



AIR POLLUTION 101

INTRODUCTION

Students will gain background knowledge of the basic sources of air pollution, along with the overview of how air pollution affects our health and our environment. They will participate in a hands-on demonstration to visually demonstrate that everyone has an impact on air pollution. Students will also write a description of each pollutant, as well develop their own ideas of the most dangerous and most significant pollutants. They will form ideas of how these pollutants can be reduced and how their air can be revitalized and the negative impacts of air pollution can be reduced.

LESSON OVERVIEW

Grade Level & Subject: Grades 9-12: Science

Length: 1 class period

Objectives:

After completing this lesson, students will be able to:

- Comprehend the basics of air pollution
- Identify the seven main air pollutants
- Describe the sources of the main air pollutants

National Standards Addressed:¹

This lesson addresses the following [National Science Education Standards](#) from the National Academies of Science:

- **Content Standard: [NS.5-8.1 SCIENCE AS INQUIRY](#)**
As a result of their activities in grades 9-12, all students should develop:
 - Abilities necessary to do scientific inquiry
 - Understandings about scientific inquiry
- **Content Standard: [NS.9-12.5 SCIENCE AND TECHNOLOGY](#)**
As a result of their activities in grades 9-12, all students should develop
 - Abilities of technological design
 - Understandings about science and technology
- **Content Standard: [NS. 9-12.6 PERSONAL AND SOCIAL PERSPECTIVES](#)**
As a result of their activities in grades 9-12, all students should develop an understanding of:
 - Personal and community Health
 - Population growth

¹ <http://www.education-world.com/standards/national/index.shtml>

- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Materials Needed:

- **Reproducible #1 – Daily Activities**
- Computers with Internet access for each group or other means of researching air pollutants
- 1 Clear, plastic (or small glass) jars recycled from café for each student
- Liquid food coloring-set for each group or table or student, depending on teacher preference. For this lesson, we used red, green, yellow, and blue.
- Ground charcoal (from pet store, or ground substance that will not dissolve in water)
- Cocoa mix and lemonade drink mix (each student will need some of each mix)
- Clean water
- 1 Large container to hold all of students' water once they have completed the demonstration
- Newspaper articles about air quality if available (optional)

Assessment:

Students will be assessed through the following activities:

- Participation in all activities
- Group work and level of understanding of the pollutants in Activity One
- Content and quality of the paper written in the extension activity

LESSON BACKGROUND

Relevant Vocabulary:

- **Carbon Monoxide:** A colorless, odorless gas formed when a compound containing carbon burns incompletely because there is not enough oxygen. It is present in the exhaust gases of automobile engines and is very poisonous.²
- **Lead:** Heavy metal that can cause mental retardation, and increase in the rate of infections and cancer by blunting body's defense mechanisms (the immune system). Lead accumulates in blood, bones, and soft tissue and may result in damage to brain, central and peripheral nervous system, and kidneys. While its suggested threshold is 0.4 part-per-million (ppm) for adults and 0.3 ppm for children, people can exhibit lead poisoning symptoms at 0.2 ppm. Lead intake can occur through water stored in lead pipes, food contaminated by lead in soil, lead-paint flakes, or motor exhaust that contains lead compounds as ant-knocking or performance enhancing additives in gasoline.³

² The American Heritage® Science Dictionary Copyright © 2005 by Houghton Mifflin Company. Published by Houghton Mifflin Company. All rights reserved. Retrieved 05 May 2011 from <http://www.thefreedictionary.com/carbon+monoxide>.

³ "What Is Lead (Pb)? Definition and Meaning." *BusinessDictionary.com - Online Business Dictionary*. Retrieved 05 May 2011 from <http://www.businessdictionary.com/definition/lead-Pb.html>.

- **NAAQS:** National Ambient Air Quality Standards. The designated level at which the presence of a criteria pollutant is deemed safe. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings.⁴
- **Nitrogen Dioxide:** A poisonous brown gas, NO₂, often found in smog and automobile exhaust fumes and synthesized for use as a nitrating agent, a catalyst, and an oxidizing agent.⁵
- **Ozone:** An unstable, poisonous allotrope of oxygen, O₃, that is formed naturally in the ozone layer from atmospheric oxygen by electric discharge or exposure to ultraviolet radiation, also produced in the lower atmosphere by the photochemical reaction of certain pollutants. It is a highly reactive oxidizing agent used to deodorize air, purify water, and treat industrial wastes.⁶
- **Particulate Matter:** Material suspended in the air in the form of minute solid particles or liquid droplets, especially when considered as an atmospheric pollutant.⁷
- **Sulfur Dioxide:** A colorless, poisonous gas or liquid with a strong odor. It is formed naturally by volcanic activity, and is a waste gas produced by burning coal and oil and by many industrial processes, such as smelting. It is also a hazardous air pollutant and a major contributor to acid rain.⁸
- **US Environmental Protection Agency (EPA):** Independent agency of the U.S. government, with headquarters in Washington, D.C. It was established in 1970 to reduce and control air and water pollution, noise pollution, and radiation and to ensure the safe handling and disposal of toxic substances. The EPA engages in research, monitoring, and the setting and enforcement of national standards. It also issues statements on the impact of operations of other federal agencies that are detrimental to environmental quality, and it supports the antipollution activities of states, municipalities, and public and private groups.⁹

⁴ "National Ambient Air Quality Standards (NAAQS)." *Air and Radiation*. EPA, 18 Apr 2011. Web. 28 Jun 2011. <http://www.epa.gov/air/criteria.html>.

⁵ The American Heritage Dictionary of the English Language, Fourth Edition, 2000 by Houghton Mifflin Company. Updated in 2009. Published by Houghton Mifflin Company. Retrieved 05 May 2011 from <http://www.thefreedictionary.com/nitrogen+dioxide>.

⁶ The American Heritage Dictionary of the English Language, Fourth Edition, 2000 by Houghton Mifflin Company. Updated in 2009. Published by Houghton Mifflin Company. Retrieved 05 May 2011 from <http://www.thefreedictionary.com/ozone>.

⁷ The American Heritage Dictionary of the English Language, Fourth Edition, 2000 by Houghton Mifflin Company. Updated in 2009. Published by Houghton Mifflin Company. All rights reserved. Retrieved 05 May 2011 from <http://www.thefreedictionary.com/particulate+matter>.

⁸ The American Heritage Science Dictionary, 2005 by Houghton Mifflin Company. Published by Houghton Mifflin Company. All rights reserved. Retrieved 05 May 2011 from <http://www.thefreedictionary.com/sulfur+dioxide>.

⁹ The Columbia Electronic Encyclopedia, 2007. Columbia University Press. Licensed from Columbia University Press. Retrieved 05 May 2011 from <http://encyclopedia2.thefreedictionary.com/Environmental+Protection+Agency>.

- **Volatile Organic Compound:** Any toxic carbon-based (organic) substance that easily become vapors or gases—e.g., solvents—paint thinners, lacquer thinner, degreasers, dry cleaning fluids¹⁰

Background Information:

Air pollution can have detrimental impacts on humans, animals, plants, and water. For the most part, air pollution is caused by humans and derives from burning coal, oil, wood, and other carbon-based fuels to run factories, cars, and to generate electricity. Pollution is a major contributor to the development of acid rain and smog, as well, as global warming. In 1970, the U.S. **Environmental Protection Agency (EPA)** was established through the original Clean Air Act to oversee pollution in the U.S. The agency was made responsible for overlooking dangerous emissions and analyzing the causes and effects. The EPA monitors the six “criteria pollutants;” **particulate matter, carbon monoxide, ground-level ozone, sulfur dioxide, nitrous oxides, and lead** to ensure that only safe concentrations are released into the atmosphere, thereby . The EPA also supports and enforces efforts to reduce pollution levels. Yet there are still many areas in the United States that do not meet EPA designated **NAAQS**.

VOCs are not one of the 6 criteria pollutants the EPA is charged with regulating. However the EPA still monitors VOC’s and its effect and because VOCs react in the atmosphere to produce ozone, the EPA can regulate their use in common products used outdoors. However, The Clean Air Act gives the EPA no authority to regulate indoor air quality. VOCs contribute to ozone pollution outside and in high concentrations can be very dangerous to human health.

Unlike the EPA, air pollution is not tied down. It travels through the air to different regions, states, and sometimes even other countries. Pollution not only degrades the environment but causes significant health problems for the human population. It’s therefore important for students to understand what’s in the air we breathe, where it comes from and what can be done to reduce the impact.

Resources:

- **Air Pollutants** *Environmental Protection Agency*
<http://www.epa.gov/air/airpollutants.html>
Thorough information about a wide range of air pollutants, including basic information, standards, and indoor air quality information.
- **50 Things You Can Do** *California Environmental Protection Agency*
<http://www.arb.ca.gov/html/brochure/50things.htm>
Detailed list of many things an individual can do to reduce air pollution
- **National Ambient Air Quality Standards (NAAQS)** *Environmental Protection Agency*
<http://www.epa.gov/air/criteria.html>
Current NAAQS for the 6 air pollutants currently regulated by the EPA
- **Indoor & Outdoor Air Pollution** *Lawrence Berkeley National Laboratory*

¹⁰ McGraw-Hill Concise Dictionary of Modern Medicine, 2002 by The McGraw-Hill Companies, Inc.
Retrieved 05 May 2011 from <http://medical-dictionary.thefreedictionary.com/Volatile+organic+compounds>.

<http://www.lbl.gov/Education/ELSI/pollution-main.html>

More information and classroom activities about air pollution.

- **Air Pollution** *National Geographic*
<http://environment.nationalgeographic.com/environment/global-warming/pollution-overview.html>
Article about air pollution and its causes.
- **Air Pollution** *National Institute of Environmental Health Sciences*
<http://www.niehs.nih.gov/health/topics/exposure/air-pollution/index.cfm>
Extensive list of links to more information, and resources for educators and students to learn about air pollution, its affects on human health, and what the NIEHS is doing about it.

LESSON STEPS

Warm-Up: *Air Pollution in Your Town*

1. Write the words “Air Quality” on the board and ask students the following questions:
 - a) Do you think the quality of the air in this area is good or bad?
 - b) How do you know? What evidence is there of air pollution? *Answers might include smog, a high occurrence of asthma or other respiratory diseases, a bad smell, or particulates settling out of the air. Or they may infer there is poor air quality without evidence because of the presence of industrial practices nearby. Alternatively, they may believe air quality is good because of the absence of all these things.*
 - c) Have you ever experienced burning eyes, itchy throat, or shortness of breath on polluted days?
 - d) What time of the year does the air seem dirtiest? *Kids may not notice, but air pollution is typically worse in the summer months because of higher temperatures and more sun which both help create certain pollutants like ozone. Also, there is less rain to wash pollutants out of the air and away.*
2. Tell students that the issue of “air quality;” or how good or bad the air is, is often in the news. Show any newspaper articles you have found.
3. Ask students why there is so much talk about air quality? Guide them to identify the importance of air for living things. Explain that bad air can contribute to a variety of illnesses such as asthma and cancer. Air pollution can also decrease the efficiency with which plants photosynthesize, making them less productive.

Activity One: *Interviewing New Pollutant Experts*

1. Divide the class into seven groups, and assign each group one of the seven pollutants defined in the “Relevant Vocabulary” section (PM, CO, O₃, SO₂, NO_x, Pb, VOCs).
2. Give the students time to use the websites in the Resources section and any others resources they might find to research their assigned pollutants.
3. Students should take notes on their pollutant, including information about its sources, effects, NAAQS, and any other relevant information they might find.
4. Once the time for research is expired, call each group individually up in front of the class and have them write the name of their pollutant on the board.

5. Allow students time to interview the group, asking important questions about that group's pollutant. The group should be able to answer all the questions well, and every member of the group should contribute to providing answers. Students should take notes as each group is interviewed.
6. Tell students to save this information for the Extension activity.

Activity Two: *What are the Consequences of Some Daily Activities?*

1. Divide your class into work groups of three to six students each
2. Give each student a clear plastic cup that is $\frac{3}{4}$ full of clean water
3. Give each work group a set of supplies (food colorings, ground charcoal, cocoa mix and drink mix)
4. Now write on the board the corresponding food coloring or drink mix (below) and explain to the students that these colors/mixes will illustrate a particular pollutant that was discussed

Air Pollutant	Corresponding color/mix
Sulfur Dioxide (SO ₂)	Pinch of lemonade mix
Nitrous Oxides (NO _x)	Pinch of cocoa drink mix
Carbon Monoxide (CO)	One drop red food coloring
Lead (Pb)	One drop green food coloring
Volatile Organic Compounds (VOCs)	One drop blue food coloring
Particulate Matter (PM)	Pinch of ground charcoal
Ozone (O ₃)	One drop yellow food coloring

5. Now tell the students that a series of daily activities will be read. If the student has participated in the activity within the past week, they are to add the appropriate amount of the corresponding pollutant into their cup of water. All activities will not apply to every student. Read the activities off of **Reproducible #1—Daily Activities**. Feel free to add or delete activities as they might relate specifically to the school or community.

Wrap-Up: *Discussing Your Impact*

Ask your students the following questions:

1. Look inside your cups. If the air pollution around you were this apparent, would you want to breathe the air? *No*
2. What other sources of air pollution, beyond those mentioned in this demonstration, could you think of as being produced in a single day? *Answers will vary but could include using other electricity or gas powered appliances.*
3. Pour each students "polluted water" into the larger container and explain how this represents some of what people breathe every day. Of course, much is diluted in the huge volume of the atmosphere, but it is getting more concentrated daily with more people increasing their activities which contribute to air pollution.

4. Help students come up with a list of things they can do to reduce their impact. Such as:

- Drive less
- Drive smart
- Buy smart (energy efficient appliances, items with less packaging, items produced with green energy, etc.)
- Choose air friendly products (soy candles, items like those mentioned above, no CFCs, etc.)
- Save energy
- Practice the 3 R's (Reduce, Reuse, and Recycle)
- Don't smoke
- Speak up for clean air

Extension: *What Has the Most Significant Impact?*

1. Tell the students to think about which pollutant they think is the most dangerous and why.
2. Tell the students to consider how much of this pollutant is released, what the risks associated with it are, and how we can reduce our emissions of this pollutant.
3. Have each student write a 500 word response detailing the “worst” pollutant, its effects, and his or her ideas of how we can reduce its atmospheric concentration. This can be written in class, or assigned as homework. *Note: Students may not all write their papers on the same pollutant, and that's okay. The key is that each student supports his or her argument with facts and a conceptual understanding of the impact his or her pollutant is having on the environment.*

CONCLUSION

After completing this lesson, students have a more comprehensive knowledge of seven of the most significant air pollutants and where they come from. They understand how people's different daily activities contribute to air pollution and have discussed ways to reduce their impact. Students developed their communication and analytical skills by taking a position on which pollutant is most harmful, and defending that position with supporting facts.

LESSON CREDITS

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Daily Activities

- 1) You drove or were a passenger in a car/truck
 - *1 drop red coloring*-represents **Carbon Monoxide (CO)** in motor vehicle exhaust
 - *1 drop blue coloring*-represents the **Volatile Organic Compounds (VOCs)** produced by the engine when gasoline or oil is burned
 - *1 pinch lemonade mix*-represents **Sulfur Dioxide (SO₂)** in auto exhaust
 - *1 pinch cocoa*-represents **Nitrogen Dioxide (NO₂)** from vehicle exhaust

- b. You enjoyed heat, air conditioning, or a warm shower
 - *1 drop green coloring*-represents **Lead (Pb)** in electricity generation
 - *1 pinch lemonade mix*-represents **Sulfur Dioxide (SO₂)** released from electric utilities
 - *1 pinch of cocoa*-represents **Nitrogen Dioxide (NO₂)** emitted by combustions used to generate electricity and heat water

- c. You used nail polish or hairspray
 - *1 drop blue coloring*-represents **Volatile Organic Compounds (VOCs)** in indoor air

- d. You used your computer, charged your mp3 player, played video games, or watched TV.
 - *1 pinch of ground charcoal*-represents **Particulate Matter (PM)** resulting from power plants burning coal to produce electricity
 - *1 drop green coloring*-represents **Lead (Pb)** resulting from power plants burning coal to produce electricity
 - *1 pinch lemonade mix*-represents **Sulfur Dioxide (SO₂)** resulting from power plants burning coal to produce electricity

- e. You or your family burned firewood or yard debris
 - *1 drop red coloring*-represents the **Carbon Monoxide (CO)** in wood burning
 - *1 pinch ground charcoal*-represents **Particulate Matter (PM)** in the burning, leaving ash and soot

- f. You or your family used paint or some type of solvent
 - *1 drop blue coloring*-represents **Volatile Organic Compounds (VOCs)** when chemicals evaporate
 - *1 drop yellow coloring*-represents **Ozone (O₃)** evaporation

- g. You or your family used gasoline-powered equipment to mow the lawn, blow yard clippings, or whack the weeds.
 - *1 drop blue coloring*-represents **Volatile Organic Compounds (VOCs)** in exhaust and gas vapors
 - *1 pinch lemonade mix*-represents the **Sulfur Dioxide (SO₂)** emitted by the equipment's engine

- *1 pinch cocoa*-represents **Nitrogen Dioxide (NO₂)** in exhaust from burning fuel
- *1 drop yellow coloring*-represents **Ozone (O₃)** from fuel combustions and evaporation

h. You or your family purchased gasoline at the gas station

- *1 drop yellow coloring*-represents **Ozone (O₃)** from evaporation while filling tank (mostly occurs on hot, sunny day)
- *1 drop blue coloring*-represents **Volatile Organic Compounds (VOCs)** when chemicals evaporate

i. You or your family had clothes dry- cleaned.

- *1 drop of blue food coloring*-represents the **Volatile Organic Compounds (VOCs)** emitted by the dry-cleaning process

j. You or someone in your family smoked a cigarette

- *1 drop red coloring*-represents **Carbon Monoxide (CO)** in tobacco smoke
- *1 pinch lemonade mix*-represents the **Sulfur Dioxide (SO₂)** gas in tobacco smoke
- *1 pinch cocoa mix* -represents traces of **Nitrogen Dioxide (NO₂)**, which can be found in tobacco smoke