THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

What is in the Air?

How does air quality in recent years compare to air quality in the past?

GRADES 9–12

Earth & Space

VAN ANDEL EDUCATION INSTITUTE

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INQUIRY-BASED SCIENCE

Earth & Space

What is in the Air?

Grade Level/Content	9–12/Earth and Space Science
Lesson Summary	Students collect data about the human and environmental impact of one of six criteria air pollutants to show changes over time as a result of actions taken after the Clean Air Act went into effect.
Estimated Time	3, 45-minute class periods
Materials	Internet access, Investigation Plan, Journals, graphing or presentation software (Google Slides, Microsoft PowerPoint, Prezi, or similar tool)
Secondary Resources	Environmental Protection Agency: Air Emission Inventories Environmental Protection Agency: Criteria Air Pollutants Environmental Protection Agency: Air Data Environmental Protection Agency: Status and Trends of Key Air Pollutants
NGSS Connection	**HS-ESS3-4** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
Learning Objectives	• Students will investigate and describe the human and environmental impact of their assigned criteria air pollutant. • Students will show changes in air quality over time for the criteria air pollutant they investigated. • Students will evaluate the relative effectiveness of the Clean Air Act in improving air quality over time for their assigned criteria air pollutant.

How does air quality in recent years compare to air quality in the past?

There are costs and benefits to everything, even dirty air. Edwin Kiester, Jr. "walked home for lunch with streetlights still blazing" when he grew up in western Pennsylvania in the 1940s. After the Great Depression, "smog meant prosperity," he said. It meant that people had jobs. But in October of 1948, the smog over Donora, Pennsylvania didn't blow away. Cold air above the smog created an inversion layer that lasted for five days. Industrial exhaust was trapped so close to the ground and made hundreds of people sick. Nineteen people died in 24 hours, and deaths continued in the days and months afterward. This incident led local, state, and federal officials to investigate the Donora Smog Disaster. In 1950, President Harry Truman convened the first national air pollution conference. This was followed by the Air Pollution Control Act of 1955, the first federal air pollution legislation designed to improve air quality and then by the Clean Air Act of 1970. In this lesson, students research and identify datasets to determine whether or not the Clean Air Act has benefitted people and the environment.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science. In all investigations:

Students don't know the "answer" they are supposed to get.

Students play a driving role in determining the process for learning.

Teachers and students construct meaning together by journaling.

Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

To collect, process, and produce representations of their data, students will need:

- Journals
- Internet access
- Investigation Plan
- Graphing or presentation software (Google Slides, Microsoft PowerPoint, Prezi, or similar tool)

Part 2

INVESTIGATION FACILITATION

Question

Introduce the investigation question.

How does air quality in recent years compare to air quality in the past?

- Introduce the investigation question and share additional background information about smog as necessary.

OPENNESS TO NEW IDEAS

Students may not have experienced smog or even know what smog is. Students need to understand the difficulties that poor air quality and acute air quality events like smog present. Provide students with some pictures of smog in different cities in the past. Ask students how smog could affect breathing, animals, homes, clothing, or sports.

Personal Knowledge

Students capture what they already know about how air quality in recent years compares to air quality in the past.

- Ask students to discuss their personal knowledge of the investigation question within small groups.
- Then, assign each student one of the six criteria air pollutants to investigate: Carbon monoxide (CO), lead, Nitrogen dioxide (NO2), ozone, particulate matter (PM), and Sulfur dioxide (SO2).
- Ask students to meet in groups based on criteria air pollutants groups to share their personal knowledge about their assigned pollutant.
- Remind students to write down what they know in their journals as well as record additional ideas shared by their peers.

RICH LANGUAGE

Challenge students to use the vocabulary particular to air pollution found in the atmosphere. All fields of science utilize descriptions and labels specific to their content. Vocabulary terms common to studies of air pollution include *emissions, particulates, exposure, accumulation, neurological, and cardiovascular*. Encourage students to share and collaboratively define these and other terms in their group discussions throughout the investigation.

Prediction

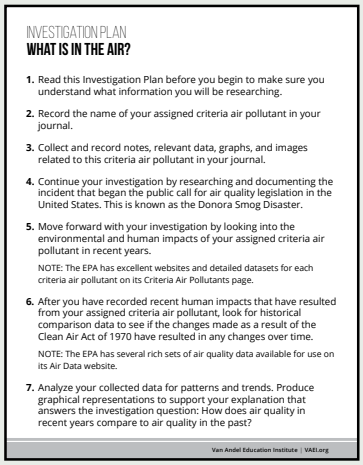
Students communicate an expected outcome, based on prior knowledge.

- Repeat the investigation question.
- Ask students to write a prediction focusing on their assigned criteria air pollutant in their journals.
- Students present the prediction as *I predict that (insert criteria air pollutant) has _____ in recent years because _____.*

Investigation Plan

Students conduct research to determine how air quality in recent years compares to air quality in the past.

- Hand out a copy of the Investigation Plan.
- Remind students to read the entire plan before they begin working.
- Students can begin their investigation by documenting the incident that began the call for air quality legislation in the United States, the Donora Smog Disaster. Primary source documents as well as contemporary news videos and articles written for anniversaries of the event are easily found online.



INVESTIGATION PLAN

WHAT IS IN THE AIR?

1. Read this Investigation Plan before you begin to make sure you understand what information you will be researching.
2. Record the name of your assigned criteria air pollutant in your journal.
3. Collect and record notes, relevant data, graphs, and images related to this criteria air pollutant in your journal.
4. Continue your investigation by researching and documenting the incident that began the public call for air quality legislation in the United States. This is known as the Donora Smog Disaster.
5. Move forward with your investigation by looking into the environmental and human impacts of your assigned criteria air pollutant in recent years.

   NOTE: The EPA has excellent websites and detailed datasets for each criteria air pollutant on its Criteria Air Pollutants page.
6. After you have recorded recent human impacts that have resulted from your assigned criteria air pollutant, look for historical comparison data to see if the changes made as a result of the Clean Air Act of 1970 have resulted in any changes over time.

   NOTE: The EPA has several rich sets of air quality data available for use on its Air Data website.
7. Analyze your collected data for patterns and trends. Produce graphical representations to support your explanation that answers the investigation question: How does air quality in recent years compare to air quality in the past?

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Investigation Plan

Observation

Students record how air quality in recent years compares to air quality in the past.

- After documenting the Donora Smog Disaster or related air pollution events, students should move forward in time and investigate the impact of their assigned criteria air pollutant on humans and the environment today. The EPA has detailed information on dedicated websites for each criteria air pollutant on the Criteria Air Pollutants page of their website.
- After students have recorded past and present human impacts resulting from the criteria air pollutant, students should look for comparison data for their assigned criteria air pollutant to see if the legislation resulted in any changes over time. The EPA conducts studies as required by law, so there is comparison data for these criteria air pollutants over several decades. An excellent set of this air quality data is available at the EPA's Air Data website.
- Students will collect and record relevant data, graphs, and images for their criteria air pollutant in their journal.

SELF-DIRECTION

Students work individually to investigate and describe the human and environmental impact of their assigned criteria air pollutant. To provide a narrative context for the Clean Air Act itself, they should begin their investigation by documenting the incident that began the call for air quality legislation in the United States, the Donora Smog Disaster.

Part 3

INVESTIGATION ANALYSIS AND DEVELOPMENT OF CLAIM

Data Analysis

Students make sense of their data by organizing it and representing it visually.

- Have students analyze their data. They may wish to use the Data Analysis prompt as a guide.
- Have students **evaluate** their data for trustworthiness.
- Then, have them analyze their data to find patterns and trends. They may **organize** the data and/or **represent** it visually to construct meaning. Encourage students to use math as appropriate to make sense of the collected data. They may also want to graph or chart results to better interpret what the data means.
- Have students **interpret** what the identified patterns or trends mean.
- Ensure they have enough data that it can be used as evidence to support a claim.

Secondary Knowledge

Students use secondary sources to understand how air quality in recent years compares to air quality in the past.

Introduce these secondary sources to provide a deeper understanding of the ongoing air quality emissions data gathering required by law.

Environmental Protection Agency: Air Emission Inventories
Environmental Protection Agency: Criteria Air Pollutants
Environmental Protection Agency: Air Data
Environmental Protection Agency: Status and Trends of Key Air Pollutants

- Also note that studies of particulate matter have changed over time as technology improved and smaller particulate sizes were included in air quality studies. For a long-range comparison of like items, students can compare the PM10 data for inhalable particulates 10 micrometers in diameter and smaller (like dust). The newer PM2.5 category is for fine inhalable particulates 2.5 micrometers in diameter and smaller (like combustion particles) that can only be detected by an electron microscope.
- After reviewing these air quality emissions websites, students should be able to describe the human and environmental impact of the criteria air pollutant they investigated.

CRITICAL THINKING

After viewing data for their assigned criteria air pollutant on the Environmental Protections Agency: Criteria Air Pollutants websites, students can review the other secondary sources for more information to add to their presentation. The EPA's Air Emission Inventory details state and local emission reporting requirements and more.

Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from the analyzed data to write an explanation that answers their investigation question. Students may wish to use the Explanation prompt as a guide. Have them write their explanation in their journal.
- Have students develop a **Claim** to answer the question: How does air quality in recent years compare to air quality in the past?
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the information obtained from this investigation as well as science principles they have learned.

Claim

Air quality measurements for ozone have decreased over each of the past 5, 10 and 25 years.

Note: Student claims that all six criteria air pollutants have been reduced since the Clean Air Act of 1970 are correct.

Evidence

The Environmental Protection Agency data summarized on the Environmental Protection Agency: Air Quality National Summary page for ozone collected since 1980 shows a reduction in the amount of this pollutant in our air using measurements from monitors located across the country.

Reasoning

Investigation: The effects of ozone on the body include wheezing and shortness of breath because ozone can cause the muscles in the airways to constrict, trapping air in the alveoli. This leads to lung diseases such as asthma, emphysema, chronic bronchitis, and chronic obstructive pulmonary disease (COPD). Ozone can damage the lungs even after the symptoms (wheezing, shortness of breath, pain when taking a deep breath, coughing, and sore or scratchy throat) have disappeared.

Science: Air Quality National Summary page for data collected since 1980 also has a Trends Summary page for each of the six criteria air pollutants. According to the Ozone Trends page, the ozone that caused so much trouble in Donora, Pennsylvania in 1948 has declined 32% between 1980 and 2015 in 212 sites across the United States.

- Once the explanation is written, have students share their results using a Present and Defend.

DISCOURSE

Have one or two students from each criteria air pollutant group conduct a Present and Defend. Students present a summary of their investigation to the class. The class analyzes the information presented and asks clarifying questions, challenges and/or supports the arguments made, and even presents alternative explanations as appropriate. Students then defend their explanation with evidence and reasoning.

Evaluation

Students reflect on the investigation.

Discuss the following questions:

- What surprised me?
- How has my understanding of air quality laws and monitoring changed as a result of this investigation?
- What question would I like to investigate next?

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION

Application

Students demonstrate understanding of how air quality in recent years compares to air quality in the past by considering longer-term impacts of the Clean Air Act.

- Now that students understand the impact of pollution and the effects of the Clean Air Act, have them consider the difference between short-term effects and long-term effects and how both impact the lives of humans and in particular, children.
- Consider and discuss how acid rain, a product of air pollution, affects both the environment and human-made items, such as buildings, statues, monuments, and tombstones.
- Dig deeper into the atmospheric chemical reactions that result in acid rain, photochemical smog, or air quality issues related to each of the criteria pollutants by documenting the geochemical chain of events (and related chemical reactions) that produce any of these criteria air pollutants.

Assessment

- For a **formative assessment**, check in with small groups of students after they have studied the Donora Smog Disaster and collected their initial data about their assigned criteria air pollutant. Evaluate their explanations on how well they:
  - identify what was in the air in Donora, Pennsylvania in October 1948.
  - explain what people wanted to do about the air quality after the Donora Smog Disaster.
  - describe their initial understanding of human and environmental impacts from the criteria air pollutant.
- For a **summative assessment**, evaluate each student's explanations on how well they:
  - investigated and described the human and environmental impact of their assigned criteria air pollutant.
  - show changes in air quality over time for their assigned criteria air pollutant.
  - evaluated the relative effectiveness of the Clean Air Act in improving air quality over time for their assigned criteria air pollutant.

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