OZONE—THE GOOD (OZONE), THE BAD (OZONE), AND THE UGLY (SMOG)

AIR & WASTE MANAGEMENT ASSOCIATION

OBJECTIVES

Students will do the following:

1. Explain that ozone can be found in the troposphere and in the stratosphere
2. Explain how stratospheric ozone is protective
3. Describe ways in which tropospheric ozone can be harmful
4. Understand that chlorofluorocarbons (CFCs) can destroy stratospheric ozone
5. Describe efforts to reduce CFC use
6. Write their own definition of "smog"
7. List the effects of smog

TOPICS: The differences between good and bad ozone

TIME:
1 class period

SUBJECTS:
Science, language arts, art

MATERIALS:
5 styrofoam balls per student
5 toothpicks per student
Poster board
Crayons, markers, or paints
Large, narrow-mouthed jar
Matches
Playdough® (homemade or commercial) or modeling clay in different colors
OPTIONAL: See extension suggestions

BACKGROUND INFORMATION

The issue of ozone in the earth's atmosphere can be confusing. On the one hand, we know that high above the earth's surface is a layer of ozone that surrounds the planet and helps block out some of the sun's harmful radiation. We hear reports of "holes" developing in this ozone shield and of the harm that the increased ultraviolet radiation can cause on earth. On the other hand, we know that higher-than-normal concentrations of ozone in the ambient air (this ozone is referred to by scientists as "ground-level" ozone) can be harmful to people, animals, plants, and various materials. Indeed, ozone is one of the criteria pollutants, those harmful substances that are most widespread in the ambient air. The ozone gas in both places is the same—it's the chemical O_3—but in the upper atmosphere it greatly benefits all life, whereas near the earth's surface it can cause problems.

The stratospheric ozone layer

High in the stratosphere a layer of ozone gas forms an important and effective protective barrier against the harmful ultraviolet radiation from the sun. There has been increasing global concern that chemical pollutants are destroying this ozone layer. The main culprits seem to be in a class of chemical compounds called chlorofluorocarbons, or CFCs. First introduced in the late 1920s, these gases have been used as coolants for air conditioners and refrigerators, propellants for aerosol sprays, and agents for producing plastic foam.

Because CFC molecules are extremely stable, they tend not to react with other substances in the troposphere, so they can rise intact into the stratosphere. Here ultraviolet radiation breaks them up into their more-reactive components, including chlorine, the culprit in the destruction of ozone.

Increased ultraviolet radiation at the earth's surface can lead to a greater incidence of skin cancer, eye problems, and immune deficiencies in humans and to decreased crop yields and reduced populations of microscopic sea plants and animals that are vital to the food chain. Efforts to protect the ozone layer now involve many different nations and industries. At an international conference in London in 1990, 93 countries agreed to eliminate CFCs entirely by the year 2000. Researchers are busy finding less-harmful, and in many cases more-economical, substitutes for the CFCs.

Ozone pollution ("ground-level" ozone)

High concentrations of ozone in the ambient air can present many problems. Because ozone molecules are highly reactive, they combine with practically every material they contact, whether it be lung tissue, crops or other vegetation, rubber, plastic, paints, etc.

What we usually refer to as photochemical "smog" is mostly ground-level ozone. Smog (whose name derives from the words *smoke* and *fog*) can be of two types: "London-type" and photochemical. London-type smog is formed when moisture in the air condenses on particulate matter given off by the burning of coal. It contains a lot of sulfur dioxide, which causes breathing problems.

Photochemical smog is the type of smog that is mostly ozone. The recipe for the formation of ozone in the ambient air includes natural atmospheric gases, volatile organic compounds (VOCs), nitrogen oxides, and sunlight. Because sunlight is a key factor, ozone pollution is worse during the day and in the summertime. Vehicle exhausts provide most of the VOCs and nitrogen oxides that help form ozone, so times of increased vehicle use (such as morning and afternoon rush hours) also increase the possibility of ozone problems. (The problem is usually greatest at midday or mid-afternoon because of the effect of the sun.) Stationary sources (such as power plants) also emit the VOCs and nitrogen oxides that contribute to photochemical smog. Ozone can cause eye, nose, and throat irritation; can damage the lungs; and can exacerbate preexisting medical conditions such as asthma and emphysema.

Weather patterns are a factor in ozone pollution, either helping to disperse the problem, or transport it to a different location, or stall it and foster the buildup of ozone to extremely hazardous levels. These high levels, which usually occur when there is a temperature inversion, are called air pollution "episodes." In 1948, a heavy buildup of London-type smog in Donora, Pennsylvania, caused 20 deaths and 6,000 illnesses, and in 1952, nearly 4,000 people died from heavy smog (sulfur dioxide and particulate matter) in London, England.

What can be done?

Both ozone problems—stratospheric depletion and tropospheric buildup—are created in large part by air pollution. The only practical approach to stopping the destruction of the ozone layer and to minimizing ground-level ozone pollution is reducing the human-generated pollutants that contribute to these problems. Finding and using alternatives to CFCs is an essential part of protecting stratospheric ozone. As individuals we can immediately repair any leaks in refrigerators, have our car air conditioners checked periodically, use alternatives to home air conditioning, use alternatives to foam insulation and containers (or foam insulation that is formed without CFCs), purchase halon-free fire extinguishers, and encourage our elected officials to pass laws requiring CFC recycling.

Decreasing our use of fossil-fuel-burning vehicles is critical to reducing ozone levels in the air we breathe. We can use public transportation for long trips, walk or use bicycles for short trips, carpool to work and other activities, and combine several errands into one outing. These steps are especially important on the days that meteorologists predict the possibility of high reading of ground-level ozone.

PROCEDURE

I. SETTING THE STAGE

A. This activity relates to Objectives 1, 2, and 3. Students will learn the difference between tropospheric and stratospheric ozone.

Third-, fourth-, and fifth-graders

You will need the following materials:

- ☐ Playdough® (homemade or commercial) or modeling clay in different colors

B. Use the masters provided to make overhead transparencies or handouts of "Ozone—Double Trouble" and "How Harmful Ozone Is Formed." (Reinforce the idea that our atmosphere is "thin" compared to the "thicker" earth. An analogy might be an apple—the skin is like the atmosphere.)

C. Use them to lead a class discussion about "good" and "bad" ozone—where each is, what makes the ozone good or bad, effects of tropospheric ozone, health consequences of the "hole" in the stratospheric ozone layer, etc. You might want to compare it to fire, which is sometimes beneficial and sometimes harmful—depending on where it is and what it is doing.

D. Divide the class into groups. Using playdough or modeling clay of different colors, have the students build a model of the earth and the layers of its atmosphere.

II. ACTIVITY. CFCs—THEY HURT GOOD OZONE

A. This activity relates to Objectives 4 and 5. It will help students understand the role that CFCs play in the harming of the "good" ozone layer.

Third-, fourth-, and fifth-graders

You will need the following materials:

- ☐ Poster board
- ☐ Crayons, markers, or paints

B. Share with students the background information about CFCs.

C. Have students make public information posters informing people about the harmful effects of CFCs on stratospheric ozone and/or about the harmful effects of increases in ultraviolet (UV) radiation.

D. Display the posters around the school.

Fifth-graders

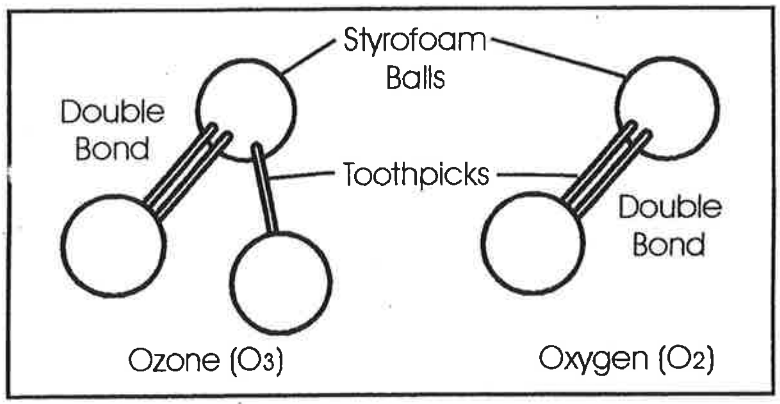
E. **OPTIONAL:** Order "On The Trail Of The Missing Ozone." (EPA 909-K-93-001, April 1993)

Let students read it during class and then have a class discussion about it.

F. Using the diagram below as a guide, have students make models of ozone (O_3) and oxygen (O_2) molecules.

You will need the following materials, for each student or group of students:

- ☐ 5 styrofoam balls
- ☐ 5 toothpicks



III. Activity. Smog—Is It Hazy to You?

A. This activity relates to Objectives 6 and 7. Students will learn what smog is and what its effects can be.

Third-, fourth-, and fifth-graders

B. Ask students the following questions:

1. What is photochemical smog? (A form of air pollution that is composed mostly of ozone. It gives the air a hazy, dirty appearance and can harm the respiratory system.)

2. Where does the name "smog" come from? (It is a combination of the words "smoke" and "fog.")

3. What causes photochemical smog? (Smog is formed when nitrogen dioxide and VOCs react in the presence of sunlight.)

4. When and where is photochemical smog most likely to form? (On sunny summer days in areas where there are lots of automobile exhaust emissions or lots of emissions from factories.)

5. What kind of harmful health effects does ozone/smog cause? (Eye, nose, and throat irritation and lung damage.)

IV. Activity. On a Smoggy Day, You Can't See Forever

A. This activity relates to Objectives 6. It is a simplified demonstration of how London-type (*not* photochemical) smog is formed.

Third-, fourth-, and fifth-graders

You will need the following materials:

- ☐ Small narrow-mouthed jar
- ☐ Matches

B. Perform this demonstration to show how London-type smog is formed:

1. Blow hard into a large narrow-mouthed jar and then quickly remove your lips.
2. Light a match and blow it out.
3. While it is still smoking, dip the match into the jar so that smoke enters.
4. Blow into the jar again and quickly remove your lips.
5. **CAUTION: EXPLAIN TO STUDENTS THE DANGERS OF FIRE AND THAT THEY SHOULD NEVER PLAY WITH MATCHES.**

C. Ask student the following questions:

1. What happened? (Smoke built up in the jar.)
2. Why did that happen? (When you stopped blowing the first time, the sudden lessening of pressure produced a cooling effect. This caused a small amount of water vapor to condense (turn back into droplets). The water vapor combined with the tiny particles of dust from the smoke to form London-type smog.

D. Explain that this is similar to the formation of London-type smog in cities where there is smoke from coal-burning and that smoke mixes with moisture in the air.

V. Follow-Up. Hopkins Hare Adventures #2

A. This activity relates to Objective 6 and 7. This story reinforces some of the information in the preceding activities.

B. Make copies of "The Continuing Adventures of Hopkins Hare in His Quest for Clean Air: Episode #2, Ozone and Smog...Hopkins Learns About a Recipe for Disaster!"

C. Depending on the reading level of the students, either let the students read and color the story or read it to them.

D. Because this story might be unsettling for younger children, discuss it with them after they have read it or heard it.

VI. Extension

A. Have students maintain a chart of the Air Pollution Index from the daily newspaper weather page.

B. Read aloud *Country Mouse/City Mouse.* Have the students write an original version in which the pollution content of the city air convinces Country Mouse to return home.

C. Write "photochemical smog" (or "ground-level ozone") on the chalkboard. Give the students 1 minute and 30 seconds to compile a list of as many words as possible out of the letters.

D. Let students create a sun visor on tagboard. Use an elastic strip to help it stay on. On top of the visor draw a picture that promotes ozone-related pollution prevention.

E. Using coat hangers, string, and index cards, have students create mobiles. On the mobiles have the students create and decorate good, bad, and ugly facts about ozone.

F. Have the students write persuasive paragraphs on CFCs and how companies should not produce products that destroy the ozone.

Resources

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Hann, Judith. *How Science Works.* London: Dorling Kindersley, 1991.

Trefil, James. *1001 Things Everyone Should Know about Science.* New York: Doubleday, 1992.

United States Environmental Protection Agency Office of Air Quality Planning and Standards. *Environmental Science Summer Institute Workbook.* Research Triangle Park, NC. 1995.

World Book Encyclopedia, 1994 edition, s.v. "Ozone."

Ozone—Double Trouble