NATIONAL GEOGRAPHIC
Activity*develop*

Movement of Pollutants

How do pollutants move through the atmosphere?

Overview

Students use models to explore how pollutants move throughout the atmosphere.

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

Directions

1. Activate students' prior knowledge about air movements in the atmosphere.

Show the **Air Pollution From a Power Plant** photograph. Tell students that pollutants emitted into the atmosphere do not stay in the atmosphere or even directly above the polluting source forever. They move throughout the atmosphere and are moved and removed by natural processes. Ask:

- *What natural process causes pollutants to move away from the pollution source?* (Wind will cause pollutants to move away from the source.)
- *What natural process would remove pollutants from the atmosphere?* (Precipitation would remove pollutants from the atmosphere.)

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 they will be asked questions about the certainty of their predictions. Let students know that 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. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. Project the **NOAA Weather Forecast Model**, which provides a good example of a computational model. Tell students that scientists use models to predict future conditions based on current information about the energy and moisture in the atmosphere. Scientists use atmospheric models, such as these, to forecast

where and when air quality may be bad.

5. Have students launch the Movement of Pollutants interactive.

Provide students with the link to the Movement of 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 they will be working through a series of pages of models with questions related to the models. Ask students to work through the interactive in their groups, discussing and responding to questions as they go.

Tell students that this is Activity 2 of the **Will the Air Be Clean Enough to Breathe?** lesson.

6. Discuss the issues.

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

- *What conditions allow for the best air quality over the city in the model* (**Model 2: Cross-Section of a City: With Graph**)*?* (In the city in the model, the best air quality is achieved when the wind is blowing toward the water or when it rains frequently.)
- *How did you get poor air quality over the city in the model* (**Model 2: Cross-Section of a City: With Graph**)*?* (Poor air quality can result when the wind is blowing towards the mountains, when there is infrequent rain, and when there is infrequent rain and intense sunlight.)
- *Where did you put factories in Model 3 so that all the cities had good air quality* (**Model 3: Satellite View of a City**)*?* (Factories should be placed south of the northeastern-most mountains so that the wind won't blow the pollutants to City A. The wind from the northeast or east will not blow pollutants into any city when the factories are located directly south of the northeastern-most mountains.)
- *How can pollution from Asia affect North America?* (The wind blows primarily from the West. Polluted air over Asia can be blown across the ocean to affect cities in North America.)
- *How could tall buildings affect a city's air quality?* (Tall buildings could form a barrier to pollutants' escape from the area. This is dependent on the wind direction.)
- *Mexico City, Mexico is surrounded by mountains on all sides. How does this affect the region's air quality?* (The air quality could be affected by the mountains because the pollution might not be able to rise up over the mountains and blow away. This could make the air quality in the city quite poor.)

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 them the following questions:

- What natural process removes pollutants from the atmosphere?
- How can air quality over an area be poor even if there are no local emissions?
- How do geographical barriers affect the pollution level in cities?

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 factors that affect air quality over a given area
- describe how pollutants move through the atmosphere
- explain how air movements affect the air quality over a given area
- explain how precipitation can improve air quality over an area

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
- 21st Century Themes
  - Global Awareness
- 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:**
Key Ideas and Details, RST.11-12.1
• **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:**
Craft and Structure, RST.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
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• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3

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 4:**

Systems and system models
• **Crosscutting Concept 5:**
Energy and matter: Flows, cycles, and conservation
• **Crosscutting Concept 7:**
Stability and change
• **Science and Engineering Practice 1:**
Asking questions and defining problems
• **Science and Engineering Practice 2:**
Developing and using models
• **Science and Engineering Practice 3:**
Planning and carrying out investigations
• **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
- NOAA Weather Forecast Model

Resources Provided: Handouts & Worksheets

- Answer Key - Movement of Pollutants

Resources Provided: Interactives

- Movement of Pollutants interactive

Resources Provided: Images

- Air Pollution From a Power Plant
- Forecast of Air Quality, December 10, 2013
- Air Quality on December 10, 2013

Background & Vocabulary

Background Information

Air quality is affected by natural processes. Wind can move pollutants from their source to far-away locations. Precipitation can remove pollutants from the atmosphere.

Scientists use computational models to predict the movement of pollutants from their sources and the formation of secondary pollutants. Satellites can monitor the movements of visible pollutants across long distances. A network of air quality monitors on the ground measures local concentrations of pollutants to provide more detailed forecasts of air quality.

Prior Knowledge

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Recommended Prior Activities

- Measuring Air Quality

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.
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.
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.
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.

Term	Part of Speech	Definition
solar radiation	*noun*	light and heat from the sun.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.

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

Funder

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