The information in this lesson plan is current as of August 12, 2004.

Effects of Ozone in the Air

Purpose

To measure ground-level ozone.

Grade Level

5th grade

Science TEKS

- 5.1 a, b
- 5.2 b, c, d
- 5.8 a

Objective

Students will learn how ground-level ozone is an air pollution problem.

Focus

Show a picture of a car tail pipe with exhaust coming out.

Materials

Ecobadge Smog Patrol Kits from Vistanomics Inc., 230 N. Maryland Ave., Suite 310, Glendale, CA 91206, Telephone: 818/409-9157. Visit their web site at: http://www.vistanomics.com/ (The TCEQ references this product for information only and does not endorse this product.)

Background

Ozone is a colorless gas. It is found in two layers in the atmosphere. High level ozone is about 10 to 30 miles above the earth. It is there naturally. This ozone layer protects the earth from the sun's harmful ultraviolet light. Without this protection, the ultraviolet light would be harmful to humans. Ground-level ozone reaches from the ground to about 10 miles above the earth. Ozone at ground level is formed as a

result of chemical reactions between oxygen and volatile organic compounds (mainly come from automobile exhaust) and nitrogen oxides (mainly come from industries and power plants) in the presence of sunlight. High concentrations of ground-level ozone are produced during warm weather (summer months). Ground-level ozone can be very harmful. It can cause breathing problems in humans. It can also injure forests and other vegetation and damage crops.

EcoBadge is a device that measures ozone levels. Treated paper in the badge can be read at short terms (1 hour) and long terms (8 hours).

Procedure

During the right weather conditions for the formation of ozone, divide students into groups of 4 or 5. Give each group an EcoBadge kit. Review instructions in kit. Each group will measure ozone levels for 4 or 5 days (depends on the number in each group). Each student will wear the EcoBadge for 8 hours and record the ozone level measured. After each member of the group has worn the EcoBadge, the group will graph its results for the 4 to 5 day period.

Have each group answer the following:

What does your graph tell you about the ozone level in your area?

During what part of the day is the ozone level the highest? Why do you think this is?

What contributes to the ozone level in your area?

What is being done to decrease harmful ground-level ozone? (Possible answers - Smokestacks and cars are now equipped with air pollution controls. People are becoming more conscious of conserving energy.)

Have the students write what they see happening.

Discuss their observations and inferences.

Add corrected notes to notebook.

Enrichment:

To learn more about ozone, visit the TCEQ's web site: http://www.tceq.state.tx.us/subject_air.html

Ground-level Ozone

Background:
Ozone is the same molecule regardless of where it is found, but its significance varies. Stratospheric ozone is found 9 to 18 miles high where it shields us from harmful ultraviolet rays from the sun. A high accumulation of ozone gas in the lower atmosphere at ground level is air pollution and can be harmful to people, animals, crops, and other materials.

Elevated levels above the national standard may cause lung and respiratory disorders. Short-term exposure can result in shortness of breath, coughing, chest tightness, or irritation of nose and throat. Individuals exercising outdoors, children, the elderly, and people with pre-existing respiratory illnesses are particularly susceptible. Chemists say the materials damaged by ozone include rubber, nylon, plastics, dyes, and paints.

Ozone pollution, or smog, is mainly a daytime problem during summer months because sunlight plays a primary role in its formation. Nitrogen oxides and hydrocarbons are known as the chief "precursors" of ozone. These compounds react in the presence of sunlight to produce ozone. The sources of these precursor pollutants include cars, trucks, power plants and factories, or wherever natural gas, gasoline, diesel fuel, kerosene, and oil are combusted. These gaseous compounds mix like a thin soup in the atmosphere, and when they interact with sunlight, ozone is formed.

Large industrial areas and cities with heavy summer traffic are the main contributors to ozone formation. When temperatures are high and the mixing of air currents is limited, ozone can accumulate to unhealthful levels.

The United States Environmental Protection Agency has set the National Ambient Air Quality Standard (http://www.TCEQ.state.tx.us/air/monops/naaqs.html) for ozone at 0.12 parts per million (ppm). Ozone concentrations of 0.125 ppm (125 in parts per billion) or above are considered an exceedance of this standard because of mathematical rounding. Four areas of Texas violate the national standard for ozone of 0.125 ppm: El Paso, Dallas-Fort Worth, Houston-Galveston-Brazoria, and Beaumont-Port Arthur. Other areas have ozone levels high enough that they are close to exceeding the standard: Austin, Corpus Christi, Tyler-Longview-Marshall, San Antonio, and Victoria.

Activity 1

Ozone And Weather

Objective: To plot data and ozone measurements for a two-or three-week period and evaluate the data collected.

Procedure:

1. Divide the class into groups of five or six students.
2. Each team should then assign a different radio station, television station, or newspaper to each student. For example, Team 1 has five students. Student A will collect data from reports on

radio station KXXX. Student B will collect data from television station WXXX. Student C will collect data from television station WBBB. Student D will collect data from newspaper X. Student E will collect data from newspaper Y. For yesterday's peak ozone concentrations in Texas' major metropolitan areas visit the web site: http://www.tnrcc.state.tx.us/air/monops/index.html#ozdata

3. The National Weather Service (http://www.nws.noaa.gov/)can also provide weather information.
4. Data Collection. Have the students obtain weather and ozone data over a two-week period. The students will need to collect the following weather information:
   - temperature
   - precipitation
   - wind speed
   - cloud cover
   - wind direction
   - time of day for report
   - location of data collected (e.g., downtown, the radio station, the local airport)
4. After the two-week period, have each group compare and contrast their reports. Ask the students the following questions:
   - Did each radio station, television station, newspaper or other source report the same information?
   - What was different?
   - What was alike?
   - What factors would cause the reports to be different or the same?
5. Mapping. Obtain maps of your city or metropolitan area for each team. Have each team research and label the following areas:
   - the major traffic arteries and hubs, including airports, train stations, and bus stations
   - manufacturing areas
   - commercial centers
   - major topographical features such as mountains, valleys, or bodies of water
6. Plotting. Ask students to review the background information on factors affecting ozone formation. Then, ask them to answer the following questions and to label each area on their maps.
   - Which areas might be high ozone producers. Label these high ozone production.
   - What places should a person with respiratory problems avoid on ozone action days? Label these sensitive.
   - Which areas are downwind from high ozone-production areas? (Hint: Use the weather data to determine prevailing winds.) Label these downwind.
   - Where are low-lying areas located in which ozone can collect? Label these depressions.
   - Are any residential areas located in or near areas identified in the areas above? Label these as critical residential areas.
   - Are any elementary or preschools located near critical areas? Label these as critical schools.

- Are any residential senior-citizen or nursing homes located near critical areas? Label these as critical senior-citizen centers.
- Are any medical centers located near critical areas? Label these as critical medical areas.

7. Interpreting patterns. Do the following:
   - Ask the students to find the three days with the highest ozone readings.
   - Ask them to identify any common factors for those three days, such as high temperatures, weather, or day of the week.
   - Explain that scientists investigate the true composition of air pollution by tracking common factors and then seeking explanations for correlations.
8. Have the students design a graph or chart that would correlate one or more factors to the high ozone readings.

The TCEQ has developed an ozone education/awareness campaign called the Ozone Action Days Program(http://www.TCEQ.state.tx.us/air/monops/ozoneaction.html). This voluntary campaign outlines reasonable actions each participating community can take, from local industries to individuals, to reduce ozone pollution.

Write the following scenarios on the chalkboard. Ask the students to determine in which scenarios they would declare an Ozone Action Day. Then they should write a paragraph for each scenario, explaining their choice.

It is 8 a.m. on a typical weekday. There is rush-hour traffic on all the highways. The weather forecast is mostly sunny skies, light winds from the southeast, temperature to reach 98 degrees, and a 30 percent chance of late morning thunderstorms. The current ozone reading is 30 parts per billion (ppb). Should you declare an Ozone Action Day?

Answer:
Yes, because of the traffic, light winds, and the temperature. The 30 percent chance for precipitation means that any showers would be isolated, so you will probably have high levels of ozone.

It is 6 a.m. on Saturday. The forecast for the day is overcast skies, light and variable winds, and a maximum temperature of 91 degrees. No ozone reading is available. Should you call an Ozone Action Day based on the information you have?

Answer:
No, sunny to partly cloudy skies are required for the photo chemical process that creates ozone.

For this question, consider the Dallas-Ft. Worth area. It is 9 a.m. Yesterday was an Ozone Action Day. The weather today is very much like the weather yesterday. One difference is that today is a holiday and many people are off from work and school. The ozone reading is 40 ppb. The safety and comfort of many people depend on your decision. What will it be?

Answer:

The answer is no because you should not expect to have the high rush-hour traffic congestion.

Adapted from the Alternative Transportation Fuels Workshop with The Texas Railroad Commission, The General Land Office, and The Texas Education Agency.

Meteorology Data and Activity

Background:

Ground-level ozone pollution is mainly a daytime problem during summer months because sunlight plays a primary role in its formation. Nitrogen oxides and hydrocarbons are known as the chief "precursors" of ozone. These compounds react in the presence of sunlight to produce ozone. The sources of these precursor pollutants include cars, trucks, power plants and factories, or wherever natural gas, gasoline, diesel fuel, kerosene, and oil are combusted. These gaseous compounds mix like a thin soup in the atmosphere, and when they interact with sunlight, ozone is formed.

Large industrial areas and cities with heavy summer traffic are the main contributors to ozone formation. When temperatures are high and the mixing of air currents is limited, ozone can accumulate to unhealthful levels.

The United States Environmental Protection Agency has set the National Ambient Air Quality Standard (http://www.tnrcc.state.tx.us/air/monops/index.html#general) for ozone at 0.12 parts per million (ppm). Ozone concentrations of 0.125 ppm (125 in parts per billion) or above are considered an exceedance of this standard because of mathematical rounding.

The Monitoring Operations Division has more ozone information at this site:
http://www.TCEQ.state.tx.us/air/monops/index.html#ozdata

Activity:

Use the following scenario to determine the likelihood of high ozone levels for Houston on March 23, 1997:

Southeast Texas Weather Synopsis for March 22, 1997, 10:00 a.m. Central Standard Time: A high pressure ridge over east Texas will result in light east to southeast winds over eastern and central Texas today and tomorrow. Low clouds will develop after sunset as warm moist air moves over the land and condenses. These low level clouds will lift and the sky will become partly cloudy by midday. No precipitation is expected. Temperatures: Lows - 60's, Highs - 80's.

Houston Forecasts:

March 22, 1997: Morning fog, then partly cloudy and warm. Wind light and variable early, becoming

southwest at 6 to10 mph this afternoon. High temperature - 84.

March 23, 1997: Increasing clouds overnight, becoming cloudy after midnight. Cloudy tomorrow morning, becoming partly cloudy during the afternoon. Wind light and varible through the early afternoon, shifting to the southeast at 6 to10 mph by mid-afternoon. Low temperature - 64, High temperature - 81.

Answer!

The answer is yes, the maximum one-hour ozone concentration was 234 ppb on March 23, 1997. The Houston weather forecast conditions that day indicated a light wind all day, sunshine during the afternoon, and warm temperatures. These are the primary meteorological ingredients that contribute to high ozone formation. Here's what actually happened:

A light land breeze (wind blowing from the relative cooler land mass to the warmer Gulf of Mexico) blew over the city through late morning. The sea breeze (as the land warms the Gulf of Mexico air becomes relatively cooler and the wind direction reverses) formed and moved across the city during the mid- afternoon. The low clouds early in the day became scattered by 1 p.m. This weather condition resulted in ozone precursors being pushed south of the city during the morning, then reversing direction and moving back over the city during the afternoon. Abundant sunshine, warm temperatures (high was 81), and light winds contributed to rapid formation of high ozone levels on this day.

Acknowledgment

Mary Sloan, University of Texas at El Paso TES Course, 1995