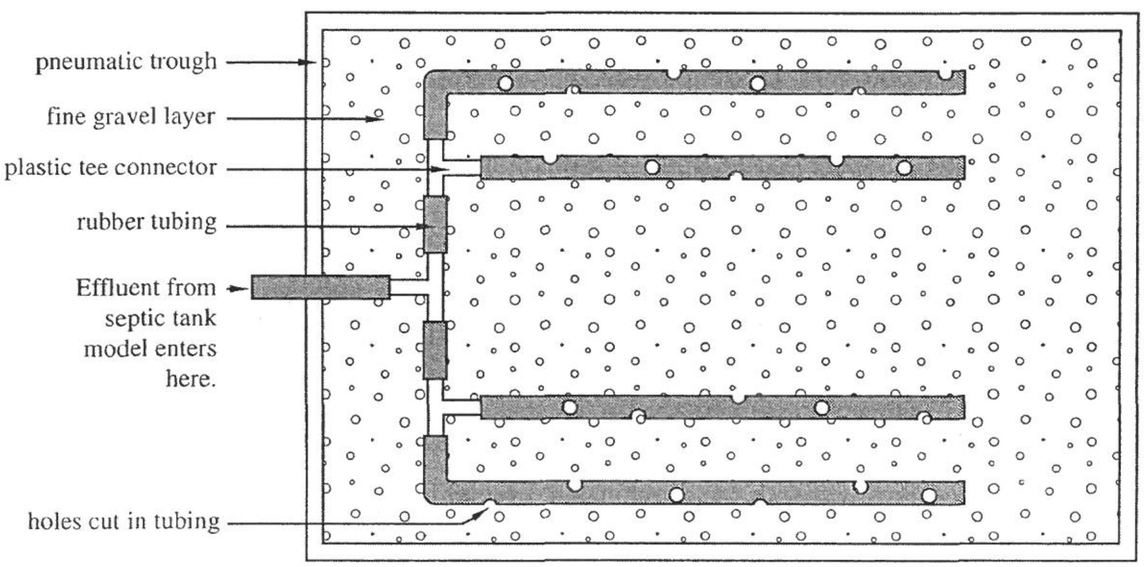
Aerial View of Drain Tiles



Septic Tank Model



Aerial View of Drain Tubing in Fine Gravel Layer



Notes

Spill It - NOT!

OBJECTIVES:

Students will be able to:
1. Notice hazardous materials that are being shipped through their community.
2. Investigate the consequences of a spill in their watershed.

Grades:
9-12

Subjects:
Ecology, Chemistry

Time Needed:
Several days or weeks for field observation
One class period for lab

Materials:
DOT Chart
Hazardous Materials Marking, Labeling and Placarding Guide

BACKGROUND:

Hazardous materials are regulated by the U. S. Department of Transportation (DOT) when they are shipped by truck, rail car, airplane, or ship. As you watch trucks on the highway, you can tell if they are carrying hazardous chemicals.

The diamond-shaped placard on the truck identifies the hazard class of the chemicals being transported. Most chemicals being shipped that are over 1000 pounds are regulated, and any quantity of the most dangerous chemicals must be identified.

If a truck has more than one placard, it is carrying multiple hazard classes of chemicals. The driver has the option of using the DANGEROUS placard for some multiple loads.

If the shipment is a bulk shipment, and is in a tank truck or tank rail car, the placard will have a four-digit number that identifies the chemical. The number is unique to one chemical or family of chemicals. Some numbers represent a small group of chemicals with similar chemical and physical properties. (See the Emergency Response Guidebook for a list of all numbers, the correspoinding chemicals, and the hazards.)

VOCABULARY:

placard

PROCEDURE:

1. Have students observe and record all the placard numbers they see from vehicles (or railcars) on the roads or railroads over a period of several days or weeks..
2. Give students the Emergency Response Guidebook to identify the contents of bulk carriers on the highways and/or railroads in their community.
3. In the classroom, students should look up the numbers in the guidebook and make a list.
4. Students should research the hazardous materials that are being transported and then predict the consequences of a spill.

EVALUATION:

1. Students should write a research report about the materials being shipped through their community. The teacher may wish to restrict the report to the most frequently observed or most dangerous chemicals.

EXTENSIONS:

1. Students could contact the local Emergency Management Agency (EMA) and report on the EMA’s planned response to any hazardous chemical spills from trucks or trains in their watershed.
2. The students should investigate what would happen to the air and water supply in case of chemical spills.

3. Ask local industries, environmental engineers, or safety and health directors to come to class to explain how hazardous shipments are handled.

ORIGINAL DEVELOPMENT RESOURCES:

Department of Transportation Chart 11, Hazardous Materials Marking, Labeling and Placarding Guide. (Free). To obtain, call 1-800-HMR49-22 OR e-mail www.dot.gov. May be obtained by writing: U>S. Dot/RSPA/HMS/OHMIT/DHM-50, 400 7th Street, S.W., Washington, DC 20590-0001.

Emergency Response Guidebook. available at www.hazmat.dot.gov/ohmforms

Are You Down In The Dumps?

OBJECTIVES:

Students will be able to:

1. Construct a demonstration landfill.
2. Discuss different types of household trash.
3. Describe ways to cut down on trash.
4. Describe and discuss decomposition.

Grades:
9-12

Subjects:
Science, Ecology, Social Studies

Time Needed:
Four weeks or longer

Materials:
small plastic containers (about 16 oz.) with lids (need 2 for each student group)
trowel
spoons
soil
newspaper
trash materials (see activity)
water
spray bottle

BACKGROUND:

In its most basic sense, a landfill is a place where garbage is hauled, deposited, and then buried. But if you look at a modern landfill in closer detail it is really much more complicated than that. A typical, modern landfill is divided into a series of sections called cells. When the solid waste is hauled to a landfill, it isn't just strewn haphazardly. Rather it is placed on what is called a working face, which is a portion of a landfill cell that is currently exposed and available for trash disposal. Only limited sites in the landfill are exposed at any given time to minimize exposure of the landfill's contents to elements like wind and rain. In fact, because a landfill is filled so systematically, often modern landfill operators can pinpoint where a specific truck's load of garbage was deposited even days, weeks, or months afterward.

At the conclusion of each day's activity in a cell, a layer of earth or ash is spread across the compacted waste in the cell to minimize odor, prevent windblown litter, and prevent insect and vermin problems. The daily cover also may consist of a layer of foam materials or sheets of synthetic materials. The landfill operator moves from working face to working face, and from cell to cell as the landfill gradually fills over periods of many years, even decades.

But as noted, a modern landfill is more than just a hole in the ground where we dump trash and forget it. Today's landfills include multiple safeguards to contain wastes and isolate them from surrounding water and soil. In many cases, for example, such safeguards involve a protective liner to prevent filtration. Liners may be made of compacted clay or impermeable materials such as plastic. When clay is used, the layer may be as much as ten feet thick. All this site preparation is done so that any liquid entering the landfill can be controlled and treated externally or retained inside the landfill, rather than being allowed to pass through the site and come out the other side.

Decomposition is the process by which material breaks down. Air, water, sunlight, and other agents break down inorganic materials. Living organisms break down organic molecules such as food waste, wood, and dead animals. Warm, moist, and well-aerated conditions are necessary for most decomposers. Certain organisms can biodegrade organic materials in the absence of oxygen (anaerobic), but the process is slow.

Materials in a landfill go through the process of decomposition but it is very slow. The procedures of burying, compacting, and covering slow down decomposition of both inorganic and organic materials. There have been many instances in which newspapers have been uncovered in a landfill after being buried for over 20 years, and they still can be read. Even some foods have not decomposed significantly in long periods of time. In this activity, students will set up a demonstration to see how long it takes different types of trash to decompose.

VOCABULARY:

biodegradable, compost, decomposition, landfill, decomposer

ADVANCE PREPARATION:

1. Introduce the terms biodegradable, compost, decomposition, landfill.
2. Have the students think about the trash their families throw out every day.
3. List the items students consider trash on the chalkboard or on an easel.
4. Divide the list of trash items into the following categories: paper products, food waste, glass, metal, plastic, yard waste, and others (items that do not fit any of the categories).
5. Have the students draw a trash can on poster board and fill up the trash can diagram with their families' "trash." Students may draw the trash or cut out pictures from magazines.
6. Display students' trash can drawings around the classroom.

PROCEDURE:

Setting the Stage

1. Read the background information about how trash is broken down. Also, explain how trash can lead to problems such as litter, overflowing landfills, toxic pollution, and wasted resources.
2. Discuss possible solutions to the problems caused by trash and have students come up with ways to make less trash.
3. Have students discuss the saying: Reduce, Reuse, Recycle.

Activity

1. Divide the classroom into small cooperative groups. Give each group two plastic containers with lids and have the students label both containers with their group number or name and label one container "A" and the other "B." The containers should also have a team name or number on them. Provide the students with, or have them bring in, enough of the following "trash" materials so that each group will have two samples each of: paper towel, aluminum foil, wax paper, plastic wrap, plastic package pieces, cracker, leaf, apple core, orange rind, banana peel.
2. Take the class outside to dig up soil for their containers. (Seek appropriate permission before digging.)
3. Choose a place that is likely to contain microorganisms such as under a tree or shrub. Make sure students take only what is necessary to fill their containers.
4. When students return to the classroom, have each team set up its containers as follows:
   • Fill each container about halfway with soil.
   • Place a piece of each "trash" item on top of the soil. Use items of the same type and size for each container.
   • Cover the items by filling up the containers with more soil.
   • Put a lid on container "A" and set the container aside. Spray the contents of container "B" with water until the soil is moist, not soggy. Leave container "B" open and place it next to container "A." At the end of each school day, spray the contents of container "B" with a little water and then put on the lid and shake the container to allow air and moisture to move among the soil particles. During the night, keep the lid on to reduce evaporation. During the day, leave the container open. Use the chart to describe what happens in each container. Then have each team make a prediction as to what will happen in each container.
5. At the end of the first week, have the teams empty the contents of each container onto a separate sheet of newspaper. Look for each of the trash items and separate them from the soil. Fill in a data chart for Week One by describing any decomposition that took place during the week in each of the items from each container. For those items that showed no signs of breaking down, write "no change" on the data sheet.

6. Put half of the soil from container “A” back into its container, put the container “A” items back inside, cover them with the remaining container “A” soil, and replace the lid. Repeat this process for container “B” but continue to keep the contents moist and to keep the lid removed during the day. At the end of a four-week period, have the teams analyze their data and discuss how accurate their predictions were. Have the teams compare data.
7. Have the students start a worm composting box outside.
8. Take the students outside and have them observe decomposition in a rotting log. Diagram and describe the decomposition.

Follow-Up

1. Have the students discuss landfills and the problems associated with them. If possible, take the students on a field trip to a landfill or bring in a guest speaker on the topic.
2. Tour the school cafeteria and analyze how much food is thrown away each day.

EXTENSIONS:

1. Have the students sponsor a community litter pick up.
2. Educate the community about the benefits of recycling.
3. Help set up a community composting program.
4. Start a campaign to have school officials and local businesses buy products made from recycled materials.
5. Investigate your community’s recycling program. What are the benefits/drawbacks?

ORIGINAL DEVELOPMENT RESOURCES:

Appelhof, M. (1982). *Worms eat my garbage*. Flower Press.

Javna, J. (1990). *50 simple things you can do to save the Earth*. Berkeley, CA: EarthWorks Press.

Keep American Beautiful http://www.kab.org

Worm composting system. Missouri Department of Natural Resources. www.dnr.state.mo.us

Goldstein. J. (1979) *Recycling*. New York: Schocken Books.

Notes

Plastic Numbers

Grades:
9-12

Subjects:
Biology, English, Chemistry
Environmental Ecology, Math

Time Needed:
60 minutes

Materials:
variety of plastic wastes

OBJECTIVES:

Students will be able to:
1. Explain the importance of plastics in our society.
2. Describe the plastics code system.
3. Demonstrate the ability to separate plastics for recycling.

BACKGROUND:

The word *plastic* is a collective term used to describe a wide assortment of products. Plastics are made from materials found in the natural environment— petroleum, natural gas, and coal. Organic compounds containing carbon, hydrogen, oxygen, and nitrogen are extracted from the materials and are combined to produce a wide variety of plastic products. Plastic is defined as an organic, synthetic, or processed polymer of high molecular weight that can be molded, cast, extruded, drawn, or laminated into objects, films, or filaments. Plastics can be found in all environments— home, work, play, health care, and industry. Plastics are used to protect, reduce weight, replace body parts, control temperature, and prevent corrosion. Because plastics are used in such a variety of places, they are a large percentage of our waste. There are at least 45 families of plastics. This could cause some confusion when trying to define the types of plastics which are recyclable. A Plastic Container Coding System has been established by the Plastics Council to aid in the recycling process.

VOCABULARY:

code, natural environment, organic, plastic, recycle, waste

ADVANCE PREPARATION:

1. Make a collection of a variety of plastic goods. Be sure all codes are covered. Students can help by bringing goods from home. Approximately 12 plastic pieces per group of 4 to 5 students are needed.
2. Have copies of the Plastic Container Code System and the Plastic Code Analysis.

PROCEDURE:

Setting the Stage
1. Introduce the topic of plastics by displaying a sample of plastics.
2. Ask for observations about types.
3. Compare and contrast plastic sample types.
4. Brainstorm uses of plastics in all settings.
5. Ask for student uses and users of recycled plastics, for example, socks and t-shirts made from plastic.

Activity
1. Group students and distribute copies of Plastic Numbers Activity including the Plastic Container Code System and the Plastic Code Analysis.
2. Discuss the objectives and background information.
3. Discuss the Plastic Container Code System; practice pronouncing plastic names.
4. Introduce the Plastic Code Analysis.
5. Students should begin identifying and recording on the analysis chart the different plastic types.
6. Using the Plastics Code Analysis workheet, students will complete a survey at the grocery store or their homes.

Follow-Up
1. After identifying the plastics, sort and group them. Observe and discuss characteristics of each group.
2. Students can write research reports about different types of polymers.

EXTENSION:
1. Students may complete the Plastics Code Analysis at home.

ORIGINAL DEVELOPMENT RESOURCES:

Waste: A hidden resource. (1988, December). TVA Environmental Educational Program.

American Plastics Council. www.plastics.org

California Department of Conservation: www.consrv.ca.gov (for plastic content code abbreviations).

Environmental Protection Agency. www.epa.gov

Plastic Code Analysis

Number Symbol	**Letter Code**	**Product**	**Observable Package Properties**
1 *2* *3* *4* *5* *6* *7*	*PETE* *HDPE* *V or PVC* *LDPE* *PP* *PS* *Other*	*In this colum, write the name of the product.*	*Flexible/Rigid* *Transparent/Opaque* *Translucent/Color* *White crease when crushed*

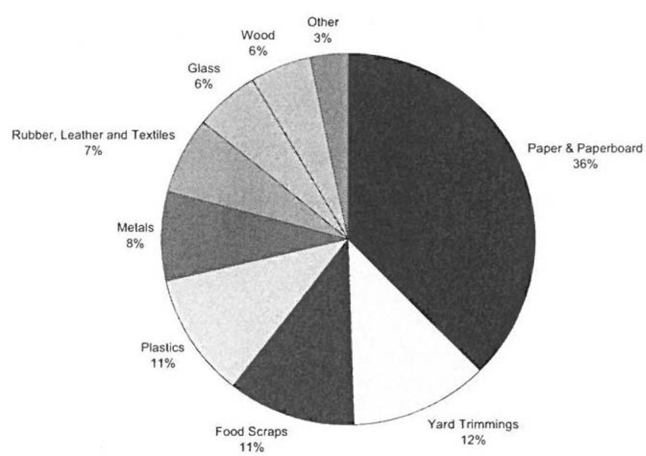
Plastic Container Code System

(found on the bottom of coded containers)

Code Abbreviation	PETE	HDPE	V	LDPE	PP	PS	Other
Full Name	Polyethylene Terephthalate	High Density Polyethylene	Vinyl	Low Density Polyethylene	Polypropylene	Polystyrene	Other resins or a mixture of resine types
Percentage of Total Bottles	48%	47%	1%	1%	1%	1%	1%
Can Be Transparent	Yes	No	Yes	No	Yes	Yes	Yes
Typical Containers	soft drink, instant coffee	milk, laundry degergent	liquid dish soap, peanut butter	grocery bags, coffee can lids	deli tubs, bottle caps, straws	foam cups, trays, egg cartons	catsup and syrup bottles

Materials Generated in MSW by Weight, 2000
(Total Weight - 232 Million Tons)

Source: EPA



Sewage Treatment Plant Model

OBJECTIVES:
Students will be able to:
1. Construct a model of a typical sewage treatment plant.
2. Explain the sewage treatment process.
3. Discuss the effects of sewage discharge on the aquatic environment.

BACKGROUND:
Waste from toilets, detergents from washing machines or dishwashers, food scraps from garbage disposals, and other organic substances are classified as sewage. Most areas have some form of sewage treatment; however, some areas use septic tanks or dump raw sewage directly into a local river or bay. This pollution often results in a foul smelling, unhealthy situation that kills aquatic life and makes the water unsuitable for recreation. Most environmental experts agree that all wastewater should undergo at least primary and secondary treatment before its release into a body of water. (See Figure 1.)

VOCABULARY:
disinfect, effluent, microorganism, primary treatment, raw sewage, scum, secondary treatment, sludge, tertiary treatment

ADVANCE PREPARATION:
1. Have students record the number of times that the toilets are flushed in their own homes , the garbage disposal is used, clothes are washed, and the dishwasher is run in a week's time.
2. Estimate the number of gallons discharged weekly.
3. Compile class results and discuss the impact on local waterways.
4. Arrange for a speaker from the local water treatment facility.

Grades:
9-12

Subjects:
Environmental Science, Biology, Geography, Math, Language Arts

Time Needed:
60 minutes for speaker, 2 weeks to complete project research and model, 2 hours for presentation and discussion

Materials:
plastic containers
aluminum cans
small boxes
straws
pipe cleaners
cardboard
plywood
sand
gravel
wire screens
PVC pipe

PROCEDURE:
Setting the Stage
1. Write the following categories on the chalkboard: the tap, a spring or well, a stream, a creek, a pond or lake, and a drainage ditch.
2. For each water source, record the number of students who respond "yes" to the question, "Would you consider drinking water from it?" If any student answers "no," ask for an explanation.

Activity
1. Divide the students into teams. Have them graph their advance prepared material.
2. Each team should research primary, secondary, and tertiary sewage treatment.
3. Each team should design and construct a functional sewage treatment plant model.
4. Each team should present its model and should defend the model to the class.

Follow-Up
1. Have the students list reasons that sewage treatment is important.
2. Have the students discuss how sewage can degrade a natural waterway, such as an estuary and bay area.

EXTENSIONS:
1. Tell students to imagine that raw sewage is being discharged from their school into a local waterway.
2. Using maps, have students trace the path that the sewage would take to the sea.
3. Have students estimate the time required for the sewage to reach the sea. (Add 25 percent for meanders and use an average flow speed of 3.2 km/hr or 2 mi/hr.)
4. Research alternative methods of sewage treatment such as using aquatic plants or constructed wetlands as is done in several Alabama towns including Fort Deposit, Luverne, enterprise, Satsuma, Robertsdale, Cintronelle, and Camp Hill. Arrange to wour one of those facilities if it is within a reasonable distance from the school.
5. Find out about septic tank regulations in the area. (See also the "rural Water" activity in this resource guide.)

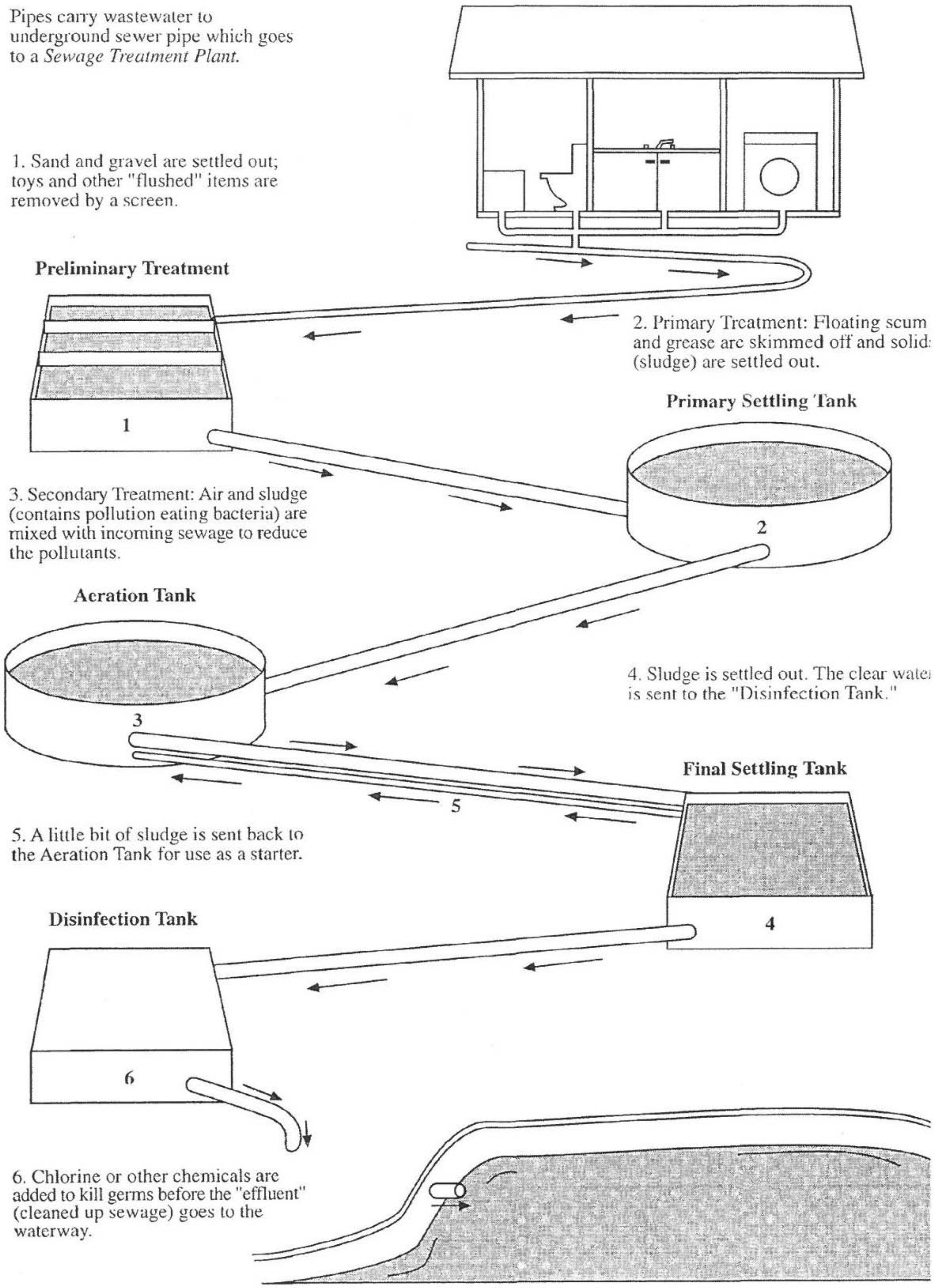
ORIGINAL DEVELOPMENT RESOURCES:
Arms, K. (1996). *Environmental science*. Austin, TX: Holt, Rinehart, and Winston.

Jacobson, C. (1983). *Water, water everywhere, but....* Loveland, CO: Hach Company.

University of South Alabama web site: www.southalabama.edu/usa/civileng/wetlands

Constructed wetlands for wastewater treatment and wildlife: www.epa.gov/owow/wetlands.

Figure 1 - Sewage Treatment



Notes