Educational Activities
9th – 12th Grade
Improving the air quality in West Michigan is important.

The West Michigan Clean Air Coalition was formed in 1995 and is working toward this goal. The West Michigan Clean Air Coalition is a partnership of businesses, academic institutions, government agencies, industry, and non-profit organizations in Kent, Ottawa, Muskegon, and Kalamazoo counties working together to achieve cleaner air in the region. The coalition works to educate the public about our air quality and its health effects, and to promote voluntary emission reduction activities that can improve our air quality.

The West Michigan Clean Air Coalition in efforts to expand the public education campaign would like to thank the Clean Air Coalition of Southeast Michigan for the permission to use their packet and adapt it to the needs of West Michigan. Information from the Michigan Department of Environmental Quality and the United States Environmental Protection Agency has been incorporated in this document as well.

Visit the West Michigan Clean Air Coalition’s webpage (https://www.wmcac.org/) and Facebook page for additional information that supports these activities.
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Introduction to Air Quality in West Michigan

Are your students curious about air quality in West Michigan? Have they noticed that sometimes the meteorologists on local weather stations talk about Clean Air Action Days? Do they know the difference between “good” ozone and “bad” ozone? Have they heard of fine particulate matter pollution? Do they know what to do on a Clean Air Action Day?

To help answer these and many more questions, the West Michigan Clean Air Coalition has lessons and a website with lots of information about air quality in West Michigan (https://www.wmcac.org/). This along with the Michigan Department of Environmental Quality’s website and the U.S. Environmental Protection Agency’s AirNow site (https://airnow.gov/) provide forecasts and real-time information about air quality in our area. Note: AirNow was updated in September 2018 but the original site is still available at: https://cfpub.epa.gov/airnow/.

Pollutants of Most Concern in West Michigan

Michigan air quality has greatly improved over the past few decades. These days, primarily two criteria pollutants - ground level ozone and fine particles – are reported at concentrations that are sometimes higher than what is considered healthy.

Ground level Ozone

First, here is a word on “good” and “bad” ozone.

The chemical structure of ozone is O₃ as compared to oxygen, which is O₂. The additional oxygen atom makes ozone very reactive, which is good in the upper atmosphere (the ozone layer) but harmful in the lower atmosphere (a component of smog). Ozone is produced through complex photochemical reactions involving natural atmospheric gases, volatile organic compounds (VOCs), nitrogen oxides and sunlight. Hot days can accelerate these reactions. Elevated levels of ground level ozone make breathing more difficult – especially for people with respiratory problems. It can also damage vegetation and materials.

The Clean Air Action Program informs people when elevated ground level ozone values are anticipated and it offers tips for reducing ozone formation. Since vehicle exhaust and gasoline vapor contribute to the chemical mix, many of the “clean air” tips involve reducing emissions from cars and equipment such as gasoline powered lawn mowers.

Ground level ozone concentrations tend to be highest in the afternoon and early evening in the lower half of the Lower Peninsula. In northern Michigan, levels tend to peak in the evening and nighttime hours after winds carry pollution northward from the population centers to the south.
Particulate Matter

And now a word about particulate matter. Although Clean Air Action Days are generally called just for ozone, there are other air quality concerns that could trigger a Clean Air Action Day.

"Particulate matter," also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. It is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

The size of particles is directly linked to their potential for causing health problems. The EPA is concerned about particles that are 10 micrometers in diameter (PM10) or smaller (PM2.5) because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

Environmental Effects – Particulate Matter

Visibility reduction
Fine particles are the major cause of reduced visibility (haze) in parts of the United States, including many of our treasured national parks and wilderness areas.

Environmental damage
Particles can be carried over long distances by wind and then settle on ground or water. The effects of this settling include: making lakes and streams acidic, changing the nutrient balance in coastal waters and large river basins, depleting the nutrients in soil, damaging sensitive forests and farm crops, and affecting the diversity of ecosystems.

Aesthetic damage
Particulate matter can stain and damage stone and other materials, including culturally important objects such as statues and monuments.

Fine particles (PM2.5) concentrations can peak anytime especially when there are fires. Although PM2.5 episodes can occur at any time, it is more likely to occur during the summer and winter months. Fine particles are so small that ambient air concentrations are the same whether you are outdoors or indoors, so staying inside has little effect on exposure levels. [Note that the same is not true for larger, coarse particle pollution.]
What is the Air Quality Index?

The Air Quality Index (AQI) is a tool for reporting daily air quality. It tells you how clean or polluted the air is, and what associated health concerns you should be aware of. The AQI focuses on health effects that can happen within a few hours (acute effects) or days after breathing polluted air (chronic effects). The AQI is reported for five major air pollutants regulated by the Clean Air Act: ground level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide.

What are Clean Air Action Days?

The Michigan Department of Environmental Quality (MDEQ) works to ensure that Michigan's air remains clean by regulating sources of air pollutants to minimize adverse impact on human health and the environment. Its goals are to meet and maintain air quality standards, limit emissions of hazardous and toxic pollutants, and inform the public about current air conditions. Clean Air Action Days provide a way to reduce pollution and to protect health on days when air quality is expected to reach Unhealthy for Sensitive Groups or above on the Air Quality Index (AQI).

The MDEQ monitors the air and keeps us informed about air quality conditions. MDEQ meteorologists forecast (i.e. predict) daily air quality. Clean Air Action Days are declared when unhealthy pollution levels are expected to occur.

Counties currently under an Action Day are shaded red on the AQI map on the MIair website (http://www.deqmiair.org). In addition, declaration information for today and tomorrow is viewable on the Action Day page. You can also receive automated electronic notification messages about air quality and Action Days via EnviroFlash.

What should be done on Clean Air Action Days?

There are many voluntary actions that can be done on Clean Air Action Days. The purpose of these actions is to work towards reducing emissions. Emission reductions help prevent the formation of ground level ozone and particulate matter. Examples of what to do include: riding a bike to work or school instead of riding in a car, avoiding car and bus idling, and many more actions as shown on the tip cars on the next page. Tip cards are available at the West Michigan Clean Air coalition website (https://www.wmcac.org/). Become familiar with the link between the Air Quality Index and health. Monitor the actual AQI online and sign up for Enviroflash (http://www.enviroflash.info/) to get notifications about air quality.
AIR QUALITY INDEX FACT SHEET

What is the Air Quality Index?
The Air Quality Index, or AQI, is an easy way to understand how clean the outside air is. It is a simple tool that provides a color coded “picture” of current air pollution levels and health effects. People can use the AQI to adjust daily activities in order to protect their health when there is more air pollution than there should be.

What air pollution is reported by the AQI?
AQI pollutants include fine particles, ground-level ozone, carbon monoxide, sulfur dioxide and nitrogen dioxide. Fine particles or ground-level ozone are the pollutants most likely to control the daily AQI. Hourly air monitor data is collected and analyzed by an automated computer program that determines how clean the air is. The AQI tells people whether the air they breathe is currently “good”, “moderate”, “unhealthy for sensitive groups”, “unhealthy”, “very unhealthy” or “hazardous”. Values are reported in near real-time via the MI Air webpage.

How clean is our air? Has the AQI ever reached “hazardous” levels in Michigan?
Michigan’s air quality usually falls in the “good” or “moderate” air quality range. Sometimes, the AQI will reach the orange “unhealthy for sensitive groups” level. Michigan hardly ever experiences air quality concentrations in the “unhealthy” range. The AQI here has never reached hazardous levels.

How does the AQI work?
Air monitors analyze air samples. Each sample is given a numerical value. If more than one kind of air pollutant is monitored at a location, the pollutant with the highest value (worst air measured) becomes the AQI. An AQI number above 100 means a pollutant has reached unhealthy levels.

Why report the AQI?
The AQI is a federally mandated program. Since 1976, the Clean Air Act has required state and local air agencies to communicate air quality information in a consistent manner. The index was revised in 1999 to provide better information about health risks linked with air pollution. Today’s air quality is reported the same way across the country. As air quality health standards change to better protect sensitive population groups, the AQI scale breakpoints are adjusted to reflect the new, more protective standard.

How is the current index different from the old one?
In 1999, the EPA added the AQI category called “unhealthy for sensitive groups” to better protect children, people with lung disease or asthma, and others who are more sensitive to air pollution than the general public. An AQI forecast has also been added so air agencies can notify the public ahead of time if poor air quality is predicted. These improvements help people to better protect their health — they can avoid prolonged, strenuous activity or reduce physical exertion when there is too much pollution in the air. People can also reduce air pollution levels by driving less and using products that conserve energy.

How can I find out what today’s AQI is?
The current AQI is available on the DEQ “Air” webpage. Go to www.michigan.gov/mi air and select the MI Air icon. The color-coded map shows monitor locations across the state. Index values are updated hourly during the day. You can view a detailed summary of AQI numerical values and the controlling pollutant for each monitor location. If you don’t have convenient access to the Internet, you can contact the DEQ Environmental Assistance Center during office hours at 1-800-662-9278. National AQI maps and information are available via EPA’s AIRNow webpage at www.airnow.gov. AQI forecasts are often reported with weather information in the news.

EnviroFlash is a free service that automatically sends out e-mail or cell phone text messages of tomorrow’s AQI forecast. Participants receive air quality messages at the health level they select. (Most people choose the “orange” level.) Messages also include information when air quality “Action! Day” advisories are issued. For more information and to enroll, go to the MI Air webpage and select the “Air Quality Notification” tab.
# The Air Quality Index Colors and Health Statements

<table>
<thead>
<tr>
<th>AQI Color, Category &amp; Value</th>
<th>Particulate Matter (µg/m³) 24-hour</th>
<th>Ozone (ppm) 8-hour / 1-hr</th>
<th>Carbon Monoxide (ppm) 8-hour</th>
<th>Sulfur Dioxide (ppm) 24-hour</th>
<th>Nitrogen Dioxide (ppm) 1-hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green: Good 1-50</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Yellow: Moderate 51-100</td>
<td>People who are unusually sensitive to air pollution should consider reducing prolonged or heavy exertion.</td>
<td>People who are unusually sensitive to air pollution should consider limiting prolonged outdoor exertion.</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Orange: Unhealthy For Sensitive Groups 101-150</td>
<td>People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.</td>
<td>Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy outdoor exertion.</td>
<td>People with cardiovascular disease, such as angina, should limit heavy exertion and avoid sources of CO, such as heavy traffic.</td>
<td>People with asthma should consider limiting outdoor exertion.</td>
<td>None</td>
</tr>
<tr>
<td>Red: Unhealthy 151-200</td>
<td>People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.</td>
<td>Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should reduce prolonged outdoor exertion.</td>
<td>People with cardiovascular disease, such as angina, should limit moderate exertion and avoid sources of CO, such as heavy traffic.</td>
<td>Children, asthmatics, and people with heart or lung disease should limit outdoor exertion.</td>
<td>None</td>
</tr>
<tr>
<td>Purple: Very Unhealthy 201-300</td>
<td>People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.</td>
<td>Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.</td>
<td>People with cardiovascular disease, such as angina, should avoid exertion and sources of CO, such as heavy traffic.</td>
<td>Children, asthmatics, and people with heart or lung disease should avoid outdoor exertion; everyone else should avoid exertion.</td>
<td>Children and people with respiratory disease, such as asthma, should limit heavy outdoor exertion.</td>
</tr>
<tr>
<td>Maroon: Hazardous 301-500</td>
<td>Everyone should avoid all outdoor exertion; people with heart or lung disease, older adults, and children should remain indoors.</td>
<td>Everyone should avoid all outdoor exertion.</td>
<td>People with cardiovascular disease, such as angina, should avoid exertion and sources of CO, such as heavy traffic; everyone else should avoid exertion.</td>
<td>Children, asthmatics, and people with heart or lung disease should remain indoors; everyone else should avoid outdoor exertion.</td>
<td>Children and people with respiratory disease, such as asthma, should limit moderate or heavy outdoor exertion.</td>
</tr>
</tbody>
</table>

For more information on the AQI, go to [www.michigan.gov/air](http://www.michigan.gov/air) and select the "MIair" icon or contact the air quality division.
Take Clean Air Actions
while saving time, money, and gas!

In the Car...
Share a Ride: Carpool or ride the bus.
Telecommute: Work from home.
Trip Chain: Combine errands and avoid cold starts.
Turn it Off: Shut off the engine if stopping for a minute or more to reduce emissions from idling.
Maintenance: Keep vehicle tuned up and tires properly inflated to reduce emissions and improve gas mileage.

At the Pump...
Refuel after 6:00 p.m.: Ozone levels are at their highest in the mid to late afternoon.
Don’t Top Off The Tank: This prevents the release of gas fumes into the air.

At Home...
Postpone Mowing: Mow the lawn late in the afternoon (after 6:00 p.m.) or use an electric or push mower.
Use Woodstoves / Fireplaces Sparingly: Burn only untreated wood in a well-maintained stove or fireplace.
Refrain from Burning Trash or Yard Waste: Recycle or compost instead.
Conserve Energy: Unplug unused appliances to reduce pollution from power plants.

For more information and forecasts go to wmcac.org or michigan.gov/deqair or call 1-800-656-0663.
Resources

Here are some of the resources available on ground level ozone and particle pollution:

*West Michigan Clean Air Coalition*  https://www.wmcac.org/
A group of concerned businesses, educational institutions, non-profit organizations, and government agencies are spreading the word about the West Michigan ozone problem. This site has specific information on when West Michigan Clean Air Action Days occur, a list of tips for Clean Air Action Days, and free materials.

*U.S. EPA’s AIRNow*  https://airnow.gov/
This information on the Air Quality Index, ozone maps and animation, air quality forecasts, a kid’s page, and facts about health issues. This site offers students the opportunity to compare air quality with meteorological events on a national scale.

*Air Quality Index (AQI) Toolkit for Teachers*  https://airnow.gov/publications/teachers/aqi-toolkit-for-teachers
Like weathercasters, teachers are a key resource for science and health information relevant to air quality thus EPA created the *AQI Toolkit for Teachers*. These lesson plans meet national science education standards and can be easily incorporated into school curricula.

*Michigan Department of Environmental Quality*  http://www.deqmiair.org
This website provides hour-by-hour ozone and particulate matter readings at selected sites and information about air quality in Michigan.

The goal of MEECS is to provide students in grades 3 through 9 with an opportunity to learn more about their environment through lessons in Science and Social Studies. The MEECS curriculum consists of seven different curriculum units: Air Quality, Climate Change, Ecosystems & Biodiversity, Energy Resources, Land Use, Land and Environment, and Water Quality.

*MEECS Online*  https://wgvu.pbslearningmedia.org/collection/meeecs-air-quality/
Ten air quality lessons from MEECS are modeled on the MEECS Online website. Lesson 8 shows how to use the MDEQ and EPA websites for the air quality index.
Michigan Science Standards

Exploring air quality in West Michigan represents a phenomenon that is on target for addressing the Michigan Science Standards. Because the student performance expectations were developed to align to a general context for all learners, the Michigan Department of Education (MDE) has worked with a variety of stakeholders to identify Michigan-specific versions of the standards for student performance expectations that address issues directly relevant to our state such as its unique location in the Great Lakes Basin, Michigan-specific flora and fauna, and our state’s rich history and expertise in scientific research and engineering. These versions of the performance expectations allow for local, regional, and state-specific contexts for learning and assessment.

In addition to the specific performance expectations that frame more general concepts and phenomena in a manner that is directly relevant to our state, there are also a number of performance expectations which allow for local, regional, or state-specific problems to be investigated by students, or for students to demonstrate understandings through more localized contexts. The Michigan specific performance expectations should be used by educators to frame local assessment efforts.

These air quality activities are designed to help students make sense of a phenomenon and explore solutions to problems by engaging in activities that integrate the three dimensions of the Michigan Science Standards (Disciplinary Core Ideas, Cross-cutting Concepts, and Science and Engineering Practices). Local and regional problems are investigated by students, who will then be able to demonstrate understandings through these more localized contexts.

The following graphics illustrate how exploration of a phenomenon leads to questions, investigations, and models, which contribute to understanding. Introducing other phenomena at the lesson level builds towards a final consensus model of the phenomenon.
Exploring Air Quality in West Michigan (Grades 9-12)

**Phenomenon:** Sometimes meteorologists forecast that the air quality in West Michigan could be unhealthy and a Clean Air Action Day is called. What does this mean?

<table>
<thead>
<tr>
<th>Essential Questions (from the MECS Air Quality Unit)</th>
<th>Performance Expectations</th>
<th>Disciplinary Core Ideas (DCI) Topics Crosscutting Concepts and Practices</th>
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</thead>
<tbody>
<tr>
<td>Why should we be concerned about air quality?</td>
<td>HS-PS1-5</td>
<td>Disciplinary Core Ideas (DCI) Topics</td>
</tr>
<tr>
<td>What are the sources of air pollution?</td>
<td></td>
<td>• Chemical Reactions</td>
</tr>
<tr>
<td>How can we monitor air quality?</td>
<td>HS-PS1-6</td>
<td>• Human Sustainability</td>
</tr>
<tr>
<td>How can we tell what the quality of air is today?</td>
<td></td>
<td>• Engineering Design</td>
</tr>
<tr>
<td>What can we do about air pollution?</td>
<td>HS-ESS3-4</td>
<td>Cross-cutting Concepts (CCC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Patterns</td>
</tr>
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<td></td>
<td></td>
<td>2. Cause and Effect</td>
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<td></td>
<td></td>
<td>3. Scale, Proportion, and Quantity</td>
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<td></td>
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<td>4. Systems and System Models</td>
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<td></td>
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<td>5. Energy and Matter in Systems</td>
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<tr>
<td></td>
<td></td>
<td>6. Structure and Function</td>
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<td></td>
<td></td>
<td>7. Stability and Change of Systems</td>
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<tr>
<td></td>
<td>HS-ESS3-6</td>
<td>Science and Engineering Practices (SEPS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Asking questions and defining problems</td>
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<td></td>
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<td>2. Developing and using models</td>
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<td>3. Planning and carrying out investigations</td>
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<tr>
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<td>4. Analyzing and interpreting data</td>
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<td>5. Using mathematics and computational thinking</td>
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<tr>
<td></td>
<td></td>
<td>6. Constructing explanations and designing solutions</td>
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<td></td>
<td></td>
<td>7. Engaging in argument from evidence</td>
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<td></td>
<td></td>
<td>8. Obtaining, evaluating, and communicating information</td>
</tr>
</tbody>
</table>

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
Sources of Air Pollution
Sources of Air Pollution

Adapted from Whirling, Swirling Air Pollution by Donna Rogers U.S. EPA

Overview

This activity simulates the cumulative effect of various air pollution sources upon the “airshed.” Through a demonstration and group work, students develop a model of the multiple sources of air pollution and how to reduce this pollution.

Time

One Class Period

Materials

Materials:

- **RED** food coloring represents car and truck pollution.
- **GREEN** food coloring represents lawn and garden, motor boat, and construction engines.
- **BLUE** food coloring represents air pollution sources in a home: consumer products, home appliances, fireplaces, paint, etc.
- **YELLOW** food coloring represents industry and commercial activities.
- Container of water (2L bottle, aquarium, or other clear container) - represents the “airshed”
- Props can be used while narrating this activity. Use your imagination. Here are some suggestions:
  - Small plastic car
  - Child size lawn mower
  - Fast food containers
  - Shower and hair products
  - Electric hair dryer
  - Perfumes
  - Product in a spray bottle
- **Visuals:** Midwest Hazecam, Sources of Pollution, Types of Pollutants, Michigan Stationary Source Emission Trends
- **Handout:** A Day in the Life of.......

Objectives

After participating in or observing the activity students will

1. List some sources of air pollution.
2. Evaluate what can be done about air pollution.
Background:

An airshed is a part of the atmosphere that behaves in a coherent way with respect to the dispersion of air pollution emissions that come from a variety of sources. The United States Environmental Protection Agency (U.S. EPA) has identified six major types of air pollutants deemed especially harmful to human health. These are carbon monoxide, sulfur dioxide, nitrogen oxides, ozone, particulate matter and lead. Ozone is a secondary pollutant, which means that it is formed in the atmosphere through chemical reactions. Another group of pollutants is air toxics. Air toxics, also known as toxic air pollutants or hazardous air pollutants, are those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects.

There are a huge number of potential contributions to air pollution generated by everyday human activities. These activities may not be immediately apparent as a source of pollution when you observe from the individual viewpoint. However, the cumulative effect can be profound.

In this activity, water is used to simulate mixing of various pollutants, which occurs in the air.

Procedure

1. Engage

Has anyone ever experienced breathing problems while outside? Have students imagine what it is like to breathe clean mountain air vs. polluted air on a city street. Show them the two Midwest Hazecam pictures. Why do the pictures look different? Arrange students into groups and have them brainstorm how outdoor air can become polluted. List the sources and types of air pollution they have identified.

2. Explore

A story will be told to illustrate how air can get polluted. Tell the students that the water in a container represents their airshed. Food coloring represents gases and flour represents particle pollution as shown in the Sources of Pollution visual. As the story is told, have students complete the air pollution sources column in the A Day in the Life of….. worksheet.

Narrate A Day in the Life of …….. (make up a name to use for a person who is going to work). Be creative with your story and embellish as needed. This can be a humorous and exaggerated depiction of how someone might excessively contribute air pollutants during their daily activities. During the narration, have students add a drop of food coloring* or a little bit of flour when something that contributes to air pollution is mentioned. The color of the food coloring relates to the source of the pollution. This activity can be done as a demonstration if materials are limited.

*Note: Instead of using food coloring directly from the container, dilute some food coloring with water and use an eye dropper. This will conserve your materials.
A Day in the Life of ……..

The Alarm goes off! Jump into the shower and get ready for the day.

- VOC sources:
  - Soap and shampoo (perfumed) in the shower.
  - Deodorant, hair spray, perfume, shaving supplies, fingernail polish

Add one drop of **BLUE** food coloring to your “airshed.”

- CO, NOX, PM2.5, SOX sources:
  - Combustion to heat water using gas or electricity.

Add one drop of **BLUE** food coloring and ¼ teaspoon of flour to your “airshed.”

Get into your car and drive to work. Single driver - no carpool; forgot your homework so back track to home; drive through a fast food place.

- VOC, CO, NOX, SOX, PM2.5 sources
  - Cold start in your automobile: High CO emissions.

Add one drop of **RED** food coloring and ¼ teaspoon of flour to your “airshed.”

Arrive at work.

- Industrial sources: PM2.5, CO, VOC, NOX, SOX
  - manufacturing, mills, construction, space heating

Add one drop of **YELLOW** food coloring and ¼ teaspoon of flour to your “airshed.”

- Commercial sources: PM2.5, CO, VOC, NOX, SOX
  - printing, painting, delivery, small manufacturing, dry cleaning, space heating

Add one drop of **YELLOW** food coloring and ¼ teaspoon of flour to your “airshed.”
Time for your lunch break.

- Drive to your friend’s boat during lunch time: PM$_{2.5}$, CO, VOC, NO$_X$, SO$_X$

Add one drop of **RED** food coloring and $\frac{1}{4}$ teaspoon of flour to your “airshed.”

- Your friend fixes you lunch (flame broiled burger with fries): PM$_{2.5}$, CO, VOC, NO$_X$, SO$_X$

Add one drop of **BLUE** food coloring and $\frac{1}{4}$ teaspoon of flour to your “airshed.”

- Enjoy a quick ride on your friend’s boat: PM$_{2.5}$, CO, VOC, NO$_X$, SO$_X$

Add one drop of **GREEN** food coloring and $\frac{1}{4}$ teaspoon of flour to your “airshed.”

- Drive back to work: PM$_{2.5}$, CO, VOC, NO$_X$, SO$_X$

Add one drop of **RED** food coloring and $\frac{1}{4}$ teaspoon of flour to your “airshed.”

Back at work.

- Same sources at work mentioned above.

Add two drops of **YELLOW** food coloring and $\frac{1}{4}$ teaspoon of flour to your “airshed.”

Time to go home!

Drive home in your car: PM$_{2.5}$, CO, VOC, NO$_X$, SO$_X$

Add one drop of **RED** food coloring and $\frac{1}{4}$ teaspoon of flour to your “airshed.”

Stop off to pick up the dry cleaning: VOC

Add one drop of **YELLOW** food coloring to your “airshed.”

Everyone’s yard looks great – except yours!

Mow the lawn: PM$_{2.5}$, CO, VOC, NO$_X$, SO$_X$

Add one drop of **GREEN** food coloring and $\frac{1}{4}$ teaspoon of flour to your “airshed.”
Those fall evenings are getting cool.

Start up your gas fireplace: PM$_{2.5}$, CO, VOC, NO$_x$, SO$_x$

Add one drop of **BLUE** food coloring and ¼ teaspoon of flour to your “airshed.”

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It’s off to bed.

- VOC sources:
  - Soap and shampoo (perfumed) in the shower.
  - Deodorant, hair spray, shaving supplies, fingernail polish

Add one drop of **BLUE** food coloring to your “airshed.”

--------------------------------------------------------------------------------------------------------------

3. Explain

Now look at the “air” in the container. Have students do a pair-share to create a model of how the “air” changed with the addition of food coloring and flour. Assemble students into small groups and have them create a story board that illustrates the sources of pollutants throughout the day using the color code in the story. Show the *Types of Pollutants* visual and have them discuss what types of pollutants were in the activities in the story. Follow up with the *Pollutant Emissions* visual explaining that a mixture of pollutants can lead to the formation of ozone under certain weather conditions and high levels of particle pollution.

4. Elaborate

Stationary sources of air pollution, including factories, refineries, boilers, and power plants, emit a variety of air pollutants. The Clean Air Act directs U.S. EPA to control these emissions by developing and implementing standards and guidelines. Ask students what the *Michigan Stationary Source Emission Trends* chart shows (i.e., decreasing amounts of pollutants emitted over the years). Note that ozone is not in the chart since it is not directly emitted by a source, but it is formed in the atmosphere. Other air pollution sources are classified as mobile (on-road), mobile (off-road), and area sources.

Pose the question: how can we tell if the air quality is good today? Follow up with an introduction to the U.S. EPA’s AirNow website ([https://airnow.gov/](https://airnow.gov/)) and Michigan MIair website ([http://www.deqmiair.org/](http://www.deqmiair.org/)).
5. Evaluate

Students can create a poster that shows what they do during a day and how their activities may contribute to air pollution. Have students do a pair-share of their results.

Students should evaluate the environmental impacts which result from the individual choices they make in their everyday activities. When you make a choice that reduces or eliminates the amount of pollution you contribute to the air you also reduce the need for technologies to remove or recycle the pollution. Have students record their ideas about the ways to reduce air pollution sources in the A Day in the Life of….. worksheet.

**Linking the activity with Clean Air Action**

1. Compare student ideas about how to reduce air pollution to the tip cards in the free materials section found at West Michigan Clean Air Coalition’s website (https://www.wmcac.org/).

2. Create a list of pollution sources at the school and formulate a strategy to reduce these sources. Share this with decision-makers.
Midwest Hazecam
A composite photo of the St. Paul skyline

PM2.5 levels of 5 μg/m³ (left) and 35 μg/m³ (right)

Source: http://www.fdlrez.com/RM/airadditional.htm
Sources of Pollution

Food coloring = gases

Flour = particulate matter

• **RED** food coloring represents mobile sources such as car, bus, train, and trucks.

• **GREEN** food coloring represents lawn and garden, motor boat, and construction engines.

• **BLUE** food coloring represents area sources such as air pollution sources in a home, consumer products, appliances, fireplaces, paint, dry cleaners, gas stations, agriculture, etc.

• **YELLOW** food coloring represents point sources such as industry, power plants, oil refineries, and some commercial activities.
# A Day in the Life of ………………

<table>
<thead>
<tr>
<th>Activity</th>
<th>Air pollution sources</th>
<th>Ways to reduce sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm goes off! Get ready!</td>
<td></td>
<td></td>
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<tr>
<td>Drive to work.</td>
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<tr>
<td>Arrive at work.</td>
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<td>Lunch Break</td>
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<tr>
<td>Back to work.</td>
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<tr>
<td>Time to go home!</td>
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<tr>
<td>The fall evenings are getting cold.</td>
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</tr>
<tr>
<td>It’s off to bed.</td>
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</tbody>
</table>
Types of Pollutants

Outdoor Sources of Contaminants
Source: U.S. EPA
Pollutant Emissions

Natural
- Lightning
- Volcanos
- Wildfires
- Forests
- Fertilizer

Mobile
- Planes
- Cars, Trucks, Buses, Motorcycles

Stationary
- Industry, Power Plants, Sewage Treatment

Area
- Cities
- Livestock
- Farms

Source: National Park Service
Ozone: Good or Bad?
Ozone: Good or Bad?

Overview

This activity allows students to look at the chemistry of ozone in the upper atmosphere (stratosphere) and ozone formation at ground level, while learning the difference between good/bad ozone, and the chemical process of its formation.

Time

Two Class Periods

Materials

• Reading: *Ozone: Good or Bad?* (reading for teachers)
• Visual: *Good vs. Bad Ozone; Formation of Ozone*
• Handout: *Ozone: Good or Bad? Questions*

Objectives

Students will be able to:

1. Distinguish between ozone in the troposphere and ozone in the stratosphere.

2. Describe the chemical makeup of ozone.

3. Identify the two main pollutants that form ozone and identify their sources.

4. Explain the health effects of ground level ozone.
Background information

Since 1995, the West Michigan Clean Air Coalition (WMCAC) has been working to educate people about the ground level ozone problem. In recent years, the WMCAC has included particle pollution in their messaging (https://www.wmcac.org/).

Ozone in the stratosphere, which is formed naturally, is good, protecting us from the sun’s harmful ultraviolet rays. When ozone from air pollution forms in the troposphere, where we breathe, ozone can be harmful to our health. This is the ozone targeted by the federal government as one of the six criteria pollutants that must be reduced in the interest of the public health as well as the ozone targeted by the Clean Air Action program.

On Clean Air Action Days we all can help minimize excessive ozone formation by voluntarily reducing the amount of hydrocarbon emissions we put into the air. The Clean Air Action tip sheet from the WMCAC contains helpful actions that can keep our air clean.

Procedure

1. Have students answer the “A.Q.” (Air Pollution Quotient) quiz. Then have them quiz friends, fellow students, and families, writing up summaries of their findings and including information about any differences in attitudes towards air quality among these different groups.

3. Conduct a brainstorming session with students about their knowledge of ozone. An important point to get across is that there is only one chemical structure for ozone – O₃.

3. Invite them to answer the following questions on the Ozone: Good or Bad? Questions by doing online research. The questions could be divided up so that small groups work on a single question resulting in a poster or a presentation (video, PowerPoint) by each group. Helpful websites listed are below:

   • West Michigan Clean Air Coalition
     https://www.wmcac.org/

   • Michigan Department of Environmental Quality
     http://www.michigan.gov/deq and search for “DEQ-Air”

   • AIRNOW page (regional and national ozone maps):
     https://airnow.gov/ and https://cfpub.epa.gov/airnow/

   • Midwest Hazecam for live pictures and air quality conditions:
     http://www.mwhazecam.net/

Note: The Ozone: Good or Bad? reading summarizes answers to the questions on the student worksheet.
Linking the activity with Clean Air Action

An important part of any lesson is turning knowledge into action – empowering students to act. Challenge students to help build awareness based on the information they have learned about West Michigan’s ozone problem. Brainstorm with students to identify ways they can contribute to the solution of this problem. The following list of actions is just the beginning.

1. Use the school radio station or newspaper to inform other students about Clean Air Action Days and Clean Air Action tips for reducing emissions.
2. Organize a school bike and carpool day (for students and teachers).
3. Teach younger students about ozone. Older students are great role models and can very effectively teach others about the environment and how to protect it.

Extension Activities

1. Use Clean Air Action forecasting to elaborate on the weather conditions that contribute to ground level ozone formation.
2. Assign research papers to students on “good” and “bad” ozone, asking them to detail the chemistry formation and environmental issues inherent to each.
3. Break students into groups. Have each group design an emissions-free city and write about whether or not they think that same city would be free of ground level ozone.
4. Assign a debate to the class on public health vs. economic considerations.
5. Assign a research paper to students on alternative energy sources (fuel cells, solar power etc.).
6. Assign students to write a position paper on “what is the role of the government in protecting public health” or “what is the role of government of regulating industry”.
7. Select a monitoring station for analysis using the Ozone Calculator to summarize hourly average ground-level ozone data.

See https://webcam.srs.fs.fed.us/tools/calculator/index.shtml
What is your A.Q. (Air Pollution Quotient)?

For students, their parents, and friends

1. Air pollution is only a problem in big cities. True False
2. Dirty air is costly to each American. True False
3. When the air is polluted, you can always see and smell it. True False
4. Clean air is the responsibility of industry alone. True False
5. The only effect of ozone air pollution is on the human body. True False
6. Cars contribute little to the air pollution problem. True False
7. Air pollution is now under control and will not be a problem in the future. True False

Source: Adapted from Clean Air Kentucky
What is your A.Q. (Air Pollution Quotient?)

Answers

1. Air pollution is a problem only in big cities.

   **False.** Everyone is affected by air pollution. The air we breathe does not stay in the same place, hovering over us. It moves. Wind carries pollution to us from all over the world as weather systems travel. Likewise, the pollution that we produce, no matter how small an amount it may seem, is significant when we combine it with everyone else’s “small amount”.

2. Dirty air is costly to each American.

   **True.** We pay in health problems caused by air pollution. As consumers, we pay costs hidden in the price of things we buy and the cost of new technology to prevent air pollution.

3. When air is polluted, you can always see and smell it.

   **False.** Some pollutants are odorless and colorless. That is why it is important to look in the newspaper, listen to or watch your favorite news station or check AirNow or MiAir websites for the latest air quality conditions.

4. Clean air is the responsibility of industry alone.

   **False.** We all have an important role to play in clearing our air. What choices can you make (and what actions can you take) to start clearing the air today?

5. The only effect of ozone air pollution is on the human body.

   **False.** Ozone pollution affects our lungs and can irritate our eyes. It also deteriorates materials, damages vegetation, effects animals and contaminates ground water.

6. Cars contribute little to the air pollution problem.

   **False.** The automobile industry has made some improvements in pollution-control devices. Individual cars and buses emit fewer hydrocarbons emission into the air today than ever before. However, more people are driving today than ever, and that adds up to a lot of pollution.

7. Air pollution is now under control and will not be a problem in the future.

   **False.** If what we do in the morning can become pollution in the afternoon, imagine how what we are doing today will affect us tomorrow. We need to be aware of how our activities contribute to pollution.
Good Up High Bad Nearby - What is Ozone?

What is ozone?

Ozone is a gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone is O\textsubscript{3} as compared to oxygen, which is O\textsubscript{2}. Ozone can be "good" or "bad" for your health and the environment, depending on its location in the atmosphere.

How Can Ozone Be Both Good and Bad?

Ozone occurs in two layers of the atmosphere. The layer closest to the Earth's surface is the troposphere. Here, ground-level or "bad" ozone is an air pollutant that is harmful to breathe and it damages crops, trees and other vegetation. It is a main ingredient of urban smog. The troposphere generally extends to a level about 6 miles up, where it meets the second layer, the stratosphere. The stratosphere or "good" ozone layer extends upward from about 6 to 30 miles and protects life on Earth from the sun's harmful ultraviolet (UV) rays.

What is Happening to the "Good" Ozone Layer?

Ozone is produced naturally in the stratosphere. But this "good" ozone is gradually being destroyed by man-made chemicals referred to as ozone-depleting substances (ODS), including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl bromide, carbon tetrachloride, and methyl chloroform. These substances were formerly used and sometimes still are used in coolants, foaming agents, fire extinguishers, solvents, pesticides, and aerosol propellants. Once released into the air these ozone-depleting substances degrade very slowly. In fact, they can remain intact for years as they move through the troposphere until they reach the stratosphere. There they are broken down by the intensity of the sun's UV rays and release chlorine and bromine molecules, which destroy the "good" ozone. Scientists estimate that one chlorine atom can destroy 100,000 "good" ozone molecules.

Even though we have reduced or eliminated the use of many ODSs, their use in the past can still affect the protective ozone layer. Research indicates that depletion of the "good" ozone layer is being reduced worldwide. Thinning of the protective ozone layer can be observed using satellite measurements, particularly over the Polar Regions.

How Does the Depletion of "Good" Ozone Affect Human Health and the Environment?

Ozone depletion can cause increased amounts of UV radiation to reach the Earth which can lead to more cases of skin cancer, cataracts, and impaired immune systems. Overexposure to UV is believed to be contributing to the increase in melanoma, the most fatal of all skin cancers. Since 1990, the risk of developing melanoma has more than doubled.
UV can also damage sensitive crops, such as soybeans, and reduce crop yields. Some scientists suggest that marine phytoplankton, which are the base of the ocean food chain, are already under stress from UV radiation. This stress could have adverse consequences for human food supplies from the oceans.

What is Being Done About the Depletion of "Good" Ozone?

The United States, along with over 180 other countries, recognized the threats posed by ozone depletion and in 1987 adopted a treaty called the Montreal Protocol to phase out the production and use of ozone-depleting substances. EPA has established regulations to phase out ozone-depleting chemicals in the United States. Warning labels must be placed on all products containing CFCs or similar substances and nonessential uses of ozone-depleting products are prohibited. If the United States and other countries stop producing ozone-depleting substances, natural ozone production should return the ozone layer to normal levels by about 2050.

What Causes "Bad" Ozone?

Ground-level or "bad" ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC.

At ground level, ozone is a harmful pollutant. Ozone pollution is a concern during the summer months because strong sunlight and hot weather result in harmful ozone concentrations in the air we breathe. Many urban and suburban areas throughout the United States have high levels of "bad" ozone. But many rural areas of the country are also subject to high ozone levels as winds carry emissions hundreds of miles away from their original sources.

How Does "Bad" Ozone Affect Human Health and the Environment?

Breathing ozone can trigger a variety of health problems including chest pain, coughing, and throat irritation. It can worsen bronchitis, emphysema, and asthma. "Bad" ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.

Healthy people also experience difficulty breathing when exposed to ozone pollution. Because ozone forms in hot weather, anyone who spends time outdoors in the summer may be affected, particularly children, older people, outdoor workers and people exercising. Millions of Americans live in areas where the national ozone health standards are exceeded.

Ground-level or "bad" ozone also damages vegetation and ecosystems. It leads to reduced agricultural crop and commercial forest yields, reduced growth and survivability of tree seedlings, and increased susceptibility to diseases, pests and other stresses such as harsh weather. In the United States alone, ground-level ozone is responsible for an estimated $500 million in reduced crop
production each year. Ground-level ozone also damages the foliage of trees and other plants, affecting the landscape of cities, national parks and forests, and recreation areas.

**What Is Being Done About "Bad" Ozone?**

Under the Clean Air Act, EPA has set protective health-based standards for ozone in the air we breathe. EPA, state, and cities have instituted a variety of multi-faceted programs to meet these health-based standards. Throughout the country, additional programs are being put into place to cut NOx and VOC emissions from vehicles, industrial facilities, and electric utilities. Programs are also aimed at reducing pollution by reformulating fuels and consumer/commercial products, such as paints and chemical solvents that contain VOC. Voluntary programs also encourage communities to adopt practices, such as carpooling, to reduce harmful emissions.

**What can you do about Good and Bad ozone?**

**High-Altitude "Good" Ozone**

- Protect yourself against sunburn. When the UV Index is "high" or "very high": Limit outdoor activities between 10 am and 4 pm, when the sun is most intense. Twenty minutes before going outside, liberally apply a broad-spectrum sunscreen with a Sun Protection Factor (SPF) of at least 15. Reapply every two hours or after swimming or sweating. For UV Index forecasts, check local media reports or visit: [https://www.epa.gov/sunsafety/uv-index-1](https://www.epa.gov/sunsafety/uv-index-1)

- Use approved refrigerants in air conditioning and refrigeration equipment. Make sure technicians that work on your car or home air conditioners or refrigerator are certified to recover the refrigerant. Repair leaky air conditioning units before refilling them.

**Ground-Level "Bad" Ozone**

- Check the air quality forecast in your area. At times when the Air Quality Index (AQI) is forecast to be unhealthy, limit physical exertion outdoors. In many places, ozone peaks in mid-afternoon to early evening. Change the time of day of strenuous outdoor activity to avoid these hours, or reduce the intensity of the activity. For AQI forecasts, check your local media reports or visit: [https://airnow.gov](https://airnow.gov).

- Help your local electric utilities reduce ozone air pollution by conserving energy at home and the office. Consider setting your thermostat a little higher in the summer. Participate in your local utilities' load-sharing and energy conservation programs.

- Reduce air pollution from cars, trucks, gas-powered lawn and garden equipment, boats and other engines by keeping equipment properly tuned and maintained. During the summer, fill your gas tank during the cooler evening hours and be careful not to spill gasoline. Reduce driving, carpool, use public transportation, walk, or bicycle to reduce ozone pollution, especially on hot summer days.

- Use household and garden chemicals wisely. Use low VOC paints and solvents. And be sure to read labels for proper use and disposal.

Source: U.S. Environmental Protection Agency
Good vs. Bad Ozone

Formation of Ozone

Source: https://www.springfieldmo.gov

Source: U.S. Forest Service
**Ozone: Good or Bad? Questions**

1. Why is ozone considered a “pollutant” in the troposphere and not in the stratosphere? What is your definition of a pollutant?

2. What is happening to the “good” ozone layer?

3. How does depletion of “good” ozone affect human health?

4. How does the depletion of “good” ozone affect the environment?

5. What is being done about the depletion of “good” ozone?

6. What causes “bad” ozone?

7. How does “bad” ozone affect human health?

8. How does “bad” ozone affect the environment?

9. What is being done about “bad” ozone?

10. What can you do to protect the high altitude “good” ozone?

11. What can you do to mitigate the effects of ground level “bad” ozone?
Synthesizing Written Information
Synthesizing Written Information

Overview

Clean Air Action in the classroom provides opportunities for students to improve reading performance along with providing important science, social studies and environmental information and skills.

Time

Two class periods.

Materials

- Online access via computers or tablets
- Handout: Exploring Air Issues Through a Community Survey

Objectives

By participating in this activity, students will:

1. Learn to gather information by reading written material.

2. Provide evidence of their understanding of the material through classroom discussion and possible writing assignments.

3. Gain hands-on experience in field research.
Background

The West Michigan Clean Air Coalition’s website (https://www.wmcac.org/) is a one stop resource for students to learn about air pollution in our area. This activity challenges students to expand their knowledge of air quality issues.

Procedure

1. Discover their depth of knowledge by asking students to research and discuss the following questions using the West Michigan Clean Air Coalition website.

   Questions
   - What is the West Michigan Clean Air Coalition?
   - What is a Clean Air Action Day?
   - What conditions prompt the declaration of a Clean Air Action Day?
   - Why is there concern about ground level ozone?
   - What are the health effects of ozone at ground level? Who is most susceptible?
   - Why is there concern about particle pollution?
   - What are the health effects of particle pollution? Who is most susceptible?
   - Why does the U.S. Environmental Protection Agency have ozone and particle pollution standards?
   - What is the current federal standard for ozone and particle pollution levels?
   - What types of actions are people asked to consider on Clean Air Action Days? Why?

2. Pose the question: based on your research, or your own experience, what is the public’s attitude toward taking action to reduce air pollution? Introduce the role of surveys in gauging attitudes. Have them brainstorm how to construct a survey and what types of surveys could be used.

3. Show an example of a survey to gauge citizen awareness of the Clean Air Action Program and local compliance with voluntary actions on Clean Air Action Days from the West Michigan Clean Air Coalition website. The surveys are found in the “Resources” tab. Review how the survey was performed, some of the questions that were asked, and the results.

4. Now give students the Exploring Air Issues Through a Community Survey with instructions to conduct a mini-survey in school with at least five students.

5. During the second class, tally the survey results and discuss the outcome.
Extensions

1. Have the student’s survey parents and other adults outside school and compare the results. Are there any differences in attitudes? Have the students explore and explain the differences.

2. Compare the results over the years in the public knowledge and attitudes found in the Citizen Awareness and Compliance Surveys found on the West Michigan Clean Air Coalition website (https://www.wmcac.org/citizen-awareness-and-compliance-surveys/).

3. Create and conduct a survey to determine if idling of buses is an issue in the school or school district. Helpful resources for this are found at https://www.epa.gov/schools-transportation/school-buses-and-healthy-schools.

4. Think about the complex relationship of clean air, government, industry and environmental activism. Monitor the newspaper for articles on issues that involve these stakeholders.

5. Make a graph showing the number of Clean Air Action Days over the years at the Grand Rapids Station as reported at the Michigan Department of Environmental Quality’s website at http://www.deqmiair.org/actionday.cfm. Write a summary of what you discovered.
Exploring air issues through a community survey

What is your community’s average vehicle occupancy? How do students travel to school? How does your community compare to others in the state? Use this sample opinion poll (or make up one of your own) to investigate air issues in your school and community.

Rate your agreement with each of the following statements on a scale of one to five, with one meaning you strongly disagree and five meaning you strongly agree:

1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

1. Air pollution is a major health problem in my community. ______
2. Industry is a major contributor to air pollution in my community. ______
3. Vehicles are a major contributor to air pollution in my community. ______
4. Other states are a major contributor to air pollution in my community. ______
5. People traveling to work should be required to carpool or take public transportation if it is available. ______
6. Students should be required to carpool or take public transit. ______
7. Taxes should be increased to support mass transit programs. ______
8. The government should increase research support for the electric car. ______
9. Auto makers need to increase fuel mileage on all cars and trucks. ______
10. Developing countries around the world should better address air pollution as a major environmental problem. ______
11. Communities should increase their construction of bike trails for workers, students and others to use. ______
12. I am willing to modify my behavior to avoid contributing to air pollution. ______

*Adapted from “Exploring Air Issues Through Community Survey” by the Wisconsin Department of Natural Resources.
“Tennis” Anyone

Class Debate
“Tennis” Anyone

Class Debate

Overview

The conversation surrounding the National Ambient Air Quality Standards for ozone and particulate matter is good material for developing critical thinking and debating skills. This activity, applicable to subjects that include government, science and health, speech and public policy, helps students learn how to use both critical and logical thinking to make decisions based on fact and testimony while acquainting students with government policy.

Time

Three Class Periods

Materials

- Newspaper articles that students find (optional)
- Visuals: Air Quality Guide for Ozone, Air Quality Monitoring Station for Ozone, Nonattainment Areas
- Reading: Meeting Air Quality Standards, Ozone Transport over Lake Michigan
- Handout: Ozone: Wind Direction, Temperature, and Precipitation

Objectives

Participating in this activity, students will

1. Practice logical thinking.
2. Utilize critical thinking skills.
3. Develop practical speaking skills.
4. Become acquainted with governmental policies.
5. Make decisions based on fact and testimony.
Background Information

The Clean Air Act, which was last amended in 1990, requires the Environmental Protection Agency (U.S. EPA) to set National Ambient Air Quality Standards for pollutants that can harm public health and the environment. The U.S. EPA has established National Ambient Air Quality Standards for six pollutants, called "criteria" pollutants. These include carbon monoxide, lead, nitrogen dioxide, ozone, particle pollution (PM$_{2.5}$ and PM$_{10}$), and sulfur dioxide.

The United States Environmental Protection Agency is required to review its National Ambient Air Quality Standards (NAAQS) every five years. With the goal of protecting public health and welfare, the standards detail the maximum amounts of certain pollutants permitted in the air. In the summer of 1997, the United States Environmental Protection Agency passed new, more stringent standards for both ozone and particulate matter. This was followed by further changes to the standards over the years.

Regions that meet the standards are said to be in “attainment”. From 1978 until 1994, West Michigan (Kent, Ottawa, and Muskegon Counties) failed to meet federal air quality standards for ozone; that non-compliance resulted in the designation of the area as a "moderate" non-attainment area by the U.S. EPA. In 1996, the State of Michigan applied for a re-designation of West Michigan (Kent & Ottawa Counties) as an attainment area, and the U.S. EPA granted the area as attainment maintenance. Muskegon followed suit the following year. The current attainment status for ozone and fine particulate matter (PM$_{2.5}$) is outlined below.

**Ozone**

All areas in Michigan are currently designated as attainment for the Environmental Protection Agency’s (U.S. EPA’s) 2008 8-hour ozone standard of 75 ppb. However, on October 26, 2015, U.S. EPA adopted new more protective National Ambient Air Quality Standards for ground-level ozone set at 70 ppb, based on extensive scientific evidence about ozone’s effects on public health. Currently, three counties in West Michigan—Allegan, Berrien, and Muskegon—are violating the latest ozone standard, and there have been official non-attainment designations for West Michigan from the U.S. EPA. Parts of these counties are designated as non-attainment, a new plan for reaching attainment will be needed. This reemphasizes the importance of individual actions taken by West Michigan residents who remain critical to our campaign to reduce ozone violations at area monitors.

**Fine Particulate Matter**

All counties in Michigan must meet an annual and daily standard for PM$_{2.5}$. All of West Michigan is currently in attainment for the 2006 daily standard of 35 μg/m$^3$. U.S. EPA
issued final designations for the 2012 annual fine particulate standard of 12 μg/m³ on December 18, 2014. All of Michigan has been designated as “unclassifiable/attainment” for the annual standard.

**Importance of Maintaining Attainment**

Across the nation, areas with nonattainment status for the ozone standard are at a distinct disadvantage. People in poor air quality areas may incur added healthcare costs. Control measures to reduce emissions can increase costs for business and residents. New businesses are not allowed to increase emissions in the region, and more stringent air permitting requirements apply in nonattainment areas. If clean air cannot be maintained after redesignation to attainment, additional measures to reduce pollution must be implemented.

The likelihood of maintaining clean air is greatly improved when businesses and individuals voluntarily take steps to reduce emissions on days when the area is particularly vulnerable to unhealthy pollution levels. Your actions do make a difference in West Michigan's air quality, so please sign up for Clean Air Action Day notifications and consider alternatives to driving, especially on these sensitive days.

**Procedure**

1. To prepare for this activity, ask students what they know about the air quality in West Michigan. Do they know how ground level ozone is formed? (see [https://www.youtube.com/watch?v=TkZ_KcQK008](https://www.youtube.com/watch?v=TkZ_KcQK008)). Are they aware of the health effects of ozone? (see *Air Quality Guide for Ozone*). Do they know that there are air quality monitoring stations in West Michigan? (see *Air Quality Monitoring Stations*) Do they know about the air quality index? (Show the current AQI loop animations from the AirNow website at [https://airnow.gov/](https://airnow.gov/)).

2. Brief the students on the National Ambient Air Quality Standards (see the Background Information). Periodically, air quality standards are evaluated and changed. If the standards become more stringent then more effort is likely to be needed to meet the standards.

3. The game of “limbo” will be used to illustrate the amount of effort needed to meet standards. The height of the limbo bar represents the air quality standards for ozone over the years. Have students go under the bar using different ozone standards, lowering the bar as the game goes along.

Use the following sequence and relate the increasing level of difficulty of going under the bar to meeting the ozone standards:

- Ozone standard in 1979 = 120 ppb
- Ozone standard in 1997 = 80 ppb
Ozone standard in 2008 = 75 ppb

Ozone standard in 2016 = 70 ppb

Show the students the Nonattainment Areas graphic, which compare counties in non-attainment for the 75 ppb ozone standard from 2008 (Figure 1) and the counties above the 70 ppb ozone standard (Figure 2). Also, show the graphic with the recently designated nonattainment areas in Michigan. What is this saying about the air quality in West Michigan?

4. Do a pair-share or small group discussion about the following questions:
   - Can people stand for health even if they do not want more stringent standards?
   - Is clean air possible while maintaining current consumer lifestyles?
   - Are corporations as well as the American people ready to make changes to improve health and safeguard the environment?
   - What communication challenges are there for the counties with partial nonattainment designations?

5. Prepare your class for a debate.
   a) Divide the class into two groups.
   b) Initiate discussion about air quality in the region, federal health standards and Clean Air Action – a voluntary emissions reduction program.
   c) Engage students in researching the National Ambient Air Quality Standards (NAAQS) from the perspectives such as:
      i. U.S. Environmental Protection Agency (U.S. EPA)
      ii. Industry
      iii. Air Quality Modelers (Note: Ground level ozone can be created in a one community and transported to neighboring communities by wind)
      iv. Public Health Organizations
      v. Citizens
      vi. Scientists
   d) Designate one side of the class as supporting a more stringent National Ambient Air Quality Standard for ozone and the other side as against a less stringent NAAQS for ozone.
   e) Allocate 30 minutes for the class to prepare arguments. Group members (all players: political, business and special interest groups, such as health and environmental) should speak as representative from their groups (for example: a mayor of a Midwest urban area, a CEO of a large utility company, etc.).
group should argue the reasons the group is for or against the more stringent NAAQS for ozone including their claims, evidence and reasoning. Groups need to determine what solution is best for both groups and why.

6. Conduct the debate.

Allocate about 30 minutes for a “tennis” debate. A tennis debate is a very informal debate where participants “volley” arguments back and forth. As moderator, the instructor could throw out questions allowing each side to respond to it or to serve as discussion starters.

Twenty-five minutes into the debate, stop and allow two minutes for one speaker from each side to present a closing argument or concede to the opposition. Have the class vote to determine if more stringent standards should be put into place or reviewed and rescinded.

7. “Tennis” Debate – Follow Up

Have students work on a homework assignment, which is to write a brief summary of why their opponents have a legitimate reason for supporting/opposing more stringent standards.

Group discussion- How will more stringent National Ambient Air Quality Standards (NAAQS) affect students? Their parents? Will it be for the better or worse (take into account jobs, public health, cost of implementation, health care costs, and quality of life)?

8. And the rest of the story……

Have students read the handout on Ozone Transport and view a video on the Lake Michigan Ozone study (https://www.youtube.com/watch?v=TQmaPax7jfU). Also, they can collect evidence about wind direction and ozone by searching historical maps in AirNow and recording their results (see Ozone: Wind Direction, Temperature, and Precipitation). Based on what they have read, reformulate the debate question and have them refine their positions to address whether West Michigan should receive special consideration for meeting the standards.

Linking the activity with Clean Air Action

1. Discuss Clean Air Action and how it can help to “clear the air”. How does this program bridge the gap between supporters and opponents of the new NAAQS? Should the program’s importance and focus change in light of a more stringent standard and information about ozone transport?

2. How can people contribute to improve air quality in West Michigan?
Air Quality Guide for Ozone

Ground-level ozone is one of our nation’s most common air pollutants. Use the chart below to help reduce your exposure and protect your health. For your local air quality, visit https://airnow.gov/ online.

<table>
<thead>
<tr>
<th>Air Quality Index</th>
<th>Who Needs to be Concerned?</th>
<th>What Should I Do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (0-50)</td>
<td>It’s a great day to be active outside.</td>
<td>Unusually sensitive people: Consider reducing prolonged or heavy outdoor exertion. Watch for symptoms such as coughing or shortness of breath. These are signs to take it easier. Everyone else: It’s a good day to be active outside.</td>
</tr>
<tr>
<td>Moderate (51-100)</td>
<td>Some people who may be unusually sensitive to ozone.</td>
<td>Sensitive groups include people with lung disease such as asthma, older adults, children and teenagers, and people who are active outdoors.</td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups (101-150)</td>
<td>Sensitive groups include people with lung disease such as asthma, older adults, children and teenagers, and people who are active outdoors.</td>
<td>Sensitive groups: Reduce prolonged or heavy outdoor exertion. Take more breaks, do less intense activities. Watch for symptoms such as coughing or shortness of breath. Schedule outdoor activities in the morning when ozone is lower. People with asthma should follow their asthma action plans and keep quick-relief medicine handy.</td>
</tr>
<tr>
<td>Unhealthy (151-200)</td>
<td>Everyone</td>
<td>Sensitive groups: Avoid prolonged or heavy outdoor exertion. Schedule outdoor activities in the morning when ozone is lower. Consider moving activities indoors. People with asthma, keep quick-relief medicine handy. Everyone else: Reduce prolonged or heavy outdoor exertion. Take more breaks, do less intense activities. Schedule outdoor activities in the morning when ozone is lower.</td>
</tr>
<tr>
<td>Very Unhealthy (201-300)</td>
<td>Everyone</td>
<td>Sensitive groups: Avoid all physical activity outdoors. Move activities indoors or reschedule to a time when air quality is better. People with asthma, keep quick-relief medicine handy. Everyone else: Avoid prolonged or heavy outdoor exertion. Schedule outdoor activities in the morning when ozone is lower. Consider moving activities indoors.</td>
</tr>
<tr>
<td>Hazardous (301-500)</td>
<td>Everyone</td>
<td>Everyone: Avoid all physical activity outdoors.</td>
</tr>
</tbody>
</table>

Source: U.S. EPA
Air Quality Monitoring Stations for Ozone

Ozone Monitors

Source: MDEQ

Figure 10. Examples of Recent High Ozone Days in the Lake Michigan Area
Note: plot is based on spatial interpolation of hourly ozone data

Source: Western Michigan Ozone Study (200)
Nonattainment Areas

Nonattainment Areas for the 2008 0.075 ppm (75 ppb) Ozone Standard

Final Designations
- Unclassifiable Attainment
- Unclassifiable
- Nonattainment (Partial County)
- Nonattainment (Whole County)

Notes:
EPA has not designated any areas outside the Continental US.

8-Hour Ozone Nonattainment Areas (2015 Standard)

Nonattainment areas are indicated by color. When only a portion of a county is shown in color, it indicates that only that part of the county is within a nonattainment area boundary.
Attainment Status for the National Ambient Air Quality Standards

The National Ambient Air Quality Standards (NAAQS) are health-based pollution standards set by EPA.

Areas of the state that are below the NAAQS concentration level are called attainment areas. The entire state of Michigan is in attainment for the following pollutants:

- Carbon Monoxide
- Lead
- Nitrogen Dioxide
- Particulate Matter

Non-attainment areas are those that have concentrations over the NAAQS level. Portions of the state are in non-attainment for sulfur dioxide and ozone (see map). Nonattainment status for ozone will be effective in late summer 2018.

**LEGEND**

- [ ] Sulfur Dioxide Nonattainment Area
- [ ] Ozone Nonattainment Area

See Page 2 for close-up maps of partial county nonattainment areas

*Updated May 2, 2018*
Meeting Air Quality Standards

The Clean Air Act, which was last amended in 1990, requires the Environmental Protection Agency (U.S. EPA) to set National Ambient Air Quality Standards for pollutants that can harm public health and the environment. The U.S. EPA has established National Ambient Air Quality Standards for six pollutants, called “criteria” pollutants. These standards are periodically reviewed and updated.

Issues

The changing standards can be a cause for debate as business, local governments, citizens, and others have different opinions about the stringency of the standards. In general, those who support the U.S. EPA’s proposed standard argue that improved public health, number of lives saved and further emission reductions would improve quality of life and the environment. Those having reservations about the standards believe that there is no clear evidence that more stringent standards are necessary and that the new standards would be difficult or impossible to meet while generating major costs and job losses.

Beyond the debate is the fact that West Michigan’s air quality does not always meet the air quality standards, especially for ozone. Plans need to be made for meeting the standards.

Failure to maintain compliance with air quality standards will result in continued nonattainment status. If these areas fail to maintain the standard after they become attainment, contingency control measures must be implemented to quickly and permanently reduce emissions. Automobile testing or additional controls on products or industry could be mandated. The costs of additional environmental measures would be borne by the community.

There is concern that requirements for emission reductions are too costly to compare fairly with the associated health benefits of reducing ground level ozone. How more stringent limits on emissions may affect the economic health of their area is an issue. Could air quality improvement programs will help “clear the air” without the new stricter standard?

The industries most affected by the expected controls are concerned about their costs and worry that they will not be able to compete in the marketplace. Consumers are also concerned about costs. Controls on utility companies, for instance, will drive consumer process higher.

On the other hand, environmental and health organizations argue that more stringent standards will achieve greater health benefits including lower rates of infant mortality, reduced hospital admissions due to respiratory problems and lower death rates in non-compliant urban areas. They see the new standards as a forward step toward cleaner air, healthier residents and health-cost savings.
Ozone Transport over Lake Michigan

The phenomenon of ozone transport over Lake Michigan and the impact on West Michigan’s air quality is well documented. Ozone transport in the region has been studied at various points in time, including new research in 2017. The Lake Michigan Ozone Study (LMOS) found that the entire eastern United States contributes to a polluted air mass over Lake Michigan, particularly during high pressure conditions. Some conclusions are:

- This polluted air mass is a result of emissions from across the eastern United States as well as emissions from the Chicago, IL – Gary, IN area.
- It was also observed that when the air mass was cut off from the rest of the United States, typically due to rain, pollution levels over the lake decreased.
- Wind was also found to have an important impact on the size and concentration of the polluted air mass over Lake Michigan.
- In addition, rural areas along northern Lake Michigan shorelines often have higher ozone concentrations than the more populated areas in the southern Lake Michigan area due to the absence of oxides of nitrogen (NOx) scavenging, which reduces concentrations in urban areas around the lake.
- Finally, wind direction plays a significant role in the presence of ozone pollution. Southeasterly wind flow meant the west shoreline received more air pollution, while a southwesterly flow meant that the east shoreline received more of the polluted air. Southerly wind flow resulted in both shores being affected.

The U.S. EPA acknowledges that ozone transport is an important factor in the high ozone concentrations observed along Michigan’s Lake Michigan shoreline. According to a U.S. EPA document (December 20, 2017), “the meteorological data strongly indicates that the violating monitors in these counties (Muskegon, Allegan, and Berrien) are predominately affected by the transport of emissions over Lake Michigan.”


================================================================

In summary, this analysis conclusively demonstrates that ozone monitors in Wisconsin’s lakeshore area are overwhelmingly affected by transport from upwind areas and that the transport of large amounts of out-of-state emissions to the Wisconsin lakeshore effectively overwhelms any impact of local emissions on monitored ozone concentrations. As a result, Wisconsin has no ability to address its lakeshore ozone issues on its own.

Source: Wisconsin Department of Natural Resources, 2017
Ozone: Wind Direction, Temperature, and Precipitation

Focus Questions: 1. How much of a problem is ozone in West Michigan?

2. Is there a relationship between weather conditions and ozone levels?

Looking at the data:

1. Using the original AirNow website (https://cfpub.epa.gov/airnow/), select the following: More maps => Archived Maps by Region then set Map Type = Ozone AQI ; Map Region = Michigan – Indiana – Ohio; Month = August; Year = 2012 followed by See Maps. Re-set the map Year to 2018.

a. How do August 2012 ozone levels compare with August ozone levels in 2018?

b. Scroll through different months and years. What patterns do you see? (ex., are (When are there high ozone levels? How many “orange” episodes are there in a given year?)

2. Select two days from with high ozone levels in August 2012 and two days without high ozone levels in August 2012. Determine wind direction, maximum temperature, and precipitation by searching the dates selected for the Muskegon Airport station at https://www.wunderground.com/history/airport/KMKG/.

<table>
<thead>
<tr>
<th>Date</th>
<th>Ozone AQI Level</th>
<th>Wind Direction</th>
<th>Maximum Temperature</th>
<th>Precipitation</th>
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a. Describe any relationships between the wind direction, maximum temperature, precipitation, and ozone levels.

b. How does this compare with the results of the Lake Michigan Ozone Study?

c. If you were a meteorologist, when would you call a Clean Air Action Day in August 2012?

Bonus: Find a month when the particle pollution AQI is elevated and do the same type of analysis.
Glossary

Air - so called “pure” air is a mixture of gases containing about 78% nitrogen; 21% oxygen; less than 1% carbon dioxide, argon, and other gases; and varying amounts of water vapor.

Air Quality Index (AQI) - a number used by government agencies to communicate to the public how polluted the air currently is or how polluted it is forecast to become. It is color coded.

Airshed - a geographic area sharing the same air.

Area sources - Sources of pollution where the emissions are spread over a wide area, such as consumer products, fireplaces, road dust and farming operations. Area-wide sources do not include mobile sources or stationary sources.

Asthma - A chronic inflammatory disorder of the lungs characterized by wheezing, breathlessness, chest tightness, and cough.

Attainment area - A geographic area in which levels of a criteria air pollutant meet the health-based primary standard (National Ambient Air Quality Standard, or NAAQS) for the pollutant. An area may have on acceptable level for one criteria air pollutant, but may have unacceptable levels for others.

Asthma - A lung disease that can make it hard to breathe.

Clean Air Action Day - A Clean Air Action Day will be called when weather forecasters have predicted that conditions will be conducive to the formation of ozone or high levels of particulate matter. On a Clean Air Action Day, West Michigan residents will be asked to take certain voluntary actions to protect their health and reduce emissions.

Clean Air Act - The original Clean Air Act was passed in 1963, but our national air pollution control program is actually based on the 1970 version of the law. The 1990 Clean Air Act Amendments are the most far-reaching revisions of the 1970 law.

Criteria air pollutants - A group of very common air pollutants regulated by EPA on the basis of criteria (information on health and/or environmental effects of pollution). Criteria air pollutants are widely distributed all over the country. These pollutants are sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, lead, and particles (soot).

Designation - The term U.S. EPA uses to describe the air quality in a given area for any of six common pollutants known as criteria pollutants. An area can be meeting air quality standards (attainment) or exceeding air quality standards (nonattainment).

Mobile sources - Mobile sources of air pollution are divided into two categories: On-road vehicles (motorcycles; passenger cars and trucks; and commercial trucks and buses) and Nonroad vehicles and engines (aircraft; heavy equipment; locomotives; marine vessels; recreation vehicles; and small engines and tools).
National Ambient Air Quality Standard (NAAQS) - Standards established by the United States U.S. EPA that apply for outdoor air throughout the country. There are two types of NAAQS. Primary standards set limits to protect public health and secondary standards set limits to protect public welfare.

Nonattainment area - A geographic area in which the level of a criteria air pollutant is higher than the level allowed by the federal standards. A single geographic area may have acceptable levels of one criteria air pollutant but unacceptable levels of one or more other criteria air pollutants; thus, an area can be both attainment and nonattainment at the same time. It has been estimated that 60% of Americans live in nonattainment areas.

Ozone - Ground level ozone is formed in the lower atmosphere primarily by nitrogen oxides (NOx) reacting with volatile organic compounds (VOCs) on warm, sunny days. Nitrogen oxides are released into the atmosphere as a by-product of any combustion.

Particle pollution - Particulate matter (PM), also known as particle pollution, is a complex mixture of extremely small particles and liquid droplets that get into the air. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

Point source - Specific points of origin where pollutants are emitted into the atmosphere such as a factory smokestack. Any of a large number of sources -- such as manufacturing operations, oil and gas refineries, food processing plants, and energy generating facilities -- that emit substances into the atmosphere.

Pollutant - Pollutants are what make the air dirty or polluted. Sometimes you can see pollutants and sometimes you can’t. Ozone is a pollutant that you can’t see. Dust and soot are pollutants that you can see. Dust and soot are also called particle pollution.

Source - Any place or object from which pollutants are released. Sources that stay in one place are referred to as stationary sources; sources that move around, such as cars or planes, are called mobile sources.

Temperature inversion - One of the weather conditions that are often associated with serious smog episodes in some portions of the country. In a temperature inversion, air doesn't rise because it is trapped near the ground by a layer of warmer air above it. Pollutants, especially smog and smog-forming chemicals, including volatile organic compounds, are trapped close to the ground. As people continue driving, and sources other than motor vehicles continue to release smog-forming pollutants into the air, the smog level keeps getting worse.
Teacher Evaluation Form

Your feedback is necessary to make these resource guides a success.
Remain anonymous, if you wish, but please do complete the following items and return this form to the West Michigan Clean Air Coalition:

Name _____________________________________________________________

School __________________________________________________________

Address __________________________________________________________________________________________________

City __________________________ State ____________ Zip ____________

Phone Number (___) (___ - ____________) Email____________________

Please tell us what grade level and/or subjects you teach: _______________

Total number of students participating in class using Clean Air Action classroom materials ____________

Circle which Clean Air Action Resource Guide(s) you used.

_ K-5     Grade 6-8     Grade 9-12

Please rate your agreement with the following statements using a scale of 1 to 5.

(1) Clean Air Action background information is complete and helpful.

1 = strongly disagree  2 = disagree  3 = neutral  4 = agree  5 = strongly agree

(2) Clean Air Action classroom science activities are useful and relevant to classroom needs.

1 = strongly disagree  2 = disagree  3 = neutral  4 = agree  5 = strongly agree

(3) Clean Air Action classroom science activities are complete and easy-to-follow.

1 = strongly disagree  2 = disagree  3 = neutral  4 = agree  5 = strongly agree

(4) Clean Air Action classroom activities are easy to integrate into daily lessons.

1 = strongly disagree  2 = disagree  3 = neutral  4 = agree  5 = strongly agree

(5) Activities are well-received by students.

1 = strongly disagree  2 = disagree  3 = neutral  4 = agree  5 = strongly agree
(6) It is worthwhile to teach about Clean Air Action in my classroom.

1 = strongly disagree  2 = disagree  3 = neutral  4 = agree  5 = strongly agree

(7) I will use Clean Air Action classroom activities and lessons again next year.

1 = strongly disagree  2 = disagree  3 = neutral  4 = agree  5 = strongly agree

What did you like best about the Clean Air Action Teacher Resource Kit? (Please give us an idea of what worked well for you.)

Please give us an idea of what did not work well for you, any information you felt was missing, etc.

What changes would most help you meet you teaching needs? Please use a separate sheet for additional comments if necessary.

Fax or send completed form to West Michigan Clean Air Coalition c/o Grand Valley Metro Council
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Grand Rapids, MI 49503
Phone (616) 776-7696
Fax (616) 774-9292