Activity*apply*

Preventing Bad Air Days

How can we prevent or reduce the number of bad air quality days?

Overview

Students use models to explore how atmospheric structure and conditions affect the severity of a pollution event. Students examine some methods of reducing emissions from pollution sources.

For the complete activity with media resources, visit:
http://education.nationalgeographic.org/activity/preventing-bad-air-days/

Directions

1. Introduce students to the environmental factors that affect air quality.

Let students know that environmental factors affect the severity and duration of pollution events. Show the **New Bridge in Bratislava on Clear Day** photograph and the **New Bridge in Bratislava with Temperature Inversion** photograph. (Download the image by clicking on the down arrow in the lower right corner of the media carousel window.) Tell students that the temperature of the atmosphere affects the movement of pollutants. Ask:

- *What happened to the temperature of the air between the first picture and the second picture?* (There is a temperature inversion in the second picture. The air is cooler at the surface than it is above the surface. Normally, the air cools with increasing elevation.)
- *What happened to change the temperature of the atmosphere?* (A temperature inversion can be caused by cool air at the surface because of snow/ice on the surface or by cooler air blowing in off a colder body of water.)

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 Preventing Bad Air Days interactive.

Provide students with the link to the Preventing Bad Air Days interactive. Divide students into groups of two or three, with two being the ideal grouping to allow groups to be able to share a computer work station. Tell students they will be working through a series of pages of questions related to the models in the activity. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Tell students this is Activity 5 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 the questions below.

NOTE: The answers provided are the correct answers; however, students should be encouraged to find these answers by using the models in the activity.

- *What conditions created a thermal inversion in Model 4 (***Model 4: Cross-Section of a City: With Thermal Inversion***)?* (The wind has to be coming from the water. The water is cooler than the land. The breeze coming off the water cools the surface of the land so it is colder than the layer of air directly above it.)
- *Why are smog events longer-lasting when there is a temperature inversion?* (Smog events are longer lasting when there is a temperature inversion because the temperature inversion prevents the air from rising through the atmosphere and dissipating over a larger area.)
- *Can thermal inversions be prevented?* (No, thermal inversions cannot be easily prevented. Thermal inversions are natural events. They are created when the surface is cooler than the air above. This can happen when there is snow on the ground, cooling the ground, while the Sun

warms the air above it. They can also happen when cooler air blows off a large body of water onto the warmer land. The sea breeze [or lake breeze] cools the lower layer of air below the temperature of the air above.

- *Is it more important to limit the pollution from cars or from power plants and factories (**Model 5: Cross-Section of a City: With Pollution Control**)?* (The data from this model indicate that limiting vehicle pollution is more important to air quality than limiting power plant/factory pollution. This may or may not apply in the real world; the model's predictive power is limited because all car emissions are treated as the same, just as all power plant/factory emissions are treated as the same. The different types of pollutants emitted by the different pollution sources are not modeled with this model. The effect of weather is not modeled well enough to make long-term predictions about which pollution type has the biggest effect on the overall city pollution level. Pollutants from other power plants/factories could blow in to this area; only a small portion of the Earth is modeled in this model.)
- *How can technology make a difference in air quality?* (Technology can be developed that can lower the emissions of cars, power plants, and factories. Technology can also increase the efficiency of the polluting sources, meaning that there would be less pollution per mile traveled/unit of electricity generated/product manufactured. Technology can also create more pollution as a side effect of more manufacturing and more demand for products that pollute.)

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 is a thermal inversion?

- What conditions lead to a thermal inversion?
- How do pollution control devices work?

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

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- describe how a thermal inversion occurs and is dissipated
- explain how pollution control devices reduce emissions of pollutants from vehicles and smokestacks
- compare methods of transportation for their ability to prevent/reduce the number of bad air quality days

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

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.6-8.1
• **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:**
Craft and Structure, RST.6-8.4
• **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
• **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:**
Key Ideas and Details, RST.11-12.1

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
• **HS. Earth's Systems:**
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
• **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 5:**
Using mathematics and computational thinking
• **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 - Preventing Bad Air Days

Resources Provided: undefined

- Preventing Bad Air Days interactive

Resources Provided: Images

- New Bridge in Bratislava on Clear Day
- New Bridge in Bratislava with Temperature Inversion
- Forecast of Air Quality, December 10, 2013
- Air Quality on December 10, 2013

Background & Vocabulary

Background Information

The temperature profile of the atmosphere plays an important role in the level of pollutants in the air above a given location. Thermal inversions can trap pollutants in an area for a long period of time, leading to bad air quality. These events can be forecast and people can change their actions to prevent or reduce the number of bad air quality days. With these forecasts, people can plan their activities to minimize their exposure to poor quality air.

Prior Knowledge

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Recommended Prior Activities

- Measuring Air Quality
- Movement of Pollutants
- Pollutants Making More Pollutants
- Visible and Invisible Pollutants

Vocabulary

Term	Part of Speech	Definition
acid	*noun*	chemical compound that reacts with a base to form a salt. Acids can corrode some natural materials. Acids have pH levels lower than 7.
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.
intensity	*noun*	measure of magnitude.
inversion	*noun*	act or circumstance of being upside-down.
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.
precipitation	*noun*	all forms in which water falls to Earth from the atmosphere.
scrubber	*noun*	device or method used to remove air pollutants from industrial exhaust.
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.

Term	Part of Speech	Definition
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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