Module 1: Activity 7

Sampling Particulate Matter

IT'S OUR AIR

SUMMARY

Students will sample particulate matter around town or campus and compare the results. They will also gather particulate matter from tailpipe emissions and compare different types of vehicles.

ESSENTIAL QUESTIONS

- What types of particles are present in the air around campus?
- How much particle pollution do cars emit?
- How can we compare how much particle pollution is emitted by different cars?

TIME NEEDED

This activity, including the warm up and wrap up, should take about 90 minutes.

North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.5.5 Explain how human activities affect air quality.

A product of the NC Air Awareness Program 2014.

MAKING CONNECTIONS

The types and amount of particle pollution your students collect around campus will vary dramatically depending on where you live and what time of year it is. However, no matter where you live, almost everyone either drives a car or spends a significant amount of time in vehicles. In this activity, students will be able to see with their own eyes some of the particulate matter that is emitted by cars and other vehicles. Much like the previous ozone activity, the students will create a qualitative comparison between particle pollution from different cars as well as from various areas around campus.

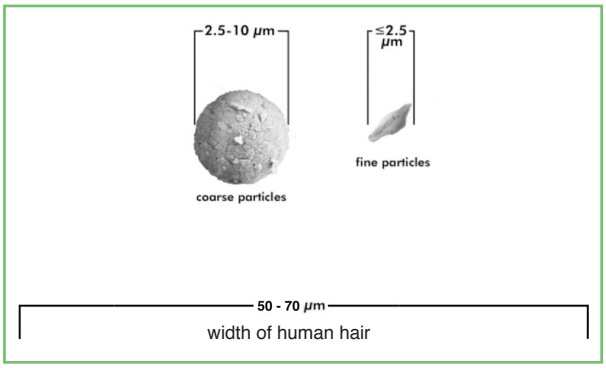
BACKGROUND

Particle pollution, or suspended particulate matter, refers to solid or liquid particles in the air. Some particles come from manmade sources, like smokestacks. Others come from natural sources, such as vegetation (pollen) and volcanoes. Some particle pollution, like dust or soot, is natural but can also be caused by human activities, such as clearcutting, poor farming practices, or wood burning. The NC Division of Air Quality and the EPA measure particle pollution by weight – micrograms per cubic meter.

Particulate matter refers to a size rather than a chemical composition. Particulate matter is divided into two categories. PM10, or "coarse" particles, refers to particles less than 10 micrometers in diameter. PM2.5, or "fine" particles, refers to particles smaller than 2.5 micrometers. For comparison, fine beach sand is about 90 micrometers in diameter, and a human hair is between 50 and 70 micrometers in diameter.

Particle pollution can be either primary or secondary pollution. A primary pollutant is emitted directly from a smokestack, exhaust pipe, chemical vat, or other specific source that can be pointed to. Secondary pollutants, also called area pollutants, are formed when primary pollutants change in the air. For example, sulfur dioxide and nitrogen oxides can react with other chemicals in the air to form tiny droplets of particle pollution such as sulfuric acid.

In fact, reactions in the atmosphere among naturally occurring and manmade chemicals (such as sulfur dioxide and nitrogen oxides) are a major source of particulate matter. Other sources include vehicle tailpipes; industrial processes; smokestacks; landfills and construction sites; unpaved roads; fields; forest fires; and fuel combustion in residences, other buildings, and power plants.



Particulate matter can be inhaled into the lungs, where it contributes to health problems, such as asthma and cardiovascular disease. Particulate matter also forms haze that restricts visibility and can change a gorgeous view into an unattractive one. Gases such as SO_2 and NO_X mix with water in the air to form a secondary acid precipitation. Acidic droplets are deposited on land and into streams and cause damage to things such as vegetation, buildings, and sculptures.

Remind students that some of the particulate matter collected will be visible and some will be invisible. There may be some particles that are too fine to be seen with a stereoscope or microscope.

MATERIALS

PART 1: Collecting Particulate Matter in the Air

Option 1: Homemade particulate samplers

- White paper or cardstock or plastic microscope slides
- Pen or permanent marker
- Straightedge for drawing a grid
- Petroleum jelly or double-sided tape
- Stereoscope or microscope
- For each collecting site (optional): two plastic plates, one plastic cup, and a hot-glue gun

Option 2: Airborne particulates examination kit (about $42 from carolina.com)

Option 3: High-volume air sampler (about $515 from carolina.com)

PART 2: Collecting Particulate Matter from Tailpipes

Option 1: Socks

- White cotton athletic socks (if lined in terry cloth, turn inside out before placing on tailpipe)
- Masking tape and marking pens (to label socks)
- Pot holders or heavy gloves
- Several different cars and trucks

Option 2: Tissues

- Stiff white posterboard, approximately 10 cm by 1 meter
- Meterstick or other pole about that length
- Box of tissues
- Scissors
- Ruler
- Tape

WARM UP

Ask students to brainstorm a list of the types of particles that might be present in the air around the school. Ask them how they might go about collecting and examining such particles.

As a class, make a list of vehicles to collect particles from. Discuss the procedure for collecting those particles, using either white cotton athletic socks or a tissue paper collector. Help your students understand that in order to compare the results, the collection procedure must be exactly the same for each vehicle. Generate hypotheses together about which vehicles might produce the most particles and why.

Teacher Tips

Set-up Time: 10-20 Mins.
Activity Time: 55-85 Mins.

I like to do the car exhaust option after the students hang the particulate collectors so that they get multiple sources of data. I try to find the oldest and newest cars available along with a bus for the best comparisons.

While the vehicles are running, I talk to my students about the difference that catalytic converters made on the emissions of vehicles after the mid-1970s. The next day the students gather their particle collectors and observe them through a microscope. Our wrap-up includes discussion about all of the sources of particulates around our school.

TIME TIPS: Making the collectors takes about 10 minutes if you just make the collectors, 15-20 if you make the roof with the plates and cup as well. It takes about 30-45 minutes to collect testers, run the cars and talk about history of catalytic converter. Students will need 15-20 minutes to observe under a microscope including set up and clean up afterward.

Do Ozone Too: I also have the students do the activity Making and Using Ozone Indicators at the same time, and that doesn't require much more time. I usually take a full period to do all of the collection, discussion, observing for both.

– Mark Townley

THE ACTIVITY

PART 1: Collecting Particulate Matter in the Air

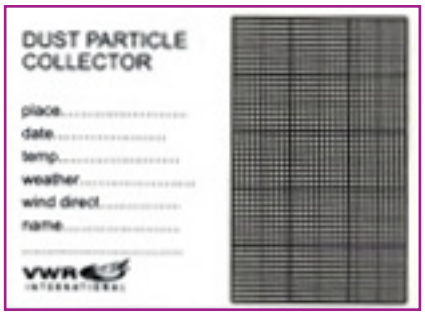
Set up particle collectors in various spots on campus: in a parking lot, near a street, in or near a natural area, in an outdoor eating area, etc. There are many ways to collect particulate matter from the air. Choose the one that best suits your budget and your purposes:

Option 1: Homemade Particulate Samplers.

- To protect the collectors from rain (optional), make a shelter by hot-gluing a plastic or paper cup, upright, between two plastic or paper disposable plates. Place the collector on the lower plate; the upper plate will serve as a roof.
- Draw a grid on a piece of white paper or cardstock or a microscope slide and smear a little bit of petroleum jelly on it, or cover it with double-sided tape.
- Place the collectors outside for 24 hours. Write the location on each collector.
- Observe the slides using a stereoscope or microscope. Can you identify particles that came from plants? From animals, particularly insects?
- Use the grid to estimate the number of particles on each collector. Which sites had the most particles?

Option 2: Airborne particulates examination kit (about $42 from carolina.com)

- You can purchase particulate matter collectors from a company such as Carolina Biological. These are small clear plastic squares imprinted with grids of different dimensions.
- To protect the collectors from rain (optional), make a shelter by hot-gluing a plastic or paper cup, upright, between two plastic or paper disposable plates. Place the collector on the lower plate; the upper plate will serve as a roof.
- When you're ready to use the collectors, peel off the backing material to expose the sticky surface.
- Leave the collector in the sampling site for 24 hours. Write the location on each collector.
- Observe the slides using a stereoscope or microscope. Can you identify particles that came from plants? From animals, particularly insects?
- Use the grid to estimate the number of particles on each collector. Which sites had the most particles?



Option 3: High-volume air sampler (about $515 from carolina.com)

You can purchase a high-volume air sampler with filters. The air sampler draws in air at a specified rate allowing you to accurately calculate particulate matter per cubic centimeter for each location where you use it.

PART 2: Collecting Particulate Matter from Tailpipes

Option 1: White Athletic Socks

Use white athletic socks to compare the particle pollution emitted by several different vehicles. For the most interesting comparisons, try to use a variety of different vehicles, such as a school bus, an old car, and a new car. If possible, include a car that uses diesel or biodiesel fuel.

Safety notes: This experiment must be done in a well ventilated area outdoors. Be careful not to burn yourself when removing the socks. Be sure the parking brake is set on each car, and that the car is not in gear while the engine is running.

- Gather several different cars and perhaps even a school bus in a parking lot outdoors.
- One at a time, place a white athletic sock over the exhaust pipe of each vehicle and run the engine for five minutes.
- After turning off the engine, remove the sock using heavy gloves or a potholder to avoid burning your hands.
- Turn the sock inside out and label it with the make, model, and year of the vehicle.
- Compare the socks of different vehicles, noting the age and fuel type of each vehicle. Compare color, intensity, and amount of discoloration. If possible, examine the socks with a magnifying glass, hand lens, or stereo-scope to see if you can discover anything more about the particles collected.

Note: You will be observing particulate matter only. This activity does not assess the amount of invisible pollutants that are being emitted, such as carbon dioxide, carbon monoxide, nitrogen oxides, and sulfur compounds.

Option 2: Tissue Paper
This is a more labor-intensive, but perhaps less expensive, method to collect particulate matter from cars. It may be a little easier to compare results from different cars with this method:

- Stiff white posterboard, approximately 10 cm by 1 meter
- Meterstick or other pole about that length
- Box of white tissues
- Scissors
- Ruler
- Tape
  - Cut a hole in the shape of a 5 cm by 5 cm square about 5 cm from the end of the piece of posterboard.
  - Cut a piece of tissue bigger than the hole (about 7 cm by 7 cm) and tape it to the posterboard so that it covers the hole. Make sure the tape does not extend into the area of the hole.
  - Tape a meterstick or long pole to the end of the posterboard that does not have the hole in it.
  - Hold the collector so that the tissue is about 10 cm away from the end of the tailpipe and hold it there for one minute.
  - Remove the tissue from the collector and attach a fresh piece of tissue.
  - Attach the dirty tissue to a piece of paper. Write on the paper the make and model of the car, its age, and type of fuel burned.
  - Compare the tissues of different vehicles, noting the age and fuel type of each vehicle. Compare color, intensity, and amount of discoloration. If possible, examine the tissues with a magnifying glass, hand lens, or stereoscope to see if you can discover anything more about the particles collected.

WRAP UP AND ACTION

Whether students sampled particulate matter in different areas of town, or from different tailpipes, have them compare the results. This can be done qualitatively – by comparing the density or color of the sample, or quantitatively – by counting the number of particles per grid-square.

In a class discussion or small groups, analyze the differences among samples and develop explanations. What types of particles are present on different samples? Are certain parts of campus or town near sources of particle pollution, such as factories, bare fields or unpaved roads? Do certain types or ages of vehicles emit more particulate matter than others?

Ask students for ideas for future investigation. For example, are there other types or ages of vehicles they would like to include in the car exhaust study? Or other times of year they would like to collect particulate matter around school – perhaps during pine pollen season?

Ask the class whether tailpipes emit other types of pollution besides particle pollution. Yes – nitrogen oxides (an ingredient of ground-level ozone), carbon monoxide, and carbon dioxide. (See other activities in this module for more information about these pollutants.)

ASSESSMENT

HAVE STUDENTS:

- Present the results of their study to another class or to a group of parents.
- Explain in writing what they learned from this project, including the types and origins of particle pollution collected, and some explanations for differences among the different samples collected.

EXTENSIONS

- Keep data collected around campus and town from year-to-year to compare.
- Collect particulate matter around campus in different seasons and compare.
- Compare tailpipe emissions from the same car with a cold engine vs. with a warm engine.
- If you live in area where particulate matter blows into town from a particular source, try making these directional particulate matter collectors:

Materials for each collector

- Can
- Clear contact paper
- Permanent marker
- Drawing compass
- Protractor
- Directional compass
- Wood or plastic disposable plates or cardboard to make a shelter
  - Cover a tin can with white paper, then clear contact paper on top of that, with the sticky side facing out.
  - Use a protractor to draw two straight lines that intersect at right angles on a piece of paper. Label the four lines north, east, south, and west.
  - Use a drawing compass to make a circle whose center is the point of intersection of the two lines and whose diameter is the same or slightly larger than the can.
  - Place the can in the circle and make four small marks on the can or contact paper where the four lines intersect it. Make the mark that corresponds to north twice as large as the other marks.
  - Leave the can in the collecting area, making sure that "north" on the cardboard is aligned with true north. Use a compass to make sure it's aligned correctly.
  - Come back in 24 hours and see whether the particulate matter is spread out evenly on all sides of the can or whether it is concentrated on a particular side or sides. If it is concentrated on a particular side, use weather reports, maps, and the internet to investigate whether the wind tends to blow in that direction, whether there is a large source of particulate matter in that direction, or both.

Note: If you are expecting any precipitation during the sampling period, make a shelter with disposable plates, cardboard or wood to protect it. The shelter should not block the wind coming from any direction. You could even place it in a bird or hamster cage.

RESOURCES

NASA has another way of making homemade particulate matter samplers, as shown on this website:
http://science-edu.larc.nasa.gov/SOLAR/labactivity-index.html

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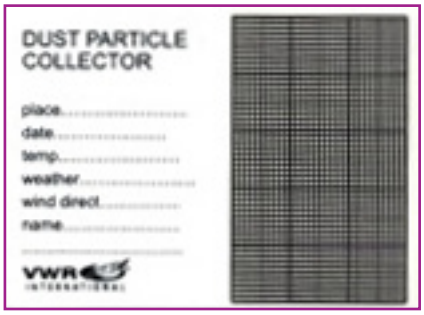
Student Page

THE ACTIVITY

PART 1: Collecting Particulate Matter in the Air

- Set up particulate matter samplers around campus and leave them in place for 24 hours.
- Write the location on each collector.
- Observe the slides using a stereoscope or microscope. Can you identify particles that came from plants? From animals (particularly insects)? Use the grid to estimate the number of particles on each collector. Which sites had the most particles? Why do you think that is?



PART 2: Collecting Particulate Matter from Tailpipes

SAFETY NOTES: This experiment must be done in a well ventilated area outdoors. Be careful not to burn yourself on the tailpipe of a car. Do not touch the tailpipe while the car is running. Be sure the parking brake is set on each vehicle, and that the car is not in gear while the engine is running.

- Gather several different cars and perhaps even a school bus in a parking lot outdoors.
- One at a time, collect particulate matter from each tailpipe using either a white athletic sock or a tissue paper collector (your teacher will explain and demonstrate which technique to use and how to do so).
- Compare the particulate matter collected from each vehicle. Compare color, intensity, and amount of discoloration. If possible, examine your collectors with a magnifying glass, hand lens, or stereoscope to see if you can discover anything more about the particles collected.
- What conclusions can you draw about particulate matter from different types and ages of vehicles?

NOTE: You will be observing particulate matter only. This activity does not assess the amount of invisible pollutants that are being emitted, such as carbon dioxide, carbon monoxide, nitrogen oxides, and sulfur compounds.