

# Air Quality

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<b>Strand</b>	Matter
<b>Topic</b>	Investigating the atmosphere and weather
<b>Primary SOL</b>	6.6 The student will investigate and understand the properties of air and the structure and dynamics of Earth’s atmosphere. Key concepts include d) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining quality.
<b>Related SOL</b>	6.3 The student will investigate and understand the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on Earth’s surface. Key concepts include a) Earth’s energy budget. 6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include c) the mitigation of land-use and environmental hazards through preventive measures.

## Background Information

Forest fires and volcanic eruptions are two natural processes that add pollutants to Earth’s atmosphere. On the other hand, many gaseous compounds and particles are released into the atmosphere as a result of human activities, such as burning fossil fuels and releasing chlorofluorocarbons (CFCs). The effects of these compounds on the atmosphere are not yet fully understood, but evidence suggests these pollutants are damaging.

Ozone, a compound formed when three atoms of oxygen combine, can form near the surface of the Earth when vehicle exhaust pollutants react with sunlight. This type of ozone pollution can cause health problems. This should not be confused with naturally occurring ozone found in the upper atmosphere, which is beneficial in shielding the Earth from ultraviolet radiation.

Life on Earth is supported by energy from the sun. The Earth’s *energy budget* is a balance between the amount of energy that reaches the Earth’s surface versus the amount of energy that is radiated back into space. Radiation with a short wavelength, mainly ultraviolet, is received from the sun and absorbed and scattered by the atmosphere, clouds, and the Earth’s surface. Long-wave radiation, known as infrared, is reflected back into space. *Heat* is the transfer of thermal energy between substances. Infrared radiation “heats” other substances by causing their molecules to gain energy and move faster. The Greenhouse Effect occurs when thermal energy is trapped within the atmospheric layers. The accumulation of thermal energy causes an abnormal rise in atmospheric temperature (global warming).

Energy received from the sun drives Earth’s weather and climate and heats Earth’s surface; in turn, the Earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining thermal energy somewhat like the glass panels of a greenhouse. Without this natural Greenhouse Effect, temperatures on Earth would be much lower than they are, and life would not be possible. Thanks to greenhouse

gases, the Earth's average temperature is a more hospitable 15°C. However, problems may arise when the atmospheric concentration of greenhouse gases increases.

Since the beginning of the industrial revolution, the amount of carbon dioxide (CO<sub>2</sub>) in the atmosphere has increased nearly 30%, methane (CH<sub>4</sub>) has more than doubled, and nitrous oxide (N<sub>2</sub>O) has risen by about 15%. Why are such gas concentrations increasing? Scientists have data to support the hypothesis that the burning of fossil fuels and other human activities are the primary reason for the increased amount of carbon dioxide in the atmosphere. There has always been a natural release of carbon dioxide into the atmosphere, but these releases have generally been in balance during the centuries leading up to the industrial revolution. During this time, carbon dioxide was recycled by plants and the oceans.

Fossil fuels burned to run vehicles, heat homes and businesses, and power factories are responsible for about 98% of U.S. carbon dioxide emissions, 24% of methane emissions, and 18% of nitrous oxide emissions. Increased agriculture, deforestation, landfills, and mining also contribute a significant share of emissions. In 1997, the United States produced about one-fifth of total global greenhouse gases emitted into the atmosphere.

### **Materials**

- 8½ x 11 inch paper for air-quality brochure
- Sample air-quality brochure
- Resource materials (e.g., textbooks, trade books, encyclopedias, Internet access)
- Copies of the attached handout

### **Vocabulary**

*atmosphere, chlorofluorocarbon, energy budget, Greenhouse Effect, pollutant*

### **Student/Teacher Actions (what students and teachers should be doing to facilitate learning)**

#### *Introduction*

1. Ask students to brainstorm everything they know about the atmosphere, greenhouse gases, the Greenhouse Effect, and global warming. As they mention their ideas, make a concept web on chart paper, showing the connections among these ideas.
2. Inform students that the goal of this lesson is to help them explore the connection between the Greenhouse Effect and global warming and to examine their own role in protecting the quality of Earth's atmosphere.

#### *Procedure*

1. Organize students into five teams in order to work on creating air-quality brochures. Inform the teams that the information contained in their brochure will be used to design a whole-group activity. Assign each team one of the following five topics on which to become an "expert":
  - Causes of Air Pollution: Human Activities and Natural Events
  - Major Pollutants in the Air and Their Sources
  - Effects of Air Pollution on Humans and Other Organisms
  - Climatic Changes Due to Pollution
  - Possible Ways to Reduce Air Pollution

2. Ask students in each team to use resource materials and Web sites to gather information on their assigned topic and share that information among their team members. Be sure students include information on ways their topic affects Earth's energy budget (see attached diagram).
3. Once each team has completed their research, have them create a simple brochure on their assigned topic. They should integrate quantitative or technical information expressed in words in the reference materials with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
4. When the brochures are finished, jigsaw students into reporting groups so that there is at least one student from each expert team per group. Have students report their finding to their new group, about which the other members of the new group will take notes.
5. Finally, have students regroup into their original groups to add information to their brochures so that each brochure now covers all five topics.
6. Instruct students to work collaboratively, using their research and the information in their brochures, to write situation cards that illustrate the relationship between human actions (both positive and negative), natural events, and the Earth's temperature. Situations could include things like burning trash, planting trees, volcanic eruptions, and driving hybrid automobiles. Creating the situation cards will allow students not only to summarize what they have learned, but also to evaluate the *effect* of each situation on the amount of CO<sub>2</sub> in the atmosphere and its consequent effect on the Earth's temperature.
7. Have the class act out the situations they have designed in step 6. For example, this could happen as follows: Appoint a group of students to act as CO<sub>2</sub> molecules in the atmosphere and another group to be the situation-card group. Give each student in the latter group one situation card to read aloud. As each card is read, the CO<sub>2</sub> group must decide whether a CO<sub>2</sub> molecule in the atmosphere is saved (i.e., joins the situation-card group) or whether more CO<sub>2</sub> is created in the atmosphere. If CO<sub>2</sub> increases, then the card's reader must join the CO<sub>2</sub> group.
8. Direct students to work together in groups of four to summarize the things they now know about the atmosphere, greenhouse gases, the Greenhouse Effect, and global warming. Instruct each group to come up with some concepts to add to the concept web created at the beginning of the lesson. These concepts should show additional connections between these ideas. Challenge each group to share one or two ideas that are new (or newly clarified) to add to the web.

## Assessment

- **Questions**
  - What is the effect of air pollution on the environment, particularly on the weather, atmosphere, and climate?
  - What we can do to protect and improve the quality of the atmosphere?
- **Journal/Writing Prompts**
  - Describe three causes and effects of air pollution and how they may impact the environment.
  - What are some ways to reduce air pollution in your community?

- **Other**
  - Use the completed air-quality brochures for assessment.
  - Assess the completed concept web on chart paper.
  - Assess students as they act out scenarios on the situation cards.

### **Extensions and Connections (for all students)**

- Have students research the positive effect that worldwide restriction of chlorofluorocarbons (CFCs) has had and is now having on the polar holes in the ozone layer. Point to this as an example of humans correcting an air-pollution problem that they caused.
- Have students research and report how much CO<sub>2</sub> their whole family produces in a year.

### **Strategies for Differentiation**

- Have students develop a cartoon strip that shows at least five things that they can do to protect and/or improve air quality.
- Have students sort illustrations from magazines, pamphlets, etc., to compare and contrast natural and human-caused pollution.
- Have students create a model of a greenhouse, using items found around their houses or the classroom (e.g., shoebox, black construction paper, plastic wrap, and thermometer). Have them use the greenhouse model to represent global warming.
- Use video clips from Internet sources such as *Discovery Education* to enhance students' understanding of air quality.
- Invite an air quality control tester or environmental specialist to present to the class.
- Invite an industry quality assurance specialist from OSHA to explain how the agency sets guidelines for air quality control for industries.
- Introduce new vocabulary and review old vocabulary by having students write each word along with its definition, a sentence that uses it, and a picture of the concept.

# Causes and Effects of Air Pollution

1. Causes of Air Pollution: Natural Events
  - Volcanic eruptions—ash, toxic gases
  - Forest fires—smoke
2. Causes of Air Pollution: Human Activities
  - Vehicle exhaust—photochemical smog (nitrogen compounds that react with sunlight to form ozone)
  - Industry/factory emissions—acid rain
  - Construction activity—particulate matter (e.g., smoke, soot, dust)
  - Power plant emissions—toxic air pollutants (e.g., carbon monoxide, smoke)
  - Burning fossil fuels for heat, generating electricity, running vehicles—smog, particulate matter, toxic air pollutants
  - Air conditioner, refrigerator, aerosol spray leakage—chlorofluorocarbons (CFCs), which damage the ozone layer
3. Effects of Air Pollution on Humans
  - Respiratory (breathing/lung) problems
  - Allergies
  - Watery eyes, other vision problems
  - Nerve damage
  - Reproductive disorders
  - Cancer
  - Heart disease
4. Effects of Air Pollution on Other Organisms
  - Reduces phytoplankton's ability to make food
  - Decreases plants' abilities to fight diseases and pests
  - Spreads pollutants' effect through the food chain when polluted organisms are eaten by other animals
5. Effects of Air Pollution on Materials and Structures
  - Corrodes metals
  - Deteriorates stone and paint
6. Natural Events That Result in Climate Change
  - Meteorite collisions, volcanic eruptions, fires, and wind erosion put particles and liquid droplets into atmosphere, blocking solar radiation, increasing cloud cover, and cooling the planet.
  - Changes in solar output (energy given off by the sun), such as sunspots
  - Changes in Earth's movement in space (changes in tilt and orbit) change amount of energy reaching parts of Earth
7. Human Activities That Result in Climate Changes
  - Burning fossil fuels, thereby putting harmful pollutants (automobile exhaust, smoke-stack emissions) into the air
  - Deforestation (cutting down trees and other vegetation without replacing them), thereby reducing the amount plant life that removes CO<sub>2</sub> from the atmosphere

8. Greenhouse Effect

- Natural atmospheric heating when gases (water vapor, carbon dioxide) trap heat. Without these gases, Earth would be too cold for life to exist. However, when air pollution increases the levels of CO<sub>2</sub>, too much heat is trapped, and Earth becomes warmer and warmer. This disrupts fragile ecosystems. This is called “global warming.”

9. Ways to Reduce Air Pollution

- Clean Air Act—federal government laws that regulate air pollution
- Developing and using alternative, non-polluting power sources (solar, wind, water)
- Conserving electricity (e.g., turning off lights and TV; opening windows instead of using air conditioners)
- Decreasing use of cars by carpooling, using public transportation, riding bikes, and walking
- Planting trees and other vegetation to help remove carbon dioxide
- Using catalytic converters on cars to change harmful exhaust gases into less harmful ones

