Teacher Resources

GOOD

MODERATE

UNHEALTHY FOR SENSITIVE GROUPS

UNHEALTHY

VERY UNHEALTHY

AQI
AIR QUALITY INDEX

Introduction

Because children's lungs and bodies are still developing, children are one of the sensitive groups at risk for health effects of air pollution. Air quality education empowers students and their families to know why and how they should protect their health when the air is polluted. The materials in this "Teachers" section of the toolkit, compiled by the U.S. Environmental Protection Agency, contain activities and resources you can use to teach students about the connections between weather, air pollution, and health concerns, as well as the actions they can take to protect their health and reduce pollution. The activities meet national education standards for science and health (see below).

This "Teachers" section of the toolkit includes:

- Easy-to-implement activities appropriate for:
  - Grades 3 through 5
  - Grades 6 through 8
- Background information and resources:
  - Air Pollution and Health
  - What Is the Air Quality Index?
  - Additional Air Quality Resources for Teachers

Education Standards

The lesson activities in this toolkit meet the following National Science Educators Standards (www.nap.edu/html/nses/html) and National Health Education Standards (www.aahperd.org/aahe/pdf_files/standards.pdf) (developed by the Joint Committee on National Health Education), as verified by an education expert:

Activity	Education Standards
Breathing, Exercise, and Air Pollution	*Unifying Concepts and Processes* Evidence, Models, and Explanation Constancy, Change and Measurement *Science as Inquiry* Abilities Necessary to do Scientific Inquiry *Life Science* Organisms and Their Environments *Science in Personal and Social Perspectives* Personal Health Types of Resources

Education Standards (cont.)

Activity	Education Standards
Particle Pollution: How Dirty is the Air We Breathe?	*Unifying Concepts and Processes* Evidence, Models, and Explanation *Science as Inquiry* Abilities Necessary to do Scientific Inquiry *Life Science* Organisms and Their Environments *Science in Personal and Social Perspectives* Types of Resources Changes in Environments
Air Pollution: What's the Solution? The Ozone Between Us	*Science as Inquiry* Abilities Necessary to do Scientific Inquiry *Life Science* Organisms and Their Environments *Science in Personal and Social Perspectives* Types of Resources Changes in Environments
Tracking Air Quality	*Unifying Concepts and Processes* Evidence, Models and Explanations *Science as Inquiry* Abilities Necessary to do Scientific Inquiry Understandings About Scientific Inquiry *Science in Personal and Social Perspectives* Personal Health Populations, Resources and Environments Risks and Benefits
Smog Alert	*Unifying Concepts and Processes* Evidence, Models and Explanations *Science as Inquiry* Abilities Necessary to do Scientific Inquiry Understandings About Scientific Inquiry *Science in Personal and Social Perspectives* Personal Health Populations, Resources and Environments Risks and Benefits

Education Standards (cont.)

Activity	Education Standards
What's "Riding the Wind" in Your Community?	*Unifying Concepts and Processes* Evidence, Models and Explanations *Science as Inquiry* Abilities Necessary to do Scientific Inquiry Understandings About Scientific Inquiry *Science in Personal and Social Perspectives* Personal Health Populations, Resources and Environments Risks and Benefits
Smog City	*Unifying Concepts and Processes* Evidence, Models and Explanations *Science as Inquiry* Abilities Necessary to do Scientific Inquiry Understandings About Scientific Inquiry

Air Quality Activities: Grades 3-5

Breathing, Exercise, and Air Pollution

Summary

Air is essential to life. Humans and other animals use the oxygen they breathe along with the food they eat to produce energy. Increased physical activity raises the body's energy demand, which increases consumption of oxygen and nutrients. When we are active, we notice an increase in breath rate. This is our respiratory system's response to increased energy demand.

More air flowing in and out of our lungs can increase our exposure to air pollution. As a result, active children, adults, and athletes are more vulnerable to the unhealthy impacts of air pollution. During episodes of unhealthy levels of air pollution, public health officials may advise that people reduce their outdoor activities (e.g., soccer, running).

Grade Level

Grades 3-5

Estimated Time

30 minutes

Materials

Stopwatch, watch, clock, or timer for each team (if using the classroom clock, the teacher or a student can be the timer for the whole class if there are not enough watches for each group)

Student Worksheet (included)

Relevant National Science and Health Education Standards

Unifying Concepts and Processes
Evidence, Models, and Explanation
Constancy, Change and Measurement

Science as Inquiry
Abilities Necessary to do Scientific Inquiry

Life Science
Organisms and Their Environments

Science in Personal and Social Perspectives
Personal Health
Types of Resources

Objective

Students will:

- Observe and record how breathing changes with physical activity

Directions

1. Have students form research teams of 2-3 persons. In the 2-person groups, one student will time and record data while the other student will be the research subject. In the 3-person groups, one student will time, one will record data, and the last will be the research subject. If time permits, each team member can take a turn as the research subject.

2. Hand out the Student Worksheet to each team. Hand out the stopwatches, if using them, or make sure the person acting as the timekeeper is ready. Each team will write their prediction on the Worksheet, answering the question, "Does a person breathe more or less during exercise?"

3. *Breathing at Rest.* The subject is sitting down. The timer/recorder will give the subject the following instructions. "When I say start, begin counting your breaths. Breathe normally." The timer tells the subject to start. After 1 minute, the timer asks the subject how many breaths he or she has taken. The timer records the number on the Worksheet under the subject's name.

4. *Breathing during Exercise.* The timer/recorder tells the subject, "When I say start, begin jumping up and down. After 15 seconds, I will say stop. Stop jumping and immediately start counting your breaths." The timer tells the subject to start. After 15 seconds, the timer tells the subject to stop jumping. After an additional 15 seconds, the timer asks the subject for a breath count. The recorder writes the number of breaths on the worksheet and multiplies it by 4. The timer asks the subject, "Did you breath more or less when you exercised?" The recorder writes down the answer.

5. Repeat Steps 3 and 4 until each team member has been the subject, if time allows for switching roles.

6. *Comparing results.* Have each team make a chart or graph showing the results of their research. Have one member of the team present their prediction and results to the class. Discuss the variety of results. What other variables could cause widely varying results (e.g., physical condition, respiratory illness such as asthma)? How could the results for the whole class could be shown?

Extension

Have students play a quick game of basketball or walk quickly up and down a flight of stairs a few times rather than jumping up and down in place, if not too disruptive.

Acknowledgments

California Air Resources Board, The KnowZone
URL: www.arb.ca.gov/knowzone/knowzone.htm

Student Worksheet — Breathing and Exercise

Prediction: "Does a person breathe more or less during exercise such as jumping up and down?"

How much more or less? ________________ (For example: Half as much? Twice as much?)

A. Subject A: ____ (name)

Breaths in one minute at rest ______
Breaths after 15 seconds of exercise _____ x 4 = ________
Is the breathing more or less after jumping? ___________________

B. Subject B: ____ (name)

Breaths during one minute at rest ______
Breaths after 15 seconds of exercise _____ x 4 = ________
Is the breathing more or less after jumping? ___________________

C. Subject C: ____ (name)

Breaths in one minute at rest ______
Breaths after 15 seconds of exercise _____ x 4 = ________
Is the breathing more or less after jumping? ___________________

D. Present your results as a chart or graph.

E. Why might it be important to be less active when air quality levels are unhealthy?

What steps could be taken to limit activity and excessive strain on our lungs? (Discuss with class. *Possible answer:* Walk instead of run)

Particle Pollution: How Dirty Is the Air We Breathe?

Summary

The atmosphere is almost completely made up of invisible gaseous substances. Most major air pollutants are also invisible, although large amounts of them concentrated in areas such as cities can be seen as smog. One often visible air pollutant is particle pollution, especially when the surfaces of buildings and other structures have been exposed to it for long periods of time, or when it is present in large amounts. Particle pollution is made up of tiny particles of solid matter and droplets of liquid, and can be produced by human activities or natural sources. Coal and oil burned by power plants and industries, and diesel fuel burned by many vehicles are the chief sources of particle pollution associated with human activities. Not all important sources are large scale, however. The use of wood in fireplaces and wood burning stoves also produces significant amounts of particle pollution in some local areas, although the total amounts are much smaller than those from vehicles, power plants, and industries. Natural sources of particle pollution include smoke from fires and volcanic ash, which can be blown about by the wind.

Grade Level

Grades 3-5

Estimated Time

30 minutes

Materials

Plastic squares (5 centimeters by 5 centimeters)

Petroleum jelly

Masking tape

Blocks of wood

White paper for each child or each group of children

Relevant National Science and Health Education Standards

Unifying Concepts and Processes
Evidence, Models, and Explanation

Science as Inquiry
Abilities Necessary to do Scientific Inquiry

Life Science
Organisms and Their Environments

Science in Personal and Social Perspectives
Types of Resources
Changes in Environments

Objectives

Students will:

- Make a simple particle pollution tester
- Collect and observe particle pollution from the air

Directions

1. Tell the students, “As we look outside, we often see a clear blue sky. Where is the pollution? We are going to make a simple tester for air pollution so we can see the pollution.”
2. Divide the class into groups. Have each group coat their plastic square with a thin, even coat of petroleum jelly. With masking tape, fasten the square, jelly side up, to the wooden blocks.
3. Place the blocks outdoors on posts, fences, walls, and/or window sills. Leave them for 24 hours.
4. Collect the blocks. In the classroom, remove the plastic squares from the blocks. Lay them on white paper.
5. Let the students examine the pollution that collected on the petroleum jelly.
6. Have the groups record the findings of their testers.
7. Have groups share their findings with the other groups. Ask: Did you collect any dirt particles? How does your square compare to those of the other groups? In what places does the air seem to be the dirtiest?
8. Say: We have seen particle pollution where we first saw none. Clean air is important for us to be healthy. What can we do to keep the air clean? *(Possible answers:* People could drive less. We can turn off lights and equipment when we’re not using them. Factories could reduce their pollution. We could use less polluting vehicles and equipment.)

Extensions

- Have students write a paper and explain the differences they observed among the plastic squares.
- Have students take their tester home to test for particle pollution for 24 hours. Students then report to the class on their findings.
- Ask students to leave the tester outside for a week, a month (sheltered from precipitation). Students keep a journal of its progress each day and report to the class.
- Have students compile data on their findings and write the mayor about their samples.

Reference

Holt Science 6th. Holt, Rinehart, and Winston Publishers, New York. p. 257.

Acknowledgment

Texas Natural Resource Conservation Commission (TNRCC)
URL: www.tnrcc.state.tx.us/air/monops/lessons/partlesson4.html

Air Pollution: What's the Solution?
The Ozone Between Us

Summary

At ground level, in the Earth's atmosphere, ozone is an air pollutant that can damage human health, animals, and vegetation and is a key ingredient of smog. Many urban areas tend to have a lot of ground-level ozone, often because of local traffic and industry. Other more rural or suburban areas without major industry or large populations can have a lot of ground-level ozone if the ozone was transported by the wind from other communities. Motor vehicles, factories, and power plants are major sources of ozone pollution. This activity allows students to explore ozone levels in different areas of the country and develop an understanding of why more ozone pollution may be present in certain areas.

Grade Level

Grades 3-5

Estimated Time

20 minutes

Materials

Internet access

Student Worksheet (included)

Relevant National Science and Health Education Standards

Science as Inquiry
Abilities Necessary to do Scientific Inquiry

Life Science
Organisms and Their Environments

Science in Personal and Social Perspectives
Types of Resources
Changes in Environments

Objectives

Students will:

- Discover that ground-level ozone occurs in many areas of the country
- Discover that ground-level ozone problems are often associated with population centers

Directions

1. Have the class access the following Internet web site:
   www.k12science.org/curriculum/airproj/lessonscore1.html

2. On this web site, have students open the pages for two items:
   Ozone Map
   Air Quality Guide for Ozone

   (Note: A modified version of the Student Worksheet is included in this Toolkit)

3. With the class, answer the questions on the Student Worksheet. The students will be able to answer the questions using the *Ozone Map* and the *Air Quality Guide for Ozone.*

Extensions

Several resources are available to obtain more information about ground-level ozone for your students. Visit the "Links" section of the above web site, and EPA's AIRNow web site at www.airnow.gov

A videotape entitled *Ozone DoubleTrouble* is available from the U.S. EPA that may be helpful for introducing the topic of ground-level ozone. The video discusses two ozone problems — the formation of too much ground-level ozone (discussed in this activity), and the deterioration of the protective upper-level ozone layer (not covered in this activity). (Contact: EPA Office of Air Quality Planning and Standards (OAQPS), Education and Outreach Group at: www.epa.gov/air/oaqps/eog/contact.html)

Acknowledgment

The Air Pollution: What's the Solution? project was developed by the U.S. EPA, the Northeast States for Coordinated Air Use Management, and the Center for Innovation in Engineering & Science Education. URL: www.k12science.org/curriculum/airproj

Student Worksheet

Air Pollution: What's the Solution?
The Ozone Between Us

Name: ______________________________ Group: ______________

Ozone Map

Review the *Air Quality Guide for Ozone*, including what the different colors mean. Then study the *Ozone Map* and answer the following questions:

1. Find Los Angeles, CA on the map. What color is it? Circle:

   Green Yellow Orange Red Purple

2. Find a city on the map that is red. Write the city and state below.

3. Find two orange cities on the map. Write the city names and states below.

4. Are there any green cities on the map? If so, list three.

5. Where are most of the red and orange areas on the map, near or far away from cities?

6. Write a sentence that compares the kinds of places where green areas are found and the kind of areas where red and orange areas are found.

7. Can you think of any reasons why more ozone pollution would be found in the red areas?

8. What are the cautions, or health concerns, for orange areas? If you lived in an area with orange ozone levels, do you think you would be affected? How?

Air Quality Activities: Grades 6-8

Tracking Air Quality

Summary

In this activity, students locate and study color-coded maps from the Internet showing air quality data for their area. By graphing the data from these maps and discussing the results, they learn how clean or polluted the air they breathe is, the extent of the ozone season in their area, and the relationship between weather and air pollution. While learning about air pollution, they build their research, graphing, and critical thinking skills.

Through this activity, they also become familiar with the Air Quality Index—a standard index for reporting daily air quality to the public. Students learn how the different colors of the AQI scale correspond to different levels of health concern. They also learn who may be affected at different levels of ozone pollution and what steps can be taken to protect health from air pollution.

Grade Level

Grades 6-8

Relevant National Science Education Standards

Unifying Concepts and Processes
Evidence, Models and Explanations

Science as Inquiry
Abilities Necessary to do Scientific Inquiry
Understandings About Scientific Inquiry

Science in Personal and Social Perspectives
Personal Health
Populations, Resources and Environments
Risks and Benefits

Estimated Time

30 minutes - 1 hour per session (6 sessions, optional)

Materials

Internet access

Student Worksheets (included with this toolkit)

Colored pencils in black, green, yellow, orange, red, and purple

Objectives

Students will:

- Observe air quality changes and the impact of weather on air quality
- Demonstrate data gathering and analysis skills and graphing skills
- Apply techniques of comparison and critical thinking

Directions

This activity has a number of variations, all of which involve accessing, observing, and gathering data from AQI color-coded air quality maps on the Internet. Students can be assigned an activity on their own, if they have individual access to the Internet. Or, they can work in teams; each team will need Internet access. If teams are used, the work can be divided in a number of ways. For example, each team can graph data for a different year (in which case three teams can be used) and then the teams can compare their data. Or, each team can focus on air quality data for a particular month in each of the three years. The team then can summarize the data for that month and note any trends.

Accessing and Navigating Air Quality Maps

1. Explain that students will research and graph daily changes in ozone levels for their geographic area.

2. Provide students with copies of the graph of "Air Quality Versus Time" (Student Worksheet #1). (This graph, provided with this toolkit, has an "x" axis labeled "date" with a scale of 31 days and a "y" axis labeled "Air Quality Index" with a scale of 0 to 300. Note: The AQI scale actually runs to 500, but pollution levels in the U.S. virtually never rise above 300, a hazardous level that would trigger health warnings of emergency conditions).

3. Have each team access the following Internet data:
   Air quality maps at: www.airnow.gov - click on "Archives" on the list to the right of the map shown, then:

   a) Click on your geographic area on the map.

   b) On the next screen, select the month and year to be researched, the region, and select "Ozone," then click on "See Map Archives".

   c) Click on the first map, which provides data for the first day of that month. The next screen shows three maps. The activities will focus on the first two maps: "Ozone - AQI Loop," which shows a "movie" of the progression of ozone pollution throughout the day, and "Ozone - Peak AQI," which shows the highest ozone reading for the day.

4. Ask students to observe the color-coded AQI scale to the right of the maps. Each color corresponds to a segment of the AQI scale. Ask students to use the colored markers to mark these segments on the "y" axis of their Worksheet graph as follows: green = 0 to 50; yellow = 51 to 100; orange = 101 to 150; red = 151 to 200; purple = 201 to 300. Have students label these segments as indicated in the key: good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy (alert).

5. Ask students to click on any of the colors displayed on the AQI scale to the right of the maps. This will take them to the *Air Quality Guide for Ozone.* Ask them to look at this guide and notice that the right-hand column has specific messages about how people can protect their health at each different level of ozone pollution.

6. Now students are ready to research and record data on their graphs. To do this, students will need to go back and forth between the three pages mentioned above: (1) the first page which allows you to choose the different sets of maps by selecting the desired region, month, year, and pollutant; (2) the second page which shows all maps for a single month (note that students can navigate from one month to the next by clicking on the triangles to the left [for pre-

vious month] and right [for the next month] of the month and year listed on top of the maps; and (3) the third page which shows three maps for an individual day within the month (the activities below use only the first two of these maps: AQI Loop and Peak AQI).

Activity 1: Graph Ozone Levels for the Warm Months of the Year

Estimated Time: 1 hour (or more depending on the number of students and the number of questions you ask them to answer)

Summary: At ground level, ozone forms when the pollutants nitrogen oxides (NOx) and volatile organic compounds (VOC) react in the presence of heat and sunlight. Therefore, ozone tends to form in warm weather. Each area's ozone season will be as long or as short as the number of warmer months. For this activity, students observe how ozone levels change over several consecutive months and record their observations on the graph "Air Quality Versus Time" (Student Worksheet #1 provided with this toolkit). If possible, ask students to gather data for all warmer months (i.e., months when temperatures tend to be consistently in the 70s or higher), as well as the cooler month just before and after the warm months. Students should have a separate graph for each month. They can gather each month's data fairly quickly by observing the page that displays all maps for that month. Though the maps are small, the colors can be observed reasonably well. If there is any question about what the colors are on the map, students can click on the map to observe it in a large size. For each day of each month, ask students to record on their "Air Quality Versus Time" graph for that month the highest AQI color they see. For example, if they see the colors green, yellow, and orange on a map, they should record that day as "orange" by marking the highest AQI level on the "orange" segment of the "y" axis (i.e., all orange days are marked as "150" which is the highest AQI level for orange; all green days are marked as "50" which is the highest AQI level for green, etc.).

Now ask students to fill out the table "Total Number of Days Each Month with Elevated Ozone Levels" (Student Worksheet #2 provided with this toolkit) to record the total number of days in each month with ozone levels that were green, yellow, orange, and red.

After preparing the graphs and table students can be asked any or all of the following questions:

1. What was the first day for that year when ozone levels were elevated (i.e., yellow or higher)?
2. What was the last day for that year when ozone levels were elevated?
3. Which month had the most green days?
4. Which month had the most yellow days?
5. Which month had the most orange days?
6. Which month had the most red days?
7. Which month had the most purple days?
8. What was the longest ozone "episode"? In other words, what was the most number of days in a row that ozone was elevated in any of these months?
9. Which month of the year was the worst month for ozone (i.e., had the most days when ozone was higher than green)? Which was the next worse ozone month?
10. Rank the months according to how bad they were for ozone, starting with the worst month at the top and the best month at the bottom. Now think about how hot these months are. What do you notice about ozone levels in hotter months?

11. How many days total over all these months were ozone levels elevated (i.e., higher than green)?
12. What percentage of days over these months were ozone levels elevated?
13. Who are the people that must be careful when ozone is at an orange level ("Unhealthy for Sensitive Groups") or above? (Refer to the health messages on the *Air Quality Guide for Ozone* at: www.airnow.gov - search the web site for "Air Quality Guide for Ozone". Note: The answer is: Active children and adults and people with respiratory disease such as asthma.)

Activity 2: Compare Ozone Levels Over Three Years

Estimated Time: 30 minutes (to answer the questions below after students have prepared the graphs and tables as described under Activity 1)

Ask students to create the graphs and table described under Activity 1 for three archived years of ozone data. For each of the questions given under Activity 1, have students compare the answers for the three years to answer these additional questions:

1. Which year had the longest ozone season (i.e., the time period from the first day ozone was observed to the last day)?
2. When you ranked the months from worst to best based on number of days of elevated ozone, were the results the same for each year or different? Does there seem to be any pattern to when ozone levels are elevated in this area? How would you describe that pattern?
3. Children can be sensitive to ozone when it reaches orange levels (see Activity 1). During what time period of the year might it be a good idea to check the AQI forecast regularly?

Activity 3: Graph and Compare Ozone Levels in One Region of the U.S. versus Another

Estimated Time: 20 minutes (after students have prepared the graphs and tables as described under Activity 1 for both regions)

Summary: Different areas of the U.S. have significantly different ozone seasons depending on a number of factors, including climate, pollution sources, and regional transport of pollution away from one area and into another. For this activity, students will create the graphs and table as described under Activity 1 for the same year for two very different areas of the United States. They will answer the questions listed under Activity 1 for each area, and then compare the two areas by answering these additional questions. This will be most interesting if you pick an area that contrasts with your region. For example, if you live in an area where ozone is less often a problem (for example, the Northwest or Hawaii), have students compare that to areas with more frequently elevated ozone levels (such as California, the South and Southwest, and the Mid-Atlantic and Northeast states)—or vice versa. Once the graphs and tables have been prepared, ask students to use the data to answer the following questions:

1. Which region has the longest ozone season? By how much do the two seasons differ? Do you think this is related to temperature in these areas?
2. Compare the total number of days in each region that ozone was elevated. How much worse was ozone pollution in one region versus the other?
3. Compare the length of the longest ozone episode in the two regions. Was the longest ozone episode in the region during the longest ozone season?

Activity 4: Graph and Compare Ozone Levels Over the Course of the Day

Estimated Time: 45 minutes

Summary: Ozone levels tend to be lowest in the morning, rise during the afternoon, and then decline during the evening. This is because (1) temperature and sunlight catalyze the formation of ozone, and (2) the pollutants from human activities (such as transportation) that react to form ozone tend to increase during the day and be lowest at night.

For this activity, students will hypothesize what they expect to observe about ozone levels over the course of a day based on an understanding of how ozone is formed. They will then observe actual ozone levels over the course of three days to test whether their hypothesis is correct. They will record their observations on the table called "Daily Air Quality for ____" (Student Worksheet #3 provided with this toolkit). The rows of the table are marked off in 1-hour increments. The columns correspond to the ozone level (as indicated by the AQI color) for each day.

Start the activity by explaining that ozone at ground level is not emitted directly. Rather, it is formed when two types of pollutants (nitrogen oxides and volatile organic compounds) react in the presence of heat and sunlight. Explain that sources of nitrogen oxide and volatile organic compound pollution include cars, power plants, and chemical plants. Ask students: If ozone needs heat and sunlight to form, when during the day do you think ozone levels will be highest? Then ask them to record data, as described below, to test their hypothesis.

For this exercise, students should use ozone maps from an area of the U.S. that tends to have elevated ozone levels in warm months (California and the South are good choices). Ask students to go to the page showing maps of one of these areas for July or August. From this month, ask them to click on a map that shows ozone at an orange or preferably red level. When they click on that map, they will go to the page that shows three larger maps of this area for that day. For this exercise, ask them to focus on the top map: Ozone — AQI Loop. This map loops through the ozone levels for that day in 20-minute increments. The date and time are shown at the bottom of the map. The animation is rapid, but tell students they can freeze the animation by clicking on the "escape" button on their keyboard. By doing so, they can record the highest AQI level (color) for each hour (i.e., 8 a.m., 9 a.m., etc.) starting with the earliest time ozone levels are provided and ending with the latest time. After they have recorded the ozone level, they will need to click the "back" key and then the "forward" key at the top of the browser to start the animation again. After the students have filled out all the ozone levels for one day, they should pick another day that has red or orange levels and do the same thing. Then, they should repeat for a third day. At this point, they should have enough data to answer the following questions:

1. Of the three days, what was the earliest time that ozone was elevated (i.e., above green)?
2. Of the three days, what was the latest time that ozone was elevated?
3. For each day, what time of day was ozone level the highest?
4. For each day, what time of day was ozone at the green level (i.e., not elevated)?
5. Based on these data, was your hypothesis about ozone correct?
6. When ozone levels are elevated, especially to an orange or red level, it's a good idea to take it easier when you're outside (so you don't breathe as much or as deeply). If the air quality forecast predicts ozone pollution for a summer day, what time of day should you think about taking it easier?

Activity 5: Graph Real-Time Ozone Data for a Month During Ozone Season

Estimated Time: 20 minutes the first day, 5 minutes per day after that, and 20 minutes for discussion on the final day.

If school is in session in your area during the ozone season, students can track the actual ozone forecast and levels each school day for a month. They can compare the forecast data to the actual data to see how accurate the forecasts are. They can also track the peak temperature each day to see whether there is a correlation between ozone levels and temperature.

Each day, at the same time of day if possible, have students record the following data on the "Daily Ozone Forecast, Peak Ozone Level, and Daily Peak Temperature" table (Student Worksheet #4 included with this toolkit):

- ***Ozone forecast.*** Ask students to visit the AIRNow web site at: www.airnow.gov . Ask them to record the day's forecast by clicking on "Local Forecasts and Conditions" which is on the right side of the web page, then click on the region of interest. This will bring them to a page that provides "Current AQI" and "Forecast" for the city. Students should record both forecasts (as available) for ozone on the table.
- ***Yesterday's peak ozone level.*** Then ask students to record the peak ozone level for that city for the prior day. Students can access yesterday's peak level data for the area by going to www.airnow.gov and clicking on "Archives" (to the right of the national map) then selecting the area of interest, then clicking on "See Map Archives" (which should already list the current month; if not, enter the correct month, year, and region, and select "Ozone"). Then click on the map for the previous day. They can then observe the second map on the page "Ozone — Peak AQI" and record the highest color AQI level for their city on that day.
- ***Yesterday's peak temperature.*** Ask students to record the peak temperature by going to www.wunderground.com then entering the city name and state in the box at the top of the page, and clicking on the icon just to the right of the box. This will take them to a page of data for that city. Ask them to scroll down the page to an area call "History & Almanac." In this box they will find yesterday's maximum temperature, which they should record on their tables.

Once students have gathered a month's worth of data, they can answer the following questions:

1. For each day of the month, compare the forecast ozone level with the actual ozone AQI level. For how many days did the forecast accurately predict the day's ozone level? For how many days did the forecast predict that ozone levels would be higher than they were? For how many days did the forecast predict ozone levels would be lower than they were?
2. Calculate the average temperature for all days when the ozone level was green. Then calculate the average temperature for all days when the ozone level was yellow, for all days when the ozone level was orange, and for all days when the ozone level was red. What do you notice about temperature and ozone levels?
3. What ideas do you have for reducing ozone pollution during the day? (Possible answers include: drive less by walking, biking, carpooling, or using public transportation; turn off lights and equipment when you aren't using them.)

Activity 6: Compare Ozone and Particle Pollution

Estimated Time: 30 to 60 minutes depending on how many months of data are gathered.

Summary: Particle pollution and ozone behave in very different ways. Ozone forms in warm weather and is generally highest in the afternoon and early evening. Particle pollution can be high at any time of year and any time of day. It can be particularly bad in winter during inversions, when warm air traps pollution in a location for a period of time. For this activity, students will gather data for levels of particle pollution throughout the year and compare these data with what they have observed for ozone in the earlier activities.

From the www.airnow.gov web site, ask students to click on "Archives," then select the region "Northeast," click on "Go," and select the region "New England" and the pollutant "ParticlesPM2.5". Then click on "See Map Archives". Tell them that they will access data for an entire year. Have students begin with the month of January (select the year 2004 or later as particle pollution data are not available on AIRNow before October 2003.) Have students access the screen that shows the data for the entire month of January, and then have them click on January 1. Ask them what difference they observe between the particle pollution map and the ozone map. *(Answer:* Particle pollution readings are given as dots/circles whereas ozone maps have continuous bands of color). Explain that this is because particle pollution is more localized than ozone, so you can't predict as accurately that the particle levels between two areas where they are measured will be the same as at the measured locations.

Ask students to look at the second map on the page for each day in the month and record on the table "Frequency of Particle Pollution" (Student Worksheet #5 included with this toolkit) the number of locations (i.e., circles) that reported yellow AQI particle levels, orange particle levels, red, and purple particle levels. Have students do this for all twelve months of the year, if possible (or have them record for four months in different seasons: e.g., January, April, July, and October). (Ideally students can be divided into several teams and each record data for one or two months to cover the whole year.) Then have students answer these questions:

1. Were there any months when particle pollution was never elevated above the green level?
2. Are there any times of year when particle pollution appears to be worse? How does this compare with ozone?

Explain that particle pollution affects health in a different way than ozone, so the advice given to protect your health when particle pollution is elevated is different than the advice given for ozone. Have students access the *Air Quality Guide for Particle Pollution* either by clicking on the AQI colors to the right of the particle pollution maps, or by going to www.airnow.gov and searching for *Air Quality Guide for Particle Pollution.* Ask:

1. Who is sensitive to particle pollution?
2. How does this differ from who is sensitive to ozone pollution?
3. If you have asthma, at what AQI level should you consider taking it easy when you are active outside? (Answer: Orange, unless you are unusually sensitive, in which case, yellow.)

Additional Followup Activities

If it is winter and you live in an area that tends to have inversions in winter, students can track real-time air pollution data for particle pollution, as well as temperature and wind speed, as described for ozone under Activity 5. Also, have students track local weather reports for information on when temperature inversions are occurring and report back to the class.

- Ask students: What did you observe with respect to particle pollution levels during the inversion? Is there a relationship between cold temperatures and inversions? Is there a relationship between wind speed and inversions?
- Have students write a report on what a temperature inversion is.

Suggested Reading

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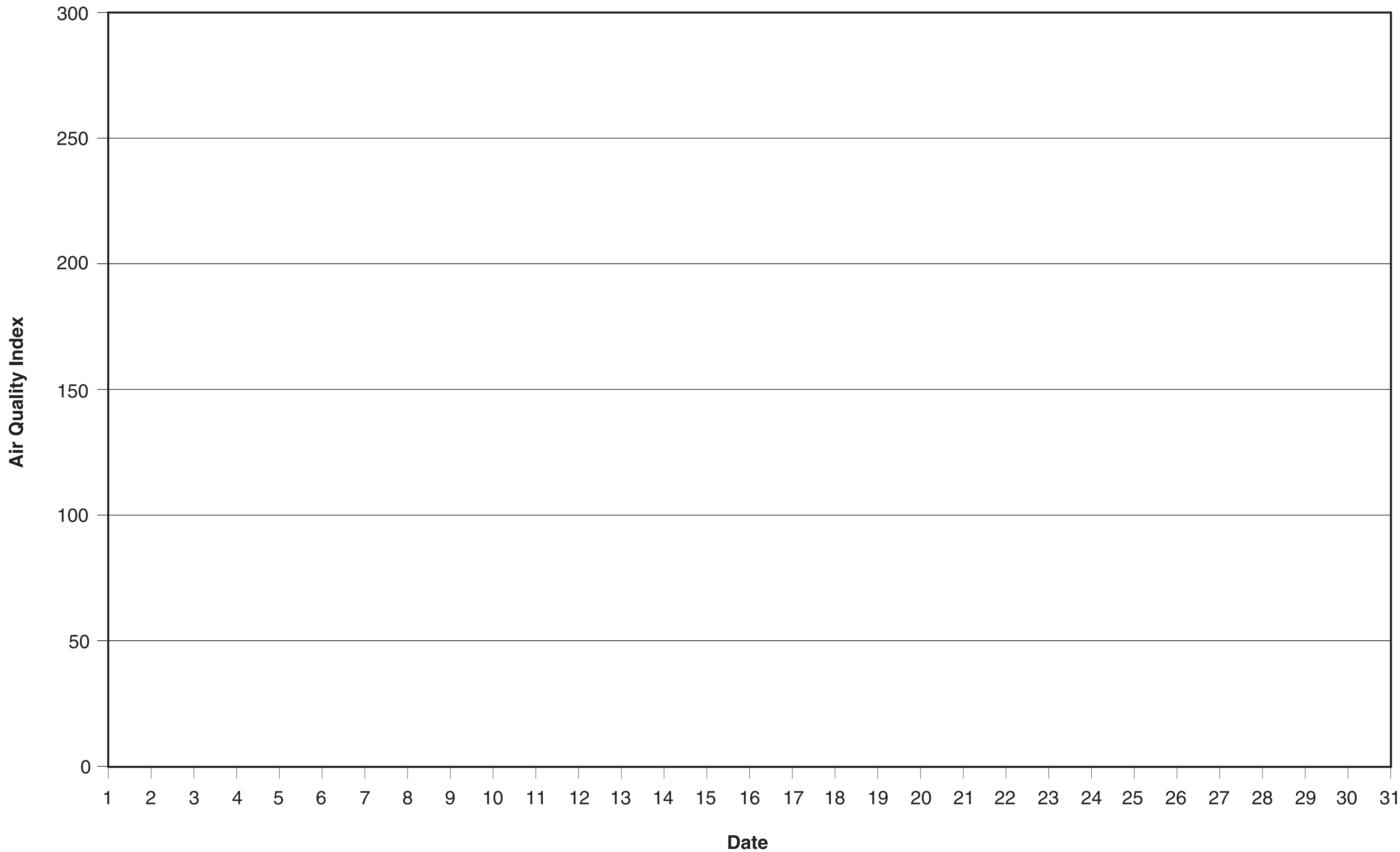
Student Worksheet #1: Activities 1, 2, and 3

Air Quality vs. Time



Month: ____________________

Student Worksheet #2: Activities 1, 2, and 3

Total Number of Days Each Month with Elevated Ozone Levels

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	TOTAL DAYS of Each Color
Green												
Yellow												
Orange												
Red												
Purple												
TOTAL DAYS Ozone was Above Green												

Student Worksheet #3: Activity 4

Daily Air Quality for ______________

	Highest AQI Color Observed on _____ (Date)	Highest AQI Color Observed on _____ (Date)	Highest AQI Color Observed on _____ (Date)
12 a.m.			
1 a.m.			
2 a.m.			
3 a.m.			
4 a.m.			
5 a.m.			
6 a.m.			
7 a.m.			
8 a.m.			
9 a.m.			
10 a.m.			
11 a.m.			
12 p.m.			
1 p.m.			
2 p.m.			
3 p.m.			
4 p.m.			
5 p.m.			
6 p.m.			
7 p.m.			
8 p.m.			
9 p.m.			
10 p.m.			
11 p.m.			

Student Worksheet #4: Activity 5

Daily Ozone Forecast, Peak Ozone Level, and Daily Peak Temperature

	Ozone Forecast Today: Tomorrow:	Actual Peak Ozone Level	Actual Peak Temperature
Day: 1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			

Student Worksheet #5: Activity 6

Frequency of Particle Pollution

Month: ____________

	Number of Monitors Showing Yellow AQI	Number of Monitors Showing Orange AQI	Number of Monitors Showing Red AQI	Number of Monitors Showing Purple AQI
Day: 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
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19				
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26				
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28				
29				
30				
31				

Smog Alert

Summary

The expression "smog" was first used in "Turn-of-the-Century" London to describe a combination of "smoke" and "fog." Smog occurred when water vapor in the air condensed on small particles of soot in the air, forming small smog droplets. Thousands of Londoners died of pneumonia-like diseases due to the poisonous air. Today, smog is usually produced photochemically, when chemical pollutants in the air, called "precursors" (notably nitrogen oxides and volatile organic compounds) are baked by the sun and react chemically to form other substances, such as ozone. The chemicals that form ground-level ozone (that is, ozone within the Earth's atmosphere) are produced by a combination of pollutants from many sources such as automobile exhaust, smokestacks, and fumes from chemical solvents like paint thinner or pesticides. Weather conditions such as the lack of wind or a "thermal inversion" can cause smog to be trapped over a particular area. (A thermal inversion occurs when a layer of warm air in the Earth's atmosphere traps cold air and pollution, including ground-level ozone, below it).

Smog can cause health problems such as difficulty breathing, aggravated asthma, reduced resistance to lung infections, colds, and eye irritation. The ozone in smog also can damage plants and trees. The haze from smog can reduce visibility, which is particularly noticeable from mountains and other beautiful vistas such as National Parks.

Severe smog and ground-level ozone problems often occur in many major cities, including much of California from San Francisco to San Diego, the mid-Atlantic seaboard from Washington, DC to southern Maine, and major cities of the Midwest.

Grade Level

Grades 6-8

(Note: This activity can also be done with careful supervision for Grades 3-5)

Estimated Time

20 minutes

Materials

Clean, dry, wide-mouth glass jar (e.g., mayonnaise jar)

Heavy aluminum foil

Two or three ice cubes

Ruler

Scissors

Stop watch or watch with second hand

Matches

Relevant National Science and Health Education Standards

Unifying Concepts and Processes
Evidence, Models and Explanations

Science as Inquiry
Abilities Necessary to do Scientific Inquiry
Understandings About Scientific Inquiry

Science in Personal and Social Perspectives
Personal Health
Populations, Resources and Environments
Risks and Benefits

Objectives

Students will:

- Create artificial “smog” in a jar
- Recognize that invisible air pollutants and weather conditions are involved in creating smog
- Understand that not all air pollution is visible
- Appreciate that human activities can cause air pollution
- Strengthen their observational skills and their ability to draw conclusions

Directions

Be careful! Teacher may want to (or be required to) use matches instead of having the students do so. If students use the matches, they should do so only under teacher supervision.

1. Explain that the class will perform an experiment in which they will create artificial “smog” in a jar. Make sure that students understand that the jar is only a model, and models by nature are limited. For example, the purpose of this model is to illustrate the appearance and behavior of smog, not the composition or effects. It is important to understand that smog is not just a “smoky fog,” but a specific phenomenon.
2. Select students to perform the experiment. Have them cut a strip of paper about 6 inches by 2 inches. Fold the strip in half and twist it into a rope.
3. Have them make a snug lid for the jar out of a piece of aluminum foil. Shape a small depression in the foil lid to keep the ice cubes from sliding off. Carefully remove the foil and set it aside.
4. Have the students put some water in the jar and swish it around to wet all the inside of the jar. Pour out the extra water.
5. The teacher (or possibly the students under teacher supervision) should light the paper “rope” with a match and drop it and the match into the damp jar. Put the foil lid back on the jar and seal it tightly. Put ice cubes on the lid to make it cold. (The ice cubes will make the water vapor in the jar condense.) Students must do this step very quickly, perhaps with some assistance.
6. Ask students to describe what they see in the jar. How is this like real smog? What conditions in the jar produced “smog”? *(Correct answer:* Moisture and soot particles from the burning matches, plus carbon dioxide and other solvent vapors.)

7. Ask the students if they have ever seen smog (not fog).

Extensions

Have students put a glass thermometer (not plastic) into the jar before they do the experiment. Have them record the temperature before proceeding to step 4. Have them record the temperature again during step 5. Ask them to describe what the temperature did and why. Let them try it again without adding water.

Assign students to small groups to answer the following questions and report back to class in two weeks. One group will consider the physical and chemical sciences and the other group will consider the health and ecological sciences. Each group should consider referring to several sources of information to answer the questions. Students could possibly interview a weather reporter or meteorologist at the local television or radio station or airport, or a health scientist from the city or county health department or air quality agency.

(a) What conditions are necessary to produce smog in the air? Under what circumstances will these conditions exist in the city? How often are they likely? Can they be predicted in advance?

(b) What are the health effects of smog on people? On plants and trees? Why doesn't everyone in the city get sick or have similar symptoms from smog? What types of people are most sensitive to smog?

Suggested Reading

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Pasternak, J. 1991. Long-Term Lung Damage Linked to Air Pollution; Respiratory Deterioration Is Found in Areas Where Air Is Dirtiest. *Los Angeles Times* (29), p. A1 (March).

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Acknowledgment

Project A.I.R.E. (Air Information Resources for Educators), U.S. EPA New England Educational Resources Library, Activity 14. URL: www.epa.gov/region01/students/pdfs/warm_e.pdf

What's "Riding the Wind" in Your Community?

Summary

Ever wonder what's floating in the air? Wind-blown particles that we can easily see range in size from approximately 20 to 100 microns. For comparison purposes, a human hair is approximately 70 microns in diameter. Although the movement of these wind-blown particles is more horizontal than vertical, a good collecting surface is a vertical plane. Sticky paper wrapped around a jar can be used as a sample collector and will work well to capture the particles. By having students make their own sample collector they will discover what actually floats in our air, determine what the sources of these particles might be, and learn which direction the particles come from.

Grade Level

Grades 6-8

Estimated Time

2.5 hours (over 2-3 days)

Materials

Small glass or plastic jar with a lid. Several jars that fit the same lid will allow for the collection of several samples.

Plywood base (approximately 24" x 24")

Wooden dowel (approximately 3" diameter, 30" long)

2 Wood screws

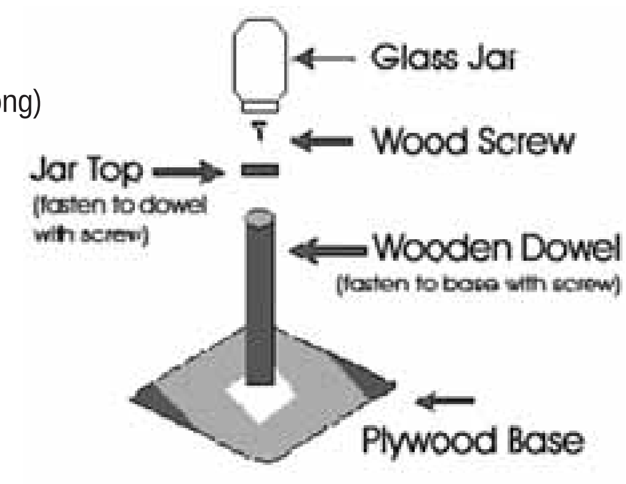
Compass

Spray can of quick drying clear lacquer

Double sided tape, or contact paper

Blank directional graphic (included)

Sample Data Table and Graph (included)



Relevant National Science and Health Education Standards

Unifying Concepts and Processes
Evidence, Models and Explanations

Science as Inquiry
Abilities Necessary to do Scientific Inquiry
Understandings About Scientific Inquiry

Science in Personal and Social Perspectives
Personal Health
Populations, Resources and Environments
Risks and Benefits

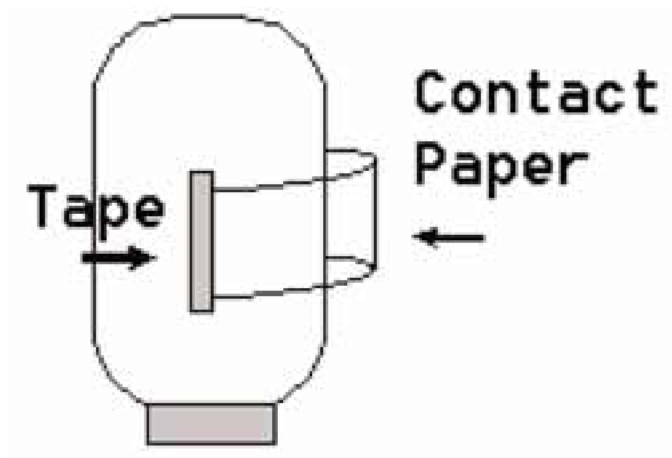
Objectives

Students will:

- Measure the number of larger particles in the air that are carried on the wind
- Determine the approximate direction these particles are coming from
- Consider sources of particles sampled during this activity

Directions

1. Assemble the sample collection stand as indicated in the picture above under "Materials".
2. Place the stand for holding the glass jar on a flat and safe area of the school grounds or roof. Try to keep the sampler as far away from obstructions as possible.
3. Wrap one strip of double-sided tape around the jar. If using contact paper be sure that the sticky side is facing away from the jar. Fasten one edge to the jar with tape and be sure that the edges overlap and stick together so that the paper will stay on the jar. Mark the exposed edge as North.



4. Screw the jar onto the cap on the stand and use a compass to be sure that the edge marked "North" is facing North.
5. Leave the jar exposed for seven days. Then spray the paper with the lacquer to fix the particles collected and to avoid having additional particles adhere to the paper.
6. After the lacquer dries, remove the tape or contact paper from the sampler and divide it into eight equal parts. One section of the strip will represent each direction, i.e., North, Northeast, East, etc. Label each section.
7. Lay the tape on the table and estimate the percent of particle coverage for each section. Use the table below to record the class's estimates.

Direction	N	NW	W	SW	S	SE	E	NE
Estimated Coverage								

8. Hand out copies of the blank directional graphic (included) and have the students draw in the data from the table. For our purposes, assume that 2 cm = 10% coverage. The sample site will be at the center of the graph. For an example of how to interpret the data, have students review the attached Sample Data Table and Graph.

9. When the directional graphics are finished, students should be able to look at them and start to form simplified ideas regarding what general direction particle pollution, and possibly other pollutants that affect your community, come from.

After finishing the graphs, be prepared to discuss the following:

1. From what direction did most of the particle pollution appear to come?

2. What do you think the source of the material is?

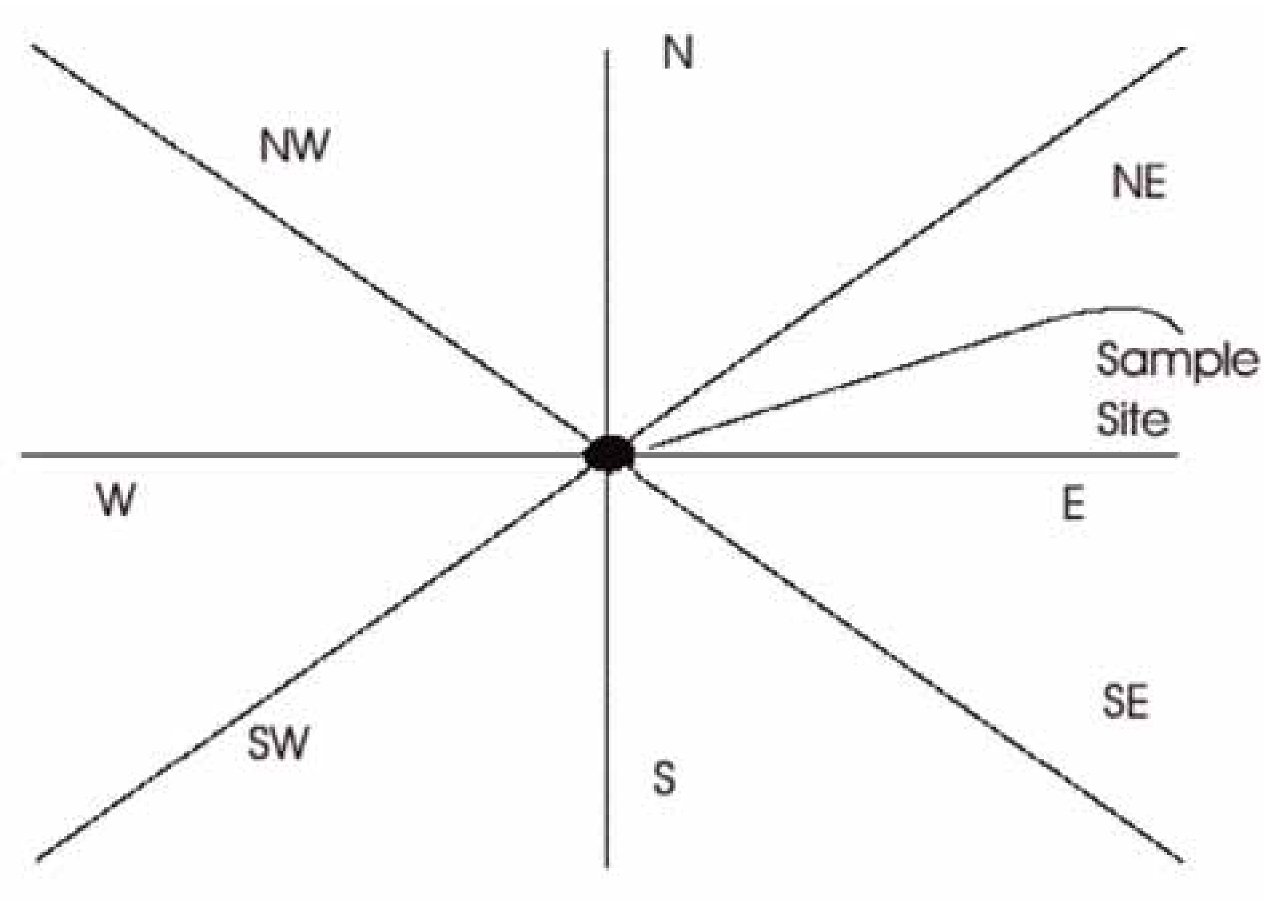
(Possible answers: Nearby dirt driveways, farm activity, metropolitan areas, vehicle exhaust, factory emissions, etc.)

Acknowledgments

Adapted from Air Pollution Control Association, *Air Pollution Experiments for Junior and Senior High School Science Classes.* Pittsburgh, PA, 1972

What's "Riding the Wind" in Your Community?

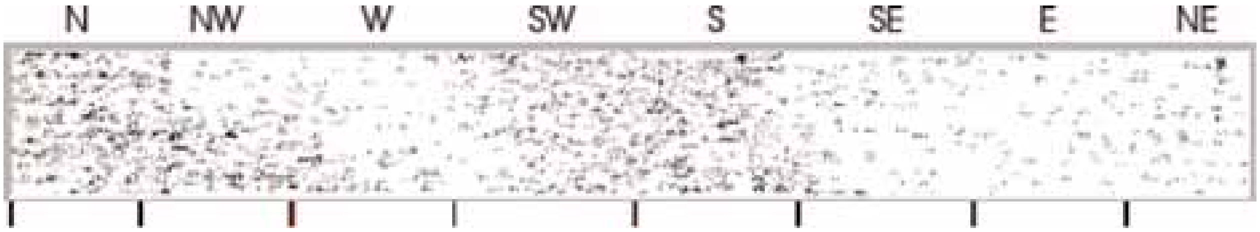
Blank Directional Graphic for Entering Data



Data Collection Site ____________________

Data Collection Dates ____________________

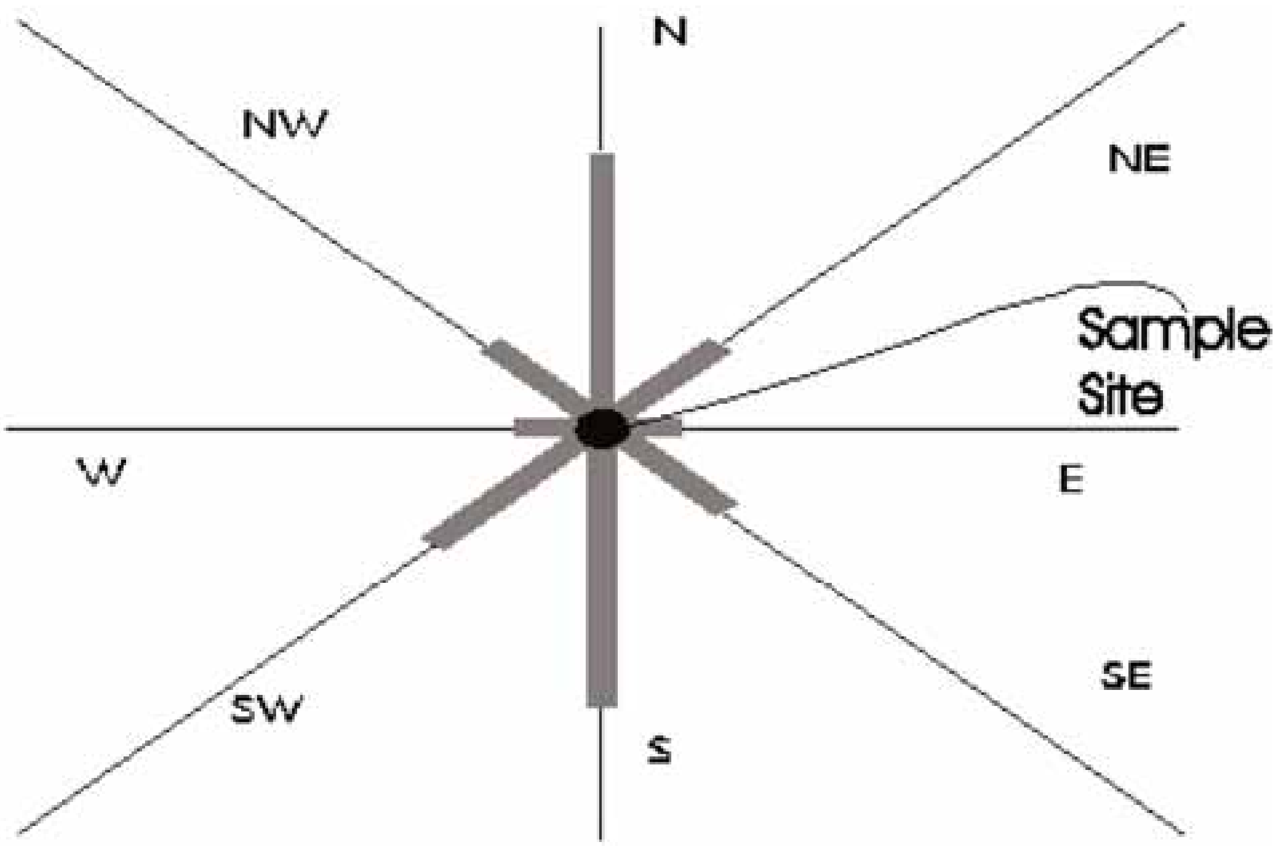
Sample Data Table and Graph



For example we estimate the strip above is covered as indicated in the table below.

Direction	N	NW	W	SW	S	SE	E	NE
Estimated Coverage	25%	10%	5%	15%	25%	10%	5%	5%

Start with the estimated particle coverage that came from the north, 25%. Since 2 cm on the graph represents 10% coverage, a 5 cm line will represent 25%. Draw a bar north extending 5 cm from the center of your directional graphic. A 2 cm bar should extend towards the northwest, and so on.



Smog City

Summary

The “Smog City” software program is an interactive tool that can help students make the connection between weather, human activities, and air pollution. The “Help” function in the Smog City program provides a brief explanation of ground-level ozone, on which Smog City is based, and of the items in the program that the students will use. For more information on ground-level ozone, see the *Air Pollution and Health Facts* and the *Air Pollution: What’s the Solution? The Ozone Between Us* activity in this toolkit.

Grade Level

Grades 6-8

Relevant National Science Education Standards

Unifying Concepts and Processes
Evidence, Models and Explanations

Science as Inquiry
Abilities Necessary to do Scientific Inquiry
Understandings About Scientific Inquiry

Materials

Internet access

Presentation screen (optional)

Writing paper

Objectives

Students will:

- Learn what weather conditions and human activities can affect air pollution
- Make and test hypotheses

Duration

20 minutes

Directions

1. Access the Smog City web site at www.smogcity.com . Click on “Run Smog City” on the left side of the toolbar, and project it on your presentation screen.

2. Point out to the class each of the following items in Smog City:

   Weather conditions
   - Temperature
   - Inversion layer (a layer of warm air in the Earth’s atmosphere that traps cold air and pollution, including ground-level ozone, below it)

- Wind speed
- Sunny or cloudy day

Population level

Emissions levels - from:
- Cars and trucks
- Off-road vehicles
- Industry
- Consumer products

3. Have students access the Smog City program on their computers. Tell the students not to click on anything just yet (it's very tempting!). Ask the students what they think would happen if they raised the emissions levels a lot from cars and trucks?

4. Tell students to go ahead and raise the emissions levels significantly from cars and trucks only, click "Start," and record the results. Did the change they expected to occur happen when they did this?

   Get more specific - ask the class:
   - What "ozone level" (green, yellow, orange, red, purple) did this change in settings result in? (See display)
   - Did the ozone level go up?
   - Did any associated ozone health warning appear or change when they did this? (See display)

6. Repeat this exercise for the other items listed above, one at a time, as time allows. Each time, have the students press "Reset" before making a change. Ask them what impact they expect the change will have on the ozone levels. Then tell the students to make a dramatic change for one item (so that differences in ozone levels are more likely to occur). Have the students press "Start" and ask them to observe and record what happened and whether their hypothesis was correct.

   Mention to students that both emissions levels and population levels are things that are within the control of people, while weather conditions are not.

Note: Smog City was developed under a U.S. Environmental Protection Agency grant and is a copyright of the Sacramento Metropolitan Air Quality Management District. Smog City is authorized for use as an educational and demonstration tool and may be downloaded for non-profit use by the general public, other agencies, associations, and educational institutions from www.smogcity.com. Smog City: Copyright 1999 Sacramento Metropolitan Air Quality Management District.

Coming in 2007—Smog City 2, which will include particle pollution in addition to ozone, at: www.smogcity2.org

Background Information and Resources for Teachers

Air Pollution and Health Facts

Through regulation and voluntary change, levels of many air pollutants have decreased significantly in recent decades. Still, in many parts of the U.S. the air is often polluted at levels that can affect our health. In fact, about 160 million people—over half the United States population—are exposed to unhealthful levels of ground-level ozone or particle pollution every year.

Ozone

What is ozone? Ozone is an odorless, colorless gas composed of three atoms of oxygen. Ozone occurs naturally in the Earth's upper atmosphere (the stratosphere) and as a pollutant at ground level. Stratospheric ozone protects us from the sun's harmful ultraviolet rays. This beneficial ozone is gradually being destroyed by manmade chemicals. At ground level, ozone is a harmful pollutant formed when emissions from vehicles, power plants, and industrial sources react in the presence of sunlight and heat.

When and where is ozone a concern? Because it needs heat to form, ozone pollution is a concern in warmer weather, particularly in the afternoon and early evening. Ozone can be transported by winds hundreds of miles from where it formed, so it can be found in both urban and rural environments.

Can we see ozone in air? By itself, ozone in air is invisible, so we can be breathing harmful ozone levels even when the air looks clear. When ozone mixes with particles (described below), it forms a brown summertime haze known as "smog."

Why is ozone pollution bad? Ozone can trigger a variety of health problems, even at relatively low levels. Health effects from ozone include aggravated asthma and increased susceptibility to respiratory illnesses like pneumonia and bronchitis. Symptoms to watch for when ozone is in the air include coughing, pain when taking a deep breath, and breathing difficulties, especially when you are active or exercising outdoors. But ozone damage can also occur without any noticeable signs. And, for some people, several months of repeated exposure to ozone can permanently damage the lungs. Ozone is also bad for our environment, damaging plants and trees and reducing crop and forest yields.

Who's at risk from ozone pollution? People with respiratory problems are most vulnerable, but even healthy people and children who are active outdoors can be affected when ozone levels are unhealthy. This is because during physical activity, ozone penetrates deeper into the parts of our lungs that are most vulnerable to ozone. Scientists estimate that about one in three people in the United States is at higher risk for experiencing ozone-related health effects.

Particle Pollution

What is particle pollution? Particle pollution includes dust, soot, dirt, and liquid droplets. Some particles are large enough to be visible. Others can only be seen under a microscope. The smaller particles cause the greatest health concern because they penetrate deeper into the lungs and can even enter our bloodstream.

What causes particle pollution? Sources of particle pollution include vehicles, factories, and power plants, as well as natural sources such as forest fires and volcanoes.

When and where is particle pollution worst? Particle pollution can be high at any time of year. It can be especially bad during winter, when warm air above cold air causes "inversions" that can trap pollutants in one area for a period of time. Particle pollution can be higher near busy roads and factories, and can reach very hazardous levels in areas downwind of forest fires. Particle pollution can be high indoors, especially when outdoor particle levels are high.

Why is particle pollution bad? Health effects from particles range from coughing and aggravated asthma to chronic bronchitis and even premature death. Many studies link particle pollution levels with increased hospital admissions and emergency room visits. If you have heart disease, particle exposure can cause serious problems in a short period of time—even heart attacks—with no warning signs. Particle pollution also has significant environmental effects. Particles are a major component of haze, which can reduce visibility, for example in national parks and other scenic vistas. Particles are a major contributor to "acid rain," which harms the environment in a number of ways, including making lakes and other water bodies more acidic, which can harm the health of aquatic life; damaging trees and soils; and deteriorating buildings and statues.

Who's at risk from particle pollution? People with heart or lung disease are at risk because particle pollution can aggravate these diseases. Many studies show that when particle levels are high, older adults are more likely to be hospitalized, and some may die of aggravated heart or lung disease, perhaps because they have undiagnosed heart or lung disease. Children are at risk because their lungs are still developing and they are usually very active.

Protect Your Health

Because ozone and particles remain a significant public health concern in many areas of the U.S., the U.S. EPA, in partnership with federal, state, and local agencies and tribes, have set up a nationwide network for reporting daily air quality information and forecasts for these two pollutants. This information is available on the Internet at: www.airnow.gov , in newspapers, via radio and television announcements, and in some areas via air quality e-alerts. Daily air quality is reported using a standard, color-coded scale called the Air Quality Index, or AQI. The AQI makes air quality reports as easy to understand as weather reports.

The best way to protect your health is to check the air quality level and forecast daily for your area, and the related health messages provided by the AQI. By doing so, you can find out when ozone or particle levels are elevated. You can also take simple precautions to minimize exposure, even when you don't feel obvious symptoms. Precautions include:

- When possible, plan activities and exercise when pollution levels are lower (e.g., typically morning or evening for ozone).
- If pollution levels are unhealthy, take it easier when you are active outside. For example, reduce the intensity of your activity (e.g., go for a walk instead of a jog) or reduce the length of your activity. That way, you will reduce the amount of pollution you breathe.
- To reduce exposure to particle pollution, exercise away from busy roadways and other pollution sources.
- Check with your health care provider if you notice any symptoms (such as coughing, wheezing, difficulty breathing, or chest pain) when the air is polluted. This is especially important if you are a member of a sensitive group (i.e., for ozone - active children or adults, and people with lung disease; for particle pollution - people with heart or lung disease, older adults, and children).

What Is the Air Quality Index (AQI)?

The AQI is an index for reporting daily air quality. It uses a simple color-coded scale to tell you how clean or polluted your air is, and how you can protect your health at different levels of pollution. The AQI helps to make daily air quality information as easy to understand as weather forecasts.

How Does the AQI Work?

The AQI is essentially a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 represents good air quality with little potential to affect public health, while an AQI value over 300 represents hazardous air quality.

An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy—at first for certain sensitive groups of people, then for everyone as AQI values get higher.

Understanding the AQI

To make it easier to understand, the AQI is divided into six categories:

Air Quality Index Values	Levels of Health Concern	Colors
When the AQI is in this range:	...air quality conditions are:	...as symbolized by this color:
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Each category corresponds to a different level of health concern:

- ***"Good"*** - The AQI value for a particular community is between 0 and 50. Air quality is considered satisfactory, and air pollution poses little or no risk.
- ***"Moderate"*** - The AQI for a community is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- ***"Unhealthy for Sensitive Groups"*** - When AQI values are between 101 and 150, members of sensitive groups may experience health effects. This means they are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.
- ***"Unhealthy"*** - Everyone may begin to experience health effects when AQI values are between 151 and 200. Members of sensitive groups may experience more serious health effects.

- ***"Very Unhealthy"*** - AQI values between 201 and 300 trigger a health alert, meaning everyone may experience more serious health effects.
- ***"Hazardous"*** - AQI values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.

How Is a Community's AQI Calculated?

Air quality is measured by monitors that record the concentrations of the major pollutants each day at more than a thousand locations across the country. These raw measurements are then converted into AQI values using standard formulas developed by EPA. An AQI value is calculated for each pollutant in an area (ground-level ozone, particle pollution, carbon monoxide, sulfur dioxide, and nitrogen dioxide). The highest AQI value for the individual pollutants is the AQI value for that day. For example, if on July 12 a certain area had AQI values of 90 for ozone and 88 for sulfur dioxide, the AQI value would be 90 for the pollutant ozone on that day.

When and How Is the AQI Reported to the Public?

In large cities (more than 350,000 people), state and local agencies are required to report the AQI to the public daily. When the AQI is above 100, agencies must also report which groups, such as children or people with asthma or heart disease, may be sensitive to those pollutants. Many smaller communities also report the AQI as a public health service.

Many cities also provide forecasts for the next day's AQI. These forecasts help local residents protect their health by alerting them to plan their vigorous activities for a time when air quality is better.

The AQI is a national index, so the value and colors used to show local air quality and the levels of health concern will be the same everywhere in the U.S. You can always find AQI reports for areas across the U.S. on the Internet at EPA's AIRNow web site: www.airnow.gov . The AQI is also frequently reported in local newspapers, on local television and radio stations, and on many state and local telephone hotlines.

What Are Typical AQI Values in Most Communities?

In many U.S. communities, AQI values are usually below 100, with values greater than 100 occurring just several times a year. Typically, larger cities have more severe air pollution problems, and the AQI in these areas may exceed 100 more often than in smaller cities. AQI values higher than 200 are infrequent, and AQI values above 300 are extremely rare.

AQI values can vary from one season to another. In winter, for example, carbon monoxide may be high in some areas because the cold weather makes it difficult for car emission control systems to operate effectively. In summer, ozone may be a significant air pollutant because it forms in the presence of heat and sunlight. Particle pollution can be elevated at any time of the year.

AQI values also can vary depending on the time of day. For example, ozone levels often peak in the afternoon, while carbon monoxide is usually a problem during morning or evening rush hours. Particle pollution can be high at any time of day.

Air Quality Resources for Teachers

Curricula and Classroom Activities

Air Pollution: What's the Solution?
This educational project, designed for students in grades 6-12, uses online, real-time air quality and weather data to guide students' understanding of the science behind the causes and effects of ground-level ozone. Available at: www.k12science.org/curriculum/airproj/

Project A.I.R.E. (Air Information Resources for Educators)
The units in this package encourage students to think more critically and creatively about air pollution problems and the alternatives for resolving them. Topics covered include air quality, rainforests, radon, the creation of environmental laws, the greenhouse effect, and ozone. Designed for grades K-12. Available at: www.epa.gov/region01/students/teacher/aire.html

Air Quality Lesson Plans and Data for Teachers (Texas Natural Resource Conservation Commission)
This site provides educators who teach kindergarten through 12th grade with background information, activities, and resources to teach the subject of air quality in the classroom. Available at: www.tnrcc.state.tx.us/air/monops/lessons/lesson_plans.html

Air Quality Index for Kids: For Teachers
This EPA web site provides links to useful materials to help teach students about the Air Quality Index and related information. Available at: www.airnow.gov (click on "Teachers" on the menu bar on the left side of the web page).

Eco Badge® Educational Products
Here you will find the Vistanomics "eco store" which sells air quality educational materials, including the Eco Badge® (a compact, easy-to-use device to measure ozone levels at home or in the work environment) and educational toolkits targeted for elementary, middle, and high school students. The site also provides examples of successful teacher programs using the Eco Badge. Available at: www.ecobadge.com

EPA Teaching Center - Air Curriculum Resources
This page links to curricula and activities on a variety of environmental topics. Explore these links and find creative ways to teach your students about acid rain, indoor air pollution, ozone, radon. Available at: www.epa.gov/teachers/curric-air.htm

Educator Resources for Air Defenders
This resource provides information about a science module called *Air Defenders: The Quest for Clean Air™,* that is available for purchase. Targeted for students 10 and older, the Air Defenders kit provides resources to help students learn about the science of what happens to garbage when we burn it, the health and environmental consequences of burning waste, and how to analyze alternatives to open burning, such as composting, recycling, and landfilling. Available at: www.airdefenders.org/teacher/index.htm

SunWise School Program
The SunWise School Program is an environmental and health education program designed to teach children and their caregivers how to protect themselves from overexposure to the sun. Available free of charge to schools, the SunWise Tool Kit contains cross-curricular classroom lessons and background information for K-8 learning levels. The Tool Kit consists of a variety of fun, developmentally appropriate activities that combine education about sun protection and the environment with other aspects of learning. Available at: www.epa.gov/sunwise

Web Sites

EPA's AIRNow Web site
The U.S. EPA's AIRNow web site provides the public with easy access to air quality information. The web site offers real-time air quality conditions and daily air quality forecasts for over 300 cities across the U.S.; provides links to more detailed state and local air quality web sites; and supplies real-time images of air quality and visibility via webcams in a number of locations. Available at: www.airnow.gov

Note that the AIRNow web site also provides a chart to easily link the AQI colors with air quality and health risks; this chart and related information can be found by visiting the AIRNow web site homepage and clicking on "Air Quality Index" on the menu bar on the left; the chart is on the bottom of this page.

Kid's Air: EPA's Air Quality Index (AQI) Web site for Kids
This web site explains the Air Quality Index (AQI) to children. It uses games, targeted for K-1 and ages 7-10, to teach children about the AQI and how they can moderate their activity to safely play outside when air pollution is elevated. Available at: www.airnow.gov (click on "Kids" on the menu bar on the left of the web page).

Publications

The following U.S. EPA publications are available in pdf and html formats (print versions can be requested free of charge) at: www.airnow.gov (click on "Publications" on the menu bar on the left of the web page):

- ***Air Quality Index - A Guide to Air Quality and Your Health.*** This booklet explains EPA's Air Quality Index (AQI) and the health effects of major air pollutants.
- ***Air Quality Guide for Ozone.*** This guide provides information about ways to protect your health when ozone levels reach the unhealthy range, and ways you can help reduce ozone air pollution.
- ***Air Quality Guide for Particle Pollution.*** This guide provides information about ways to protect your health when particle pollution levels reach the unhealthy range, and ways you can help reduce particle air pollution.
- ***Particle Pollution and Your Health.*** This short, colorful pamphlet tells who is at risk from exposure to particle pollution (also known as particulate matter), what health effects may be caused by particles, and simple measures that can be taken to reduce health risk.
- ***Ozone and Your Health.*** This short, colorful pamphlet tells who is at risk from exposure to ozone, what health effects are caused by ozone, and simple measures that can be taken to reduce health risk.
- ***Smog - Who Does it Hurt?*** This 8-page booklet provides more detailed information than "Ozone and Your Health" about ozone health effects and how to avoid them.
- ***Summertime Safety: Keeping Kids Safe from Sun and Smog.*** This document discusses summer health hazards that pertain particularly to children and includes information about EPA's Air Quality Index and UV Index tools.

- ***Ozone: Good Up High, Bad Nearby.*** Ozone acts as a protective layer high above the earth, but it can be harmful to breathe at ground level. This publication provides basic information about ground-level and high-altitude ozone.

The following publication is available in pdf format at: www.airnow.gov (search for the title):

- ***Facts About the Expanded AQI Forecasts.*** This brochure provides basic information for the public about AQI forecasts.

CDs

GOOD

MODERATE

UNHEALTHY FOR SENSITIVE GROUPS

UNHEALTHY

VERY UNHEALTHY

CD #1

- PowerPoint slide presentations and handouts for Grades 3-5, Grades 6-8, and Civic Groups.

CD #2

- Forecast Earth: Air Aware Video (About Air Pollution and Health). Produced in 2004 by The Weather Channel and U.S. EPA.