NATIONAL GEOGRAPHIC
Activity*develop*

Visible and Invisible Pollutants

How do different types of pollutants affect human and environmental health?

Overview

Students explore data about the sources and consequences of different types of pollutant emissions.

For the complete activity with media resources, visit:
http://education.nationalgeographic.org/activity/visible-and-invisible-pollutants/

Directions

1. Activate students' prior knowledge about types of pollutants.

Show the **1980 Mount St. Helens Eruption** photograph. Tell students that there are two types of pollutants: visible pollutants and invisible pollutants. Ask:

- *What kind of pollutants can you see in this picture?* (You can see ash emitted, rock fragments, and gas clouds.)

Tell students that there are many different types of invisible, or gaseous, pollutants. Let students know that they will be exploring the sources of visible and invisible pollutants and their effects on human and environmental health in this activity.

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Let students know that they can see examples of scientists' uncertainty in forecasting air quality. Tell students that air quality is measured by the Air Quality Index. Show students the **Air Quality Index**, which includes explanations of the ranges used in the air quality index. Then project the **Forecast of Air Quality on December 10, 2013** image and **Air Quality on December 10, 2013** image. (Click on the link in the media carousel above and download using the arrow in the lower right corner of the window.) Tell students that these are snapshots of the air quality forecast and the real-time air quality in the United States on December 10, 2013. Ask:

- *Did the forecast accurately predict which areas would have poor quality air?* (The forecast air quality overlaps with many of the poor air quality areas, but it does not cover all of them. The air quality in some areas [Northern California] is much worse than the forecast predicted.)

- *Why do you think scientists did not accurately predict the air quality for more of the United States?* (Student answers will vary. The air quality forecast is affected by human activities that may not be easily predicted.)

Tell students that they will be asked questions about the certainty of their predictions. Let students know they should think about what scientific data is available as they assess their certainty with their answers, and encourage them to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of stocks and flows in a system.

Tell students that materials flow into and out of systems. The flow of the materials over time can change and can be influenced by many different factors and interacting parts. Scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a stock and flow in a system, as described in the scenario below.

There is a bathtub with water flowing in from the faucet and water leaving through the drain. Ask:

- *When the drain is plugged, what happens to the level of water in the bathtub?* (The water level will increase because the outflow of water is stopped, but water keeps coming in from the faucet.)
- *When the faucet is turned off, what happens to the level of water in the bathtub?* (The water level will decrease because the inflow of water is stopped, but the water keeps leaving through the drain.)
- *How can the level of water in the bathtub be kept at the same level?* (The water in the bathtub can be kept at the same level by making the inflow equal to the outflow. Then, the water that comes in through the faucet will be offset by the water that leaves through the drain.)

Tell students they will be following the flow of materials, in this case the amount of air pollution, in the system. Let students know they will be exploring some environmental and human factors that contribute to changes in the amount of pollution being added to and removed from the modeled system.

4. Have students launch the Visible and Invisible Pollutants interactive.

Provide students with the link to the Visible and Invisible Pollutants interactive. Divide students into groups of two or three, with two being the ideal grouping to allow groups to share a computer workstation. Tell students that they will be working through a series of pages of data with questions related to the data. Ask students to work through the interactive in their groups, discussing and

responding to questions as they go.

Tell students that this is Activity 3 of the **Will the Air Be Clean Enough to Breathe?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *What types of particulate pollutants are produced naturally, and what types are produced through human actions?* (Some natural particulates include sand and salt particles, as well as ash and soot from forest fires. Ash and soot are also produced through human actions as materials are burned for fuel in transportation, heating, and electricity production. Humans cause some forest fires, making those “natural” sources really anthropogenic sources.)
- *How do invisible (gaseous) pollutants affect the environment?* (Invisible pollutants such as SO_2 and NO_x can combine with water to form acidic precipitation. The acidic precipitation can harm plants and animals. VOCs and CO are harmful to animals' health as well as human health.)
- *Why are particulate pollutants hazardous to human health?* (Particulates can be inhaled deep into the lungs and cross over into the bloodstream. Then they can travel around the body, causing effects to many organ systems.)
- *Show* the **NO_x Emissions, 2008** pie chart (page 6 of the interactive*). How many of the NO_x emissions are from human sources?* (Almost all of the NO_x emissions are anthropogenic. Up to 1% [miscellaneous and fires] could be from natural sources.)
- *What types of materials can cause indoor air pollution?* (Carpets, perfumes, hairsprays, furniture, and poorly ventilated heating/cooking devices can cause indoor air pollution.)
- *Why is indoor pollution more hazardous to human health than most outdoor pollution?* (Indoor pollution cannot be blown away by the wind or precipitated out of the air by rain or snow. It can be more concentrated because there is less dilution with clean air than is possible outdoors.)
- *How can increasing fuel efficiency reduce the emissions of gaseous pollutants (SO_2, NO_x, CO)?* (Increasing fuel efficiency can reduce the emissions of gaseous pollutants because less fuel needs to be burned to go the same distance [in a vehicle] or produce electricity [in a power plant]. If less fuel is used, there will be fewer emissions.)

TipTeacher Tip

If you want to save students' data for grading online, register your class for free at the High-Adventure Science portal page.

TipTeacher Tip

This activity is part of a sequence of activities in the **Will the Air Be Clean Enough to Breathe?** lesson. The activities work best if used in sequence.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

- What are some common visible and invisible pollutants?
- What is the effect of particulate emissions on human health?
- How do invisible (gaseous) pollutants affect the environment?

2. Use the answer key to check students' answers on embedded assessments.

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- identify common sources of particulate and gaseous pollutants
- explain how particulate emissions affect human health
- explain how gaseous emissions can result in acid rain
- explain how human health is affected by gaseous pollutants such as VOCs and carbon monoxide

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions

- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

National Science Education Standards

• (5-8) Standard A-1:
Abilities necessary to do scientific inquiry
• (5-8) Standard D-1:
Structure of the earth system
• (5-8) Standard F-1:
Personal health
• (5-8) Standard F-4:
Risks and benefits
• (9-12) Standard A-1:
Abilities necessary to do scientific inquiry
• (9-12) Standard A-2:
Understandings about scientific inquiry
• (9-12) Standard C-5:
Matter, energy, and organization in living systems
• (9-12) Standard F-1:
Personal and community health
• (9-12) Standard F-2:
Population growth
• (9-12) Standard F-4:
Environmental quality
• (9-12) Standard F-5:

Natural and human-induced hazards

Common Core State Standards for English Language Arts & Literacy

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.6-8.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3

ISTE Standards for Students (ISTE Standards*S)

- **Standard 3:**
Research and Information Fluency
- **Standard 4:**
Critical Thinking, Problem Solving, and Decision Making

Next Generation Science Standards

- **Crosscutting Concept 1:**
Patterns
- **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
- **Crosscutting Concept 3:**
Scale, proportion, and quantity
- **Crosscutting Concept 7:**
Stability and change
- **Science and Engineering Practice 1:**
Asking questions and defining problems
- **Science and Engineering Practice 4:**
Analyzing and interpreting data
- **Science and Engineering Practice 6:**

Constructing explanations and designing solutions
• **Science and Engineering Practice 7:**
Engaging in argument from evidence
• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

What You'll Need

Required Technology

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per small group, Interactive whiteboard, Projector

Physical Space

- Classroom
- Computer lab
- Media Center/Library

Grouping

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

Resources Provided: Websites

- Air Quality Index (AQI) Basics

Resources Provided: Handouts & Worksheets

- Answer Key - Visible and Invisible Pollutants

Resources Provided: Interactives

- Visible and Invisible Pollutants interactive
- NOx Emissions, 2008 pie chart

Resources Provided: Images

- 1980 Mount St. Helens Eruption
- Forecast of Air Quality, December 10, 2013
- Air Quality on December 10, 2013

Background & Vocabulary

Background Information

Air pollutant emissions have an effect on human and environmental health. Particulate emissions (the visible pollutants) can be inhaled into the nose and lungs. The smallest particles can cross the alveolus-capillary barrier and make their way into the bloodstream.

Invisible pollutants (nitrogen oxides, sulfur dioxide, volatile organic compounds, carbon monoxide) also pose a threat to health. Carbon monoxide displaces oxygen in red blood cells, leading quickly to death if the carbon monoxide concentration is high. Nitrogen oxides, sulfur dioxide, and volatile organic compounds irritate the sensitive tissues of the airway; they are particularly irritating to people with pre-existing lung conditions such as asthma or emphysema.

In addition to posing a threat to human health, nitrogen oxides and sulfur dioxide are irritating to plants. Plants' leaves can be burned by dry deposits of nitrogen oxides and sulfur dioxide. When these pollutants combine with water in clouds, they form acid precipitation. The acidic precipitation can cause plant damage and destruction of aquatic habitats as the waters become more acidic.

Prior Knowledge

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Recommended Prior Activities

- Measuring Air Quality
- Movement of Pollutants

Vocabulary

Term	Part of Speech	Definition
air quality	*noun*	measurement of pollutants and other harmful materials in the air.
atmosphere	*noun*	layers of gases surrounding a planet or other celestial body.
carbon monoxide	*noun*	Carbon monoxide is a colorless, odorless, and tasteless gas that is slightly less dense than air. It can be toxic to humans.
emission	*noun*	discharge or release.
intensity	*noun*	measure of magnitude.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
nitrogen oxide	*noun*	one of many chemical compounds made of different combinations of nitrogen and oxygen.
particulate	*adjective, noun*	microscopic solid or liquid particle, often suspended in the atmosphere as pollution.
pollutant	*noun*	chemical or other substance that harms a natural resource.

Term	Part of Speech	Definition
precipitation	*noun*	all forms in which water falls to Earth from the atmosphere.
smog	*noun*	type of air pollution common in manufacturing areas or areas with high traffic.
solar radiation	*noun*	light and heat from the sun.
sulfur dioxide	*noun*	greenhouse gas that can cause acid rain.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.
volatile organic compound (VOC)	*noun*	gas released from some solids or liquids that may cause harm to people and the atmosphere.

For Further Exploration

Websites

- National Geographic Encyclopedic Entry: air pollution
- National Geographic Encyclopedic Entry: smog
- National Geographic Encyclopedic Entry: Volcanic Ash
- National Geographic Environment: Air Pollution

Partner

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