

# High School Lesson Plans

These kinesthetic and interactive lesson plans were largely developed by the Environmental Protection Agency to teach students about air quality and wildfire smoke preparedness. Please visit the [EPA education site](#) for more resources and projects for your classroom.

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## Lessons

Field Testing for Ozone

Whirling Swirling Air Pollution

[Confederated Salish and Kootenai Fire on the Land \(multi-disciplinary curriculum\)](#)

[Do It Yourself Box Fan Filters for Clean Air In Your Home](#): Teach students about how wildfire smoke affects indoor air quality and how they can make a cost-effective air cleaner for their family. One page description in this PDF

# Field Testing for Ozone

EPA

JUNE 2024

**Grades: 9-12**

**Subject: Earth Science, Chemistry**

**NGSS (DCI) Connections: HS-ESS3-4**

**Time: 2 Class Periods (1 Week Apart)**

## Student Objectives

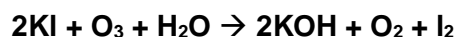
- Distinguish between tropospheric and stratospheric ozone.
- Define smog.
- Discuss air quality and related health and welfare issues involving tropospheric and stratospheric ozone.
- Perform simple measurement of ozone concentration in the outdoor air.

## Materials

- Potassium iodide
- Filter paper (can use coffee filters)
- Corn starch
- Glass stirring rod
- Small paint brush
- 250 mL beaker
- Heat source (preferably a hot plate)
- 9" microwaveable plate or paper plate
- Clear jar with lid or zipper lock plastic bag
- Distilled water
- Heat safe glass plate
- Full-splash safety goggles
- Aprons
- Scissors
- Schoenbein Color Scale (provided)
- Relative Humidity Schoenbein Number Chart (provided)
- Bulb psychrometer (optional)

## Student Activity

This test is based on the oxidation capability of ozone. Ozone in the air will oxidize the potassium iodide on the Schoenbein paper to produce iodine. The iodine reacts with starch and produces a purple color. The exact shade of purple correlates to the amount of ozone present in the air. The two reactions involved are:



**$I_2$  + starch  $\rightarrow$  starch turns a shade of purple**

## Background Information

The issue of ozone in the earth's atmosphere can be confusing. On one hand, we know that high above the earth's surface in the stratosphere is a layer of ozone that surrounds the planet and helps block out some of the sun's harmful radiation. We hear reports of "holes" developing in this stratospheric ozone shield and of the harm that the increased ultraviolet radiation can cause on earth. On the other hand, we know that higher than normal concentrations of ozone in the air we breathe in the troposphere (ground-level) can be harmful to people, animals, plants, and various materials. The ozone gas in the stratosphere and troposphere is the same, the chemical  $O_3$ . In the upper atmosphere (stratosphere) it greatly benefits all life. Near the earth's surface (troposphere), it can cause problems.



## Background Info (Cont.)

### The Stratospheric Ozone Layer

High in the stratosphere, a layer of ozone gas forms an important and effective protective barrier against the harmful ultraviolet (UV) radiation from the sun. In the 1970s, scientists discovered that certain human-made chemicals containing chlorine and bromine were depleting stratospheric ozone. This led to the adoption in 1987 of the Montreal Protocol, a global environmental treaty to protect the ozone layer by phasing out the production and consumption of chemicals that destroy the ozone layer. All countries have signed on to the Montreal Protocol, and the ozone layer is now expected to recover to healthy levels by mid-century. Researchers across the globe continue to study the ozone layer, the causes of its depletion, and the effects of ozone layer depletion on humans and the environment. Visit EPA's website to learn more: <https://www.epa.gov/ozone-layer-protection>.

Increased UV radiation at the earth's surface can lead to a greater incidence of:

- Skin cancer, eye problems such as cataracts, and immune deficiencies in humans
- Decreased crop yields, and reduced populations of microscopic sea plants and animals that are vital to the food chain

### Ozone Pollution in the Troposphere

High concentrations of ozone in the ambient air that we breathe in the troposphere can cause many problems. Because ozone molecules are highly reactive, they have an effect on practically every material they contact, whether it be lung tissue, crops or other vegetation, rubber, plastic, paints, etc.

What we often refer to as "smog" is mostly ground-level ozone. The recipe for the formation of ozone in the ambient air includes volatile organic compounds (VOCs), nitrogen oxides, and sunlight. Because sunlight is a key factor, ozone pollution is generally worse during the day (particularly the afternoon) and in the summertime. Vehicle exhaust provides most of the VOCs and nitrogen oxides that form ozone, so times of increased vehicle use (such as morning and afternoon rush hours) also increase the possibility of ozone problems.

Ozone can cause eye, nose, and throat irritation, and can damage the lungs. Visit EPA's website to learn more about ozone pollution in the troposphere: <https://www.epa.gov/ozone-pollution>.



# Field Testing for Ozone



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## Student Directions

1. Place 100 mL of water in a 250 mL beaker on your heat source, then add 5 grams of corn starch.
2. Heat and stir mixture until it gels. The mixture is gelled when it thickens and becomes somewhat translucent.
3. Remove the beaker from the heat and add 1 gram of potassium iodide and stir well. Allow the solution to cool.
4. Lay a piece of filter paper (you can use coffee filters) on a glass plate and carefully brush the paste onto the filter paper. Turn the filter paper over and do the same on the other side. Apply the paste as uniformly as possible. The paper can be exposed for immediate testing at this point.
5. If you plan to test at a later time, allow the paper to dry. To save time, place the paper on a microwave-safe plate and microwave for one minute.
6. Cut the paper into small strips. To store the strips, seal them in a clear jar or zipper lock plastic bag out of direct sunlight.
7. When you are ready to sample, dip a prepared strip of test paper in distilled water and hang it at a data collection site out of direct sunlight. Make sure the strip can hang freely.
8. Expose the paper for approximately eight hours. Seal it in an airtight container if the results will not be recorded immediately.
9. To observe and record test results, dip the paper in distilled water. Observe the color and determine the Schoenbein Number using the Schoenbein color scale.
10. Determine the relative humidity of the data collection site by using a bulb psychrometer or local weather data.
11. Round the relative humidity reading to the nearest 10 percent. (Higher relative humidity makes the paper more sensitive to ozone, and a higher Schoenbein Number is observed. To correct for this, the relative humidity must be determined and figured into the calculation of the ozone concentration.)
12. Refer to the Relative Humidity Schoenbein Number Chart. Along the bottom of the chart, find the point that corresponds to the Schoenbein Number that you recorded. From that point, draw a line upward until it intersects with the curve that corresponds to your relative humidity reading. To find the ozone concentration in parts per billion, draw a perpendicular line from the Schoenbein Number/relative humidity point of intersection to the left side of the chart (see example below).  
*NOTE: The color of the paper may not be uniform. Determine the Schoenbein Number by the color in the area with the most noticeable change.*

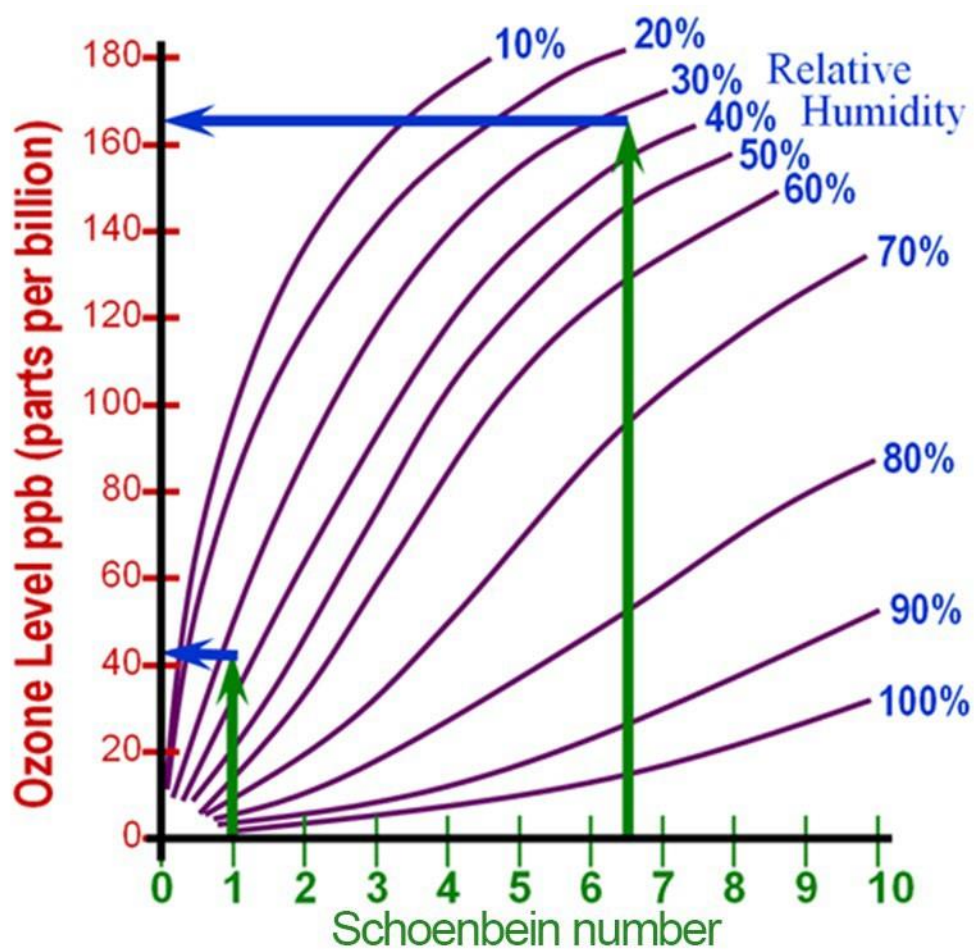




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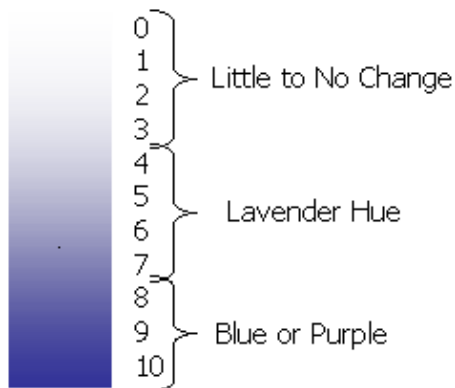
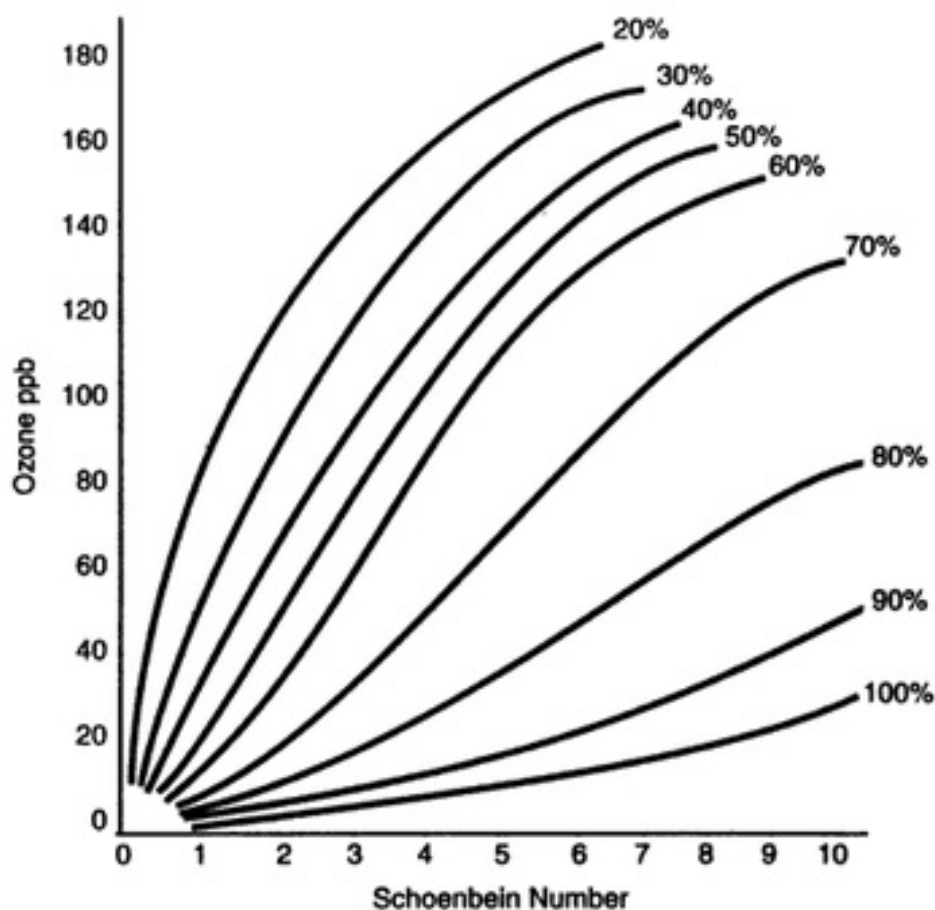


# Field Testing for Ozone

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## Relative Humidity Schoenbein Number Chart



# Field Testing for Ozone

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## Student Directions

1. What change in the test paper, if any, did you observe?
2. Compare your test paper to those of other students. Do all the test papers appear the same? (Individual test papers will vary depending on the amount of oxidants at that site. Be aware that false positive results can occur from nitrous oxides in heavy traffic areas.)
3. Was the relative humidity for your test day high or low? (Individual results will vary depending on the specific relative humidity of the site.)
4. Why do you think the test papers did not all appear the same?
5. Would the ozone parts per billion (ppb) be the same for a Schoenbein Number of 4 at a relative humidity of 30 percent and 70 percent? (Hint: Refer to the Relative Humidity Schoenbein Number Chart.)
6. Based on the data you collected, do you think this method is a good way to measure tropospheric ozone? Why or why not?
7. Compare data with those from a [local monitoring station\\*](https://gispub.epa.gov/aimow/?contours=ozone). Also, if possible, get information about the wind direction during your study and determine how it affected your measurements.

\*<https://gispub.epa.gov/aimow/?contours=ozone>

## What Can Be Done?

Both ozone problems, stratospheric depletion and tropospheric build-up, are created in large part by air pollution. The only practical approach to stopping the destruction of the ozone layer and to minimizing ozone pollution in our ambient air is reducing the human-generated pollutants that contribute to these problems. Ozone-depleting substances include classes of chemicals called chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) that are commonly used in refrigeration equipment, air conditioners, foam products, and fire suppression. Finding and using alternatives to ozone-depleting substances is an essential part of the solution. By 2020, the U.S. phased out the new production and import of most HCFCs and EPA's Significant New Alternatives Policy (SNAP) program has reviewed over 500 alternatives to ozone-depleting substances. As individuals, we can immediately repair any leaks in refrigerators, have our car and home air conditioners checked periodically, use alternatives to home air conditioning, and use alternatives to foam insulation and containers.

Decreasing our use of vehicles burning fossil fuels and assuring our vehicle emission control systems are functioning properly is also critical to solving the problem of tropospheric ozone. We can use public transportation for long trips, walk or use bicycles for short trips, carpool to work, and combine several errands into one outing. Some areas have "ozone action days", which encourage citizens and industries to follow procedures to reduce their impact on the formation of harmful ozone. On these days, citizens are encouraged to postpone mowing their lawns and refilling their automobile's gas tanks until the evening hours, avoid using lighter fluid for charcoal, and carpool or use public transportation.





# Whirling Swirling Air Pollution

EPA

JUNE 2024

**Grades: 9-12 and Adult Subject:**

**Science**

**Time: 1 hour**

## Student Objectives

- Bring awareness to the air pollutants that we contribute to the airshed each day.
- Commit to reducing activities that contribute to air pollution.

## Materials

- Water
- Clear plastic cups
- Food coloring (green, yellow, blue, and red)
- Props can be used while narrating this activity. Use your imagination. Here are some suggestions:
  - Small plastic car
  - Shower and hair products
  - Electric hair dryer
  - Perfumes
  - Bug spray

## Background Information

There are numerous ways that everyday human activities can contribute to air pollution. These activities may not be immediately apparent as a source of pollution when you consider them from an individual viewpoint. However, the cumulative effect can be profound. This activity

attempts to simulate the cumulative effect of various air pollution sources upon the airshed.

An airshed is a geographic area with all parts of the area being subject to similar conditions of air pollution. The boundaries of an airshed may be defined by weather patterns or by topographic features, like mountain ranges or bodies of water. Identifying emissions that impact an airshed can help improve and maintain the confined air quality within it.

Potential emissions include the following:

- Particulate Matter (PM)
- Volatile Organic Compounds (VOCs)
- Nitrogen Oxides (NOx)
- Sulfur Oxides (SOx)
- Carbon Monoxide (CO)

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

## Setting the Stage

- **RED** food coloring represents car and truck pollution.
- **GREEN** food coloring represents lawn, boat, and construction engines.
- **BLUE** food coloring represents consumer products and paints.
- **YELLOW** food coloring represents industry and commercial activities.
- Small clear cups half full of water represent the airshed.
- Students should work in pairs





# Whirling Swirling Air Pollution

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## Activity

**Narrate A Day** in the life of... (anyone: adults, teenagers, a movie star in New York City, etc.). 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. Tell the students the water represents their airshed. During the narration they are to add a drop of food coloring when they hear something that contributes to air pollution. Have fun with this!

**Alarm goes off!** Get ready for your day.

- VOC sources: perfumed soap, shampoo and shaving supplies; use an excessive amount of hot water.
- Use deodorant, an electric hair dryer, hair spray, and perfume.
- CO, NOX, PM2.5, SOX sources: Combustion to heat water.

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

**Jump into your car and drive to work!** You don't carpool. You forget your dry cleaning and backtrack to home. Then you go to the drive-thru at your coffee shop.

- VOCs, CO, NOx, SOx, PM sources.
- Cold start in your automobile: High CO emissions.
- Add one drop of **RED** food coloring to your airshed.

- **Arrive at Work!** Choose any job that might contribute air pollutants.
- Industrial sources: PM, CO, VOCs, NOx, SOx from manufacturing, mills, construction, space heating.
- Commercial sources: PM, CO, VOCs, NOx, SOx from printing, painting, delivery, small manufacturing, or dry cleaning.

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

**Time for your lunch break!** Take four friends with you.

Two co-workers want a burger. You sit in a drive-thru line for 10 minutes on a high ozone day. Your other two co-workers want tacos – idling in another drive-thru line with the AC on.

- PM, CO, VOCs, NOx, SOx

Add one drop of **RED** food coloring to your airshed.

Eat your lunch (flame broiled burger with fries):

- PM, CO, VOCs, NOx, SOx

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

**Drive back to work!**

- PM, CO, VOCs, NOx, SOx

Add one drop of **RED** food coloring to your airshed.

**Back at work!** You turn the AC up. Same sources mentioned above.

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



## Activity (Cont.)

**Time to go home!** Drive home in your car. You're almost home, but you had to turn around to go to the grocery store.

- PM, CO, VOCs, NOx, SOx

Add one drop of **RED** food coloring to your airshed.

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### Pick up the dry cleaning!

- VOCs

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

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**Get ready for the barbeque!** It's 4:30, just enough time to mow the yard before sundown.

- PM, CO, VOCs, NOx, SOx

Add one drop of **GREEN** food coloring to your airshed.

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**Cookout!** The mosquitos are out - spray everyone with the repellant. Use lighter fluid to get the charcoal hot.

– Grill the hamburgers.

- PM, CO, VOCs, NOx, SOx

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

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**Now look at the airshed in the glass.** The original water was clear and pristine.

- What happened to the airshed?
- What contributed to the pollution?
- What actions were unnecessary?
- What would you do differently?

## Discussion

Individuals should evaluate the environmental impacts that result from the choices we make in our 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 the students design a sequence which describes their daily activities. Ask the students if they are willing to make one or two lifestyle changes for a semester.

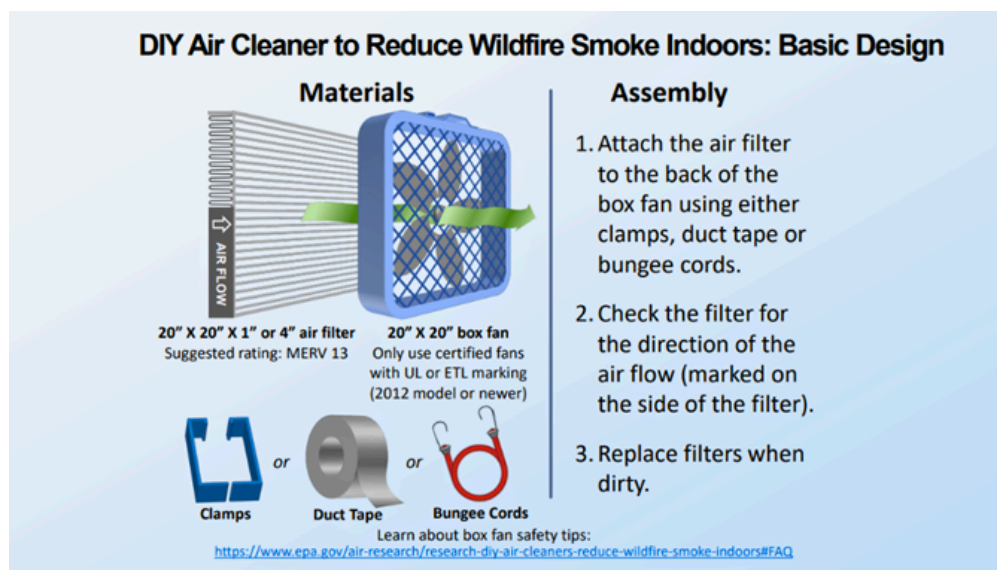
# DIY Air Cleaner Instructions



Smoke from wildfires in Montana can affect indoor as well as outdoor air quality, putting people's health at risk from exposure to particulate matter and other pollutants. When outdoor air is unhealthy, a HEPA air cleaner is recommended for your home. If a HEPA air cleaner is not available, a DIY Air Cleaner is an inexpensive and effective alternative to achieving cleaner indoor air.

The Basic Design for a DIY Air Cleaner is inexpensive, easy to build, and effective in small and medium sized rooms. The second image is a more complex design that will improve the effectiveness of the DIY cleaner.

How to Video from the Washington Department of Ecology for a Basic Box Fan DIY Cleaner:  
<https://youtu.be/4qr1Aj6Di7w?si=4gPDUKMCg7rI9Pxx>



Two filters taped with cardboard to form a triangle against the fan (video from the Confederated Tribes of the Colville Reservation): <https://youtu.be/ukyF2xm8cws?si=MDCv25sGtbr4V0MX>

