GRIME SCENE INVESTIGATION

PLANNING OVERVIEW

SUBJECT AREAS:
Language Arts, Ecology, Environmental Science, Government, Math

TIMING:
Preparation: 30 minutes
Activity: 3–5 45-minute class periods; some students will spend extra time outside of class

Summary

Students form detective agencies to gather evidence regarding air pollution in their own community.

Objectives

Students will:

- Identify particulate matter as an air pollutant.
- Identify energy sources that don't contribute to particulate (and other) air pollution.
- Design and build particulate matter collection devices.
- Develop hypotheses predicting the amount of particulate deposition found at each experiment site.
- Measure the rate at which different sources deposit particulate matter in a given locale.
- Identify possible sources of deposited particulate matter in a specific area.
- Prepare a class master list of experiment procedures and results.
- Prepare experiment write-ups, using the scientific method.
- Draw conclusions regarding particulate pollution in a certain area.
- Prepare summary reports based on the entire class's findings.
- Optional: Conduct extension activities regarding other types of air pollution.

Materials

For warm-up demonstration:

Small mirror

Paraffin wax candle and candleholder

Matches

Tongs and oven mitt

For activity, per group:

Copy of "Air Pollution's Heavy Hitters," page 103

Optional: Copy of Scientific Method Form, page 3 of the Appendix

Particulate Chart, page 8

Wax pencil or other means to mark glass slides

Glass microscope slides (minimum of two per group)

Petroleum jelly or double-sided tape

Clean jar lids and plastic wrap or petri dishes in which to place slides

Maps of your city or area

Information on industries in your area from the chamber of commerce (optional)

Entire class:

Microscopes, handheld microscopes, or hand lenses. (Each detective group should examine the particle samples under the same magnification, or use the same type of magnifying lenses.)

Other materials for devices to protect particulate matter collection slides, including sturdy dowels or other posts, empty coffee cans, cardboard boxes, aluminum pie plates, foil, Superglue, nails/hammer, and so forth

Optional: Other materials for extension activities (see Extensions, page 7)

Making the Link

Sometimes it's hard for students (and even adults!) to picture that the air around them, while invisible, is actually full of many different substances, an excess of which may be bad for their health and for the environment.

This may be especially true for students who don't live in an obviously hazy or smoggy urban area. These students may be surprised to find that their air contains contaminants (such as those from farming, logging, or a factory miles away, whose pollutants are carried by wind). Those who live in congested, urban areas will more easily recognize the effects of smog, smoke, or other pollutants.

While it is difficult to measure the gases in the air with ordinary classroom or science lab equipment, we can measure some of the materials released into the air from human activities. These released materials are tiny solid and liquid particles called particulate matter that become suspended in the air.

It is normal to have some particulates in the air (as from volcanic eruptions, forest fires, dust, and pollens). In fact, without some airborne particles, we wouldn't have rain. However, humans have been producing an excessive amount of particulates from combustion of fuels, contributing to poor air quality. As discussed in "Energy and the Environment," the reaction that occurs when we burn fuels for energy is one that releases different types of gases and small solid particles. Certain other industries also put extra substances into the air.

After conducting this activity students may have a heightened sense of what is in the air they breathe every day. The study may also provide motivation for action regarding what they learn. (An action plan activity is included in Chapter 5, "Energy Policy and Management.")

Teaching Notes

Acting as detective teams, students will attempt to identify possible sources of airborne particulate matter by collecting samples. An increased rate of deposit in the vicinity of, for example, a local factory or fossil-fuel power plant may point to it as a possible source of particulate pollution. Students can then conduct further research, such as contacting the Environmental Protection Agency, your local air quality board, or other organizations that may have information to substantiate their hypotheses.

If time and resources are limited, consider conducting the Adaptation or one of the Extension investigations as an alternative to this activity. You may also choose to do a data exchange with other classes to share and compare your findings.

Warm-up

Use this quick demonstration to show how byproducts are often created when we burn something. Light the candle. Wearing an oven mitt, grasp the mirror at one corner with the tongs. Hold it over (not in) the candle flame for about five seconds. Take the mirror away and show it to your students. They should see a dark sooty residue on the mirror.

Ask what the sooty residue might be. Guide the discussion to the idea that whenever something is burned, a chemical reaction called combustion occurs. Combustion refers to the chemical combination of certain materials with oxygen and the release of energy.

When we burn a paraffin candle, heat, light, and some byproducts are given off. (The byproducts occur because the combustion reaction is incomplete. With complete combustion the only products, besides energy, are water and carbon dioxide. Complete combustion is rare and occurs only under specially controlled circumstances.) These byproducts show up as the residue on the mirror. In large quantities they are considered pollutants.

If any students have been camping, they can also relate this demonstration to the soot they see inside the lantern of a used kerosene lamp. Kerosene is a form of fossil fuel, as is the paraffin commonly used to make candles.

Explain to students that they will be investigating industries that may add to particulate pollution in their area. They will also identify industries that may not contribute to this type of pollution.

The Activity

STAGE ONE

1. Go over the background information in the "Energy and the Environment" Discussion section with your students. Review the chart on page 103, (Air Pollution's Heavy Hitters). Ensure that students have a clear understanding of "particulate matter."

2. Post a map of your community and, if possible, display literature from your chamber of commerce on local industries. (For this activity, the term "industries" includes any place of work, including retail businesses, service industries, manufacturing firms, repair firms, high-tech companies, home offices, and academic institutions.)

   Use the map and the business literature, along with your class's general knowledge of the community, to brainstorm a list of the possible industry sources of particulates in your locale. Make another list of industries that students think might generate little or no particulate pollution. One of these sites could certainly be your school.

3. Next, ask students to identify the industries to which they personally have safe and easy access. This could include places where their parents, other relatives, or friends work or attend classes. Narrow these down to those industries that seem the most likely to grant permission to set up experiment stations.

   As a class, compare each of these places to the lists made in Step 2. From this comparison, make a list of six to eight places (depending on how many groups you have) to contact. Remember that some of these should be suspected generators of particulate matter and others should not.

4. As a class, compose and send a letter (or e-mail) to the general manager of each of these industries or businesses, explaining the purpose of the project and asking permission for specific students (or their adult contact) to set up an experiment station on the firm's premises. Be sure to mention the connection — parent, neighbor, etc. — that the student has at that industry. A copy of this letter should be sent to each student who has a connection, as well as to the connections themselves.

   Keep your lists from Step 2 handy, so that your class can select another potential site if any of your inquiries results in a negative answer.

5. While waiting for answers to the inquiries, divide your class into teams.

   It is optimal to have at least six teams, even if there are only two or three students on a team. The more research sites, the better. Explain that each team is to form a "detective agency." Their assignment: to identify some industries in your area that may be particulate matter polluters, as well as some that may not be.

   You might allow time for each team to develop a name for its agency, as well as a pseudonym for each detective participant.

The student who has the connection at a potential experiment station site could be the team leader.

If some of the teams do not have a specific connection, or if one of the selected industries denies the request, assist these groups in selecting and contacting another potential experiment station from the lists developed in Step 2. As an alternate, use public property, skipping the permission process.

6. Make a master list to organize and collect experiment designs and results. When your initial inquiries are answered in the affirmative, place in the far-left column the names of the industries that have agreed to participate. Write the student team names and team members in the next column. Highlight the team member with the industry connection. Allow for other columns to show information such as the number of slides placed and the particulate count for each. (See example below.)

Assist students in following up with industries that don't respond to your first inquiry.

7. As a class, decide how many slides will be left at each location. The more slides, the more accurate the data. Make sure that each team plans to leave the same number of slides.

8. Show the class the materials you have available for each group to make protective set-ups to safeguard their collection slides for one week. Have each group draw up a plan that will use these materials, plus any others they think of that are reasonable to acquire (e.g., Sam's mom is the manager of a shipping company and always brings home discarded, but usable, packing materials).

You may wish to give students an example of a protective device: An uncovered empty coffee can could be attached, using hammer and nails, to the top of a pole inserted into the ground. The collection slides could be placed inside the can to prevent their being disturbed.

Once completed, have each group present their plans to the rest of the class. After discussing the merits of each, have the class vote on the best (and most feasible) plan. Then all the groups will construct the same protective devices. Groups might wish to make a separate protective set-up for each different slide. If so, all groups should do so.

Make arrangements to acquire any additional materials and make a copy of the chosen plan for each group. Allow time for groups to construct their devices.

10. Assist students in making arrangements to take these devices to the selected experiment sites. Remind students that once the collection devices are set up, the covers are removed.

Experiment Site	Adult Contact	Team	Number of Slides Placed	Particulate Count

11. Pass out a copy of the Particulate Chart, page 8, to each group and explain that when they retrieve their devices they will be comparing the amount of particulates left on their collectors to the amounts on the chart. Explain that the chart shows an approximate amount of particles per square inch (which can be recalculated in centimeters).

    For the write-up of this experiment, you can have students use the Scientific Method Form on page 3 of the Appendix or have them use one of your own. Pass out copies to your students. Review your expectations for each category.

    Explain that, though they will be working in groups, each student will fill out his or her own write-up.

    Have each student develop a hypothesis predicting how much particulate matter he or she thinks will be deposited at the team's site, based on an average taken from all of their group's collection devices.

STAGE TWO

1. After seven days, the collection devices are retrieved and brought to class. Ask students to cover them, taking care that nothing touches the slides' surfaces.

2. Each team then carefully examines its slides with a microscope or hand lens. Ask students to make a list of what they think the particles may be and to draw what they see. Have them compare their drawings to the Particulate Chart on page 8 and estimate the amount of particulate matter collected on each slide. Have them calculate the average number of particles deposited at their site. Explain that the rate of deposit is this amount per the time period (in this case, seven days).

3. Have student groups finish the write-up of their findings using their scientific method form. For the Research portion, students can cite the Chapter 4 and your classroom discussion (You may wish to have students do other research as well.) For the Procedure section, you can ask them to briefly summarize the steps they took. For the Data section, students should identify their test site and list the count of particulates for each slide. You may also wish to have them draw a picture of what they see on each slide. Then the average of all slides should be listed. For the Conclusion, each student will be revisiting his or her Hypothesis, saying whether it was correct or not, and explaining why.

Wrap-up

Have each team report its findings to the class, using their write-ups. Record the results on the master list. As a class, identify the experiment site that produced the most particulates and the possible types of particulates found. Discuss how this compared to their original suspicions. What results did they find for the suspected nonpolluters? Were there any surprises? Where could particulate matter be coming from at what was thought to be a clean site?

Ask each group to write a brief summary of the entire class's findings, drawing conclusions based on all the evidence gathered.

Each group should also write a thank-you letter to the establishment that allowed an experiment to be set up on its premises.

As a class, talk about how more extensive tests could be conducted to determine if the suspect is the actual source of the pollution. Additionally, your class may wish to contact your local air quality board or the U.S. Environmental Protection Agency (EPA) to see if they have data that might corroborate student findings.

Assessment

Students will have had the opportunity to:

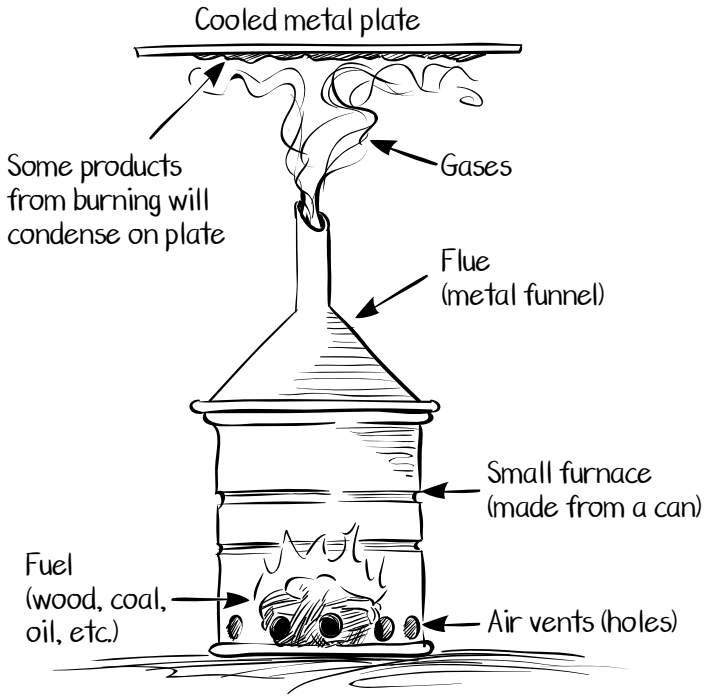
- Select experiment sites and ask permission to test for particulate matter pollution.
- Develop hypotheses predicting the amount of particulates deposited at various test sites.
- Design and build particulate matter collection devices.
- Measure the rate at which particulate matter is deposited in a specific locale.
- Develop a class master list of experiment procedures and results.
- Compose experiment write-ups using the standard scientific method.
- Prepare summary reports.

Adaptation

If your students aren't able to go into the field to collect samples, you may wish to simulate the conditions that produce particulates. Under controlled circumstances, burn wood, other dried biomass, paraffin candles, charcoal, or use a kerosene lantern and compare the particles gathered to those collected in a cleaner location in your room or lab.

In this case, you may wish to make a simple furnace using an inverted metal funnel on top of an empty can. Use a cooled metal plate or mirror as your collection device. Set the furnace on a noncombustible surface and provide adequate ventilation. Follow all safety rules for working around heat and flames. Wear goggles and have a bucket of sand, a fire extinguisher, or a fire blanket handy. Place the charcoal, wood, candle, or dried biomass directly in the can, ignite it, and use tongs and an oven mitt to hold the cooled metal plate or mirror over a funnel to collect particles. The kerosene lantern can be lighted and the collection device held directly over its chimney.

You may be able to examine the particulates using a hand lens or handheld microscope and compare them to the Particulate Chart on page 8. Relate your findings to possible sources of particulates in your community.



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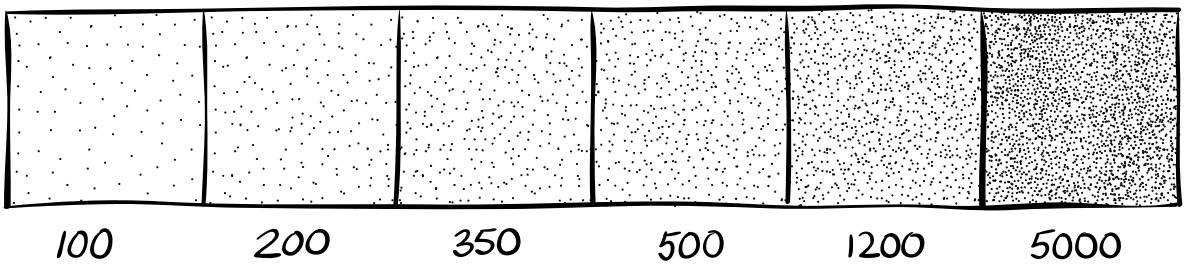
Extensions

- Research the feasibility of an electric utility company that uses fossil fuels (or other heavy polluter such as a charcoal production plant) switching to cleaner energy sources that don't contribute to particulate matter pollution. If one of your test sites was a heavy particulate polluter, discuss diplomatic ways to share your findings with the owners, along with suggestions for alternatives.
- Discuss the idea that some of the evidence may have blown in from another source. Consider ways to verify that the particles collected actually came from the source identified.
- Contact the EPA or local air quality board for information about how scientists determine and quantify levels of various air pollutants.
- Learn more about how industries try to control air pollution.
- If your specific situation allows, plan a day when everyone in your class, or even in the entire school, gets to school without burning fossil fuels. Suggest that students (as well as teachers and staff!) walk or ride a non-fossil fuel-powered vehicle (bike, electric scooter, skateboard, or an electric train or bus). For safety, and depending on the age of your students, encourage students to travel with a buddy, in small groups, or with an adult.
- Devise demonstrations to show relationships between the greenhouse effect and global warming, using simple materials such as a small clear box, two thermometers, and an incandescent lamp or sunlamp. Bring the two thermometers to the same temperature by placing them under the lamp for a few minutes. Place one thermometer under the clear covered container and the other in the open, both under the lamp. List the beginning temperature, then the temperature of each thermometer for every minute thereafter.

  Make a chart or graph of the results. Relate findings to information in the previous section on global warming. Note: Explain to students that other factors also affect the temperature readings inside and outside a greenhouse. The warming inside a greenhouse also results from the isolation of the inside air from the outside world, so the heat cannot escape. Additionally, the outside thermometer is being air cooled, while the inside one is not.) Even so, this demonstration is a fun and simple way to bring a big concept down to classroom size.
- Explore the effects of a household acid on ordinary materials, and compare them to the effects of acid precipitation. Obtain things to test (such as hard-boiled eggs, leaves, chicken bones), two clean glass jars, water, and vinegar. Place the same amount of a test item in each jar. Cover one with water and the other with the same amount of vinegar. Label the jars; cover and leave for several hours or days. Check at regular intervals and make notes of your observations. Try testing other items. Relate your findings to what you have learned about acid precipitation.

GRIME SCENE INVESTIGATION

PARTICULATE CHART



Number of particles per square inch