Guide to Weather

Supplement One

Air Quality

Environment Canada Environnement Canada

Canada

In this chapter

- **What is Smog?** *Particulate Matter • Ground-Level Ozone*
- **Smog Behaviour** *Local Meteorology • Long-Range Transport*
- **Effects of Pollution** *Health Effects • Other Effects of Pollution*
- **Air Quality Prediction** *Smog Forecasts • Smog Advisories*
- **What Can We Do To Reduce Pollution?**

SUPPLEMENT 1

Every living thing on earth needs air: plants, trees, animals, birds, humans and everything in between. The air we breathe is made up of different gases (78% nitrogen, 21% oxygen, 0.9% argon, 0.03% carbon dioxide and the remaining 0.07% a mixture of water vapour and other trace components). In order for us to survive, we require oxygen (O_2). In order for plants to survive, they need a different gas, called carbon dioxide (CO_2). When we breathe, our lungs take in all the gases in the air around us. Thus it is important for the future of our planet, and the health of all living things, that we do what we can to keep the air clean.

WHAT IS SMOG?

As you know, the air around you is invisible. Most of the pollution in the air is also invisible. Sometimes, especially if you live in a large city, pollution concentrations can be high enough that you can actually see the pollution in the air. Pollution, whether visible or invisible, is also known as smog.

To illustrate to your students the difference between visible and invisible pollution, try Activity number 1 in the Activities section.

The term smog originally described a mixture of smoke and fog in the air. Now it is used to describe a mixture of pollutants. This mixture can often be seen as a brownish-yellow or greyish-white haze in the air. The two key components of smog are particulate matter (PM), also known as airborne particles, and ground-level ozone (O_3). Other pollutants include sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and hydrogen sulphide (H_2S).

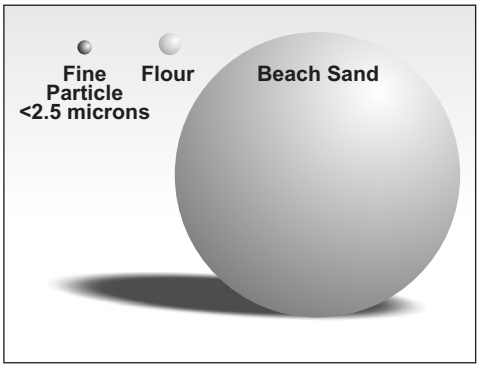
FACT

Motor vehicle exhaust contains five of the components of smog: carbon monoxide, particulate matter, lead, nitrogen oxides, and volatile organic compounds.

Particulate Matter (Airborne Particles)

Particulate matter (PM) is made up of very tiny solid or liquid particles that are small enough to remain suspended in the air. Scientists separate the particles into two categories, depending on their size. Coarse particles, referred to as PM_{10}, are under 10 micrometres in size. A micrometre is 1 millionth of a metre. Coarse particles are 1/8th the size of a human hair. The fine particles, which are less than 2.5 micrometres in size, are in the category referred to as $PM_{2.5}$. These particles are smaller than a single particle of flour.

The relative size of beach sand, a grain of flour, and a fine particle ($PM_{2.5}$).



Source: Malm, William C., Introduction to Visibility

Particulate matter includes dust, dirt, soot, smoke and tiny particles of chemical pollutants. The major sources of particulate pollution are factories, power plants, trash incinerators, motor vehicles, construction activity, fires and natural dust blown around by the wind. The amount of particulate matter in the air can be worse in winter because we burn wood and other fuel to heat our houses, releasing tiny particles of pollutants. In big cities, where there are lots of cars, particulate matter can be worse than in rural areas where there are fewer cars. The amount of particulate matter can also be greater in places where there are lots of factories and industries that release pollutants into the air.

Activity:
Particulate matter in the air can be collected. Have your students cover the outside of a small jar, or a small square of plastic, with petroleum jelly and place it outside. Leave it for 24 hours and then observe the dirt particles that were collected. It may be helpful to place a piece of white paper behind and/or use a magnifying glass. Several of these set-ups can be placed in different areas around the school or at home to see which area will collect the most particles.

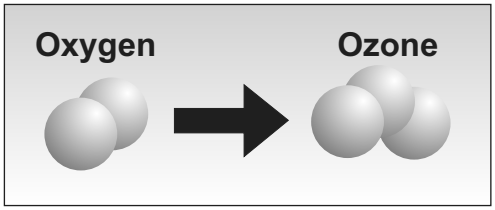
FACT

20% of homes in Canada use wood as a secondary heating source. That number is higher in Atlantic Canada.

Ground-Level Ozone

Ozone is the same gas, whether it is high up in the atmosphere or near the ground. In the stratosphere, ozone forms a protective barrier for harmful radiation from the sun (Refer to pages 12 and 44 in the Sky Watcher: Guide to Weather for more information). Near the ground, ozone is considered a pollutant and can be harmful to people, animals, plants and other materials.

Oxygen, O_2, is two oxygen atoms bonded together. The formula for ozone is O_3, which is three oxygen atoms.



Source: Malm, William C., Introduction to Visibility

Unlike particulate matter, ozone is generally a colourless gas and cannot be seen in the air. However, at very high concentrations, ozone can have a bluish tinge. Ground-level ozone is referred to as a secondary pollutant. This means it is formed from other pollutants already present in the air. The other pollutants, mainly nitrogen oxides (NO_x) and volatile organic compounds (VOCs), react with oxygen and energy from the sun to produce ground-level ozone. Because sunlight is required to form ozone, the concentrations in the air are normally higher in the summer, when the sun's rays are stronger.

TIPS

To help your students better understand the role of the sun in forming ozone, you may want to use a comparison with making Rice Krispie squares. Without heat to melt the marshmallows, you have no squares. The other pollutants will not form ozone without the energy from the sun to start the reaction.

You may want to revisit Activity 1 on page 49 in the Sky Watcher Guide to Weather about the sun's rays relative to the earth's rotation to illustrate the difference in the strength of the sun during different seasons.

The pollutants that are "cooked" to make ozone are formed by both man-made and natural sources. Nitrogen oxides are produced whenever natural gas, gasoline, diesel fuel, kerosene and oil are combusted; the sources include cars, trucks, power plants and factories. They are also released into the air by nature during forest fires and by volcanoes. Volatile organic compounds are produced whenever the fuels above evaporate into the air or released directly to the atmosphere by trees.

Activity:
To demonstrate the pollution from burning, light a candle and pass the bottom of a white glass plate through the flame. There should be a dark mark on the bottom of the plate where the flame touched. This is the pollution released from the burning of the wax.

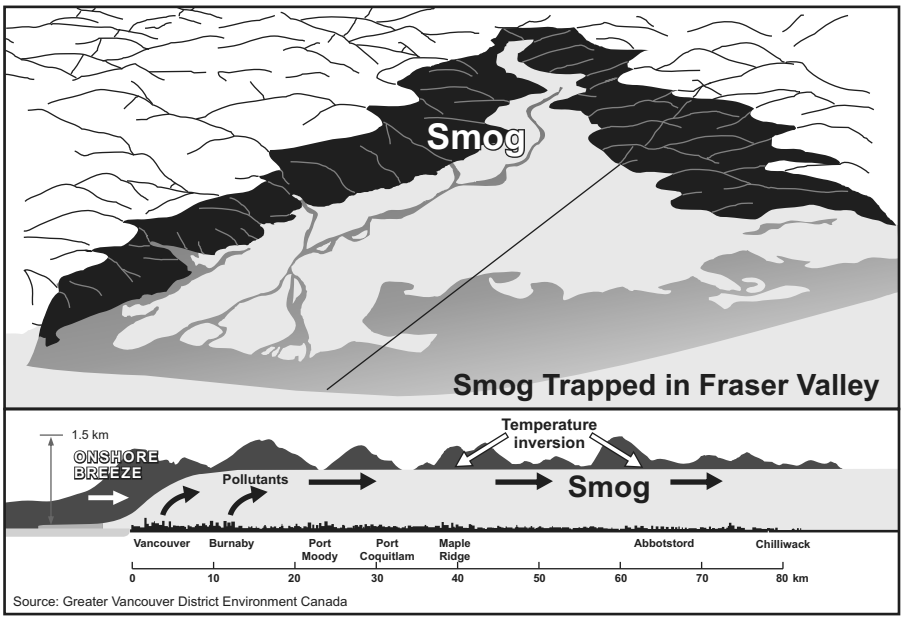
To monitor the ground-level ozone concentrations in your area, try Activity 2 in the Activities section.

providing stronger sunlight and warmer temperatures. Typically, the warmer air will rise and the pollution will be dispersed by the wind. However, pollution can be trapped near the ground when a temperature inversion occurs. Normally the temperature decreases in the troposphere with height. A temperature inversion will form instead when the temperature increases with height resulting in a stable layer of air. This stable layer acts as a "lid" on the lower atmosphere, resulting in an environment more susceptible to higher pollution concentrations. When this occurs, the winds are light, and the pollution becomes trapped. In southern British Columbia, the delicate interaction between the local topography and the Pacific Ocean is especially important. These features, coupled with a strong temperature inversion, frequently result in atmospheric conditions favorable for elevated ground-level ozone episodes. For example, several cities, including the greater Vancouver region, lie within the Fraser Valley where the mountain walls trap the air. These unique geographical features, along with sea-to-shore breezes off the Strait of Georgia, promote the formation of a temperature inversion. As a result, air-flow patterns become restricted and help to contribute to the area's ozone problem. The air is often polluted by automobile exhaust and other sources and is trapped close to the ground where we breathe it in.

SMOG BEHAVIOUR

Local Meteorology

Local weather conditions play a major role in the movement of air pollution. The severity of air pollution can be increased when local wind conditions and/or the unique topography of a region cause the pollutants to become trapped near the ground in a layer of relatively still air. Ground-level ozone is usually formed when there is a slow-moving high pressure system influencing the area



Classical smog behaviour in Southern British Columbia.

Long-Range Transport

In Chapter 2 of the Sky Watchers Guide to Weather, you learned about the global wind patterns that travel around the earth. Pollution may be carried around the earth by these winds. The pollution that is generated in one place is transported by the wind and can affect people in other areas. Ground-level ozone and other pollutants can travel long distances, from hundreds to a few thousand kilometres in a single day. During this travel, pollutants can be deposited on the ground or on buildings, and undergo chemical changes. These chemical changes can result in an entirely different pollutant being formed. Volatile organic compounds and nitrogen oxides, for instance, may react with oxygen and energy from the sun to form ground-level ozone that will ultimately affect another area. There is always someone downstream of where pollution is released.

Have your students try Activity 3, The Clean Air Game, in the Activities section. It will help them to remember the concepts and vocabulary covered so far.

Activity:
Have your students log on to the internet and watch the movement of pollutants on moving maps. This website has been set-up in cooperation with the United States Environmental Protection Agency (EPA) and shows ground-level ozone concentrations from across eastern North America. To access the website, log on to the following URL, go to the Ground-Level Ozone Maps section and then the AIRNOW site.

http://www.ec.gc.ca/air/introduction_e.cfm

EFFECTS OF POLLUTION

Health Effects

Our lungs inhale all the things in the air around us, including particulate matter and ground-level ozone. Elderly people and those with heart or lung disease - such as asthma, emphysema and chronic bronchitis - are particularly sensitive to air pollutants. When pollution levels are high, sensitive people may experience symptoms after only one or two hours outdoors. Children and active adults are also at a greater risk because they

Principal Ozone Problem Areas in Canada

Maritime Provinces:
New Brunswick, Nova Scotia and Prince Edward Island receive air pollution from the Lower Great Lakes region, Southern Quebec and the eastern seaboard of the United States. Cross border pollution, due to long-range transport, is the major contributor to this region's smog problem.

Windsor-Quebec City Corridor:
This heavily populated corridor covers a strip about 100 km wide along the Canadian border, extending from Windsor through Toronto and Montreal to Quebec City. This area experiences high levels of ozone more often and for longer periods than any other part of the country. While much of the smog here is generated locally, air pollution transported from the United States contributes significantly to ground-level ozone in the region.

Lower Fraser Valley:
This valley, which includes the City of Vancouver, is bordered by the Coastal Mountains to the north and the Cascade Mountains to the southeast. These unique geographical features, along with the sea-to-shore breezes off the Strait of Georgia, restrict air-flow patterns and contribute to the area's ozone problem. Here, the majority of the smog is generated locally. Motor vehicles in the Vancouver area are one of the major sources of smog in this region.

typically spend more time outside and engage in physical activities that increase their heart rate. Also, children tend to be more sensitive than adults because they require more air and thus breathe faster than adults - twice as much air per pound of body weight compared to adults (Journal of Environmental Health Perspectives).

According to the Canadian Lung Association, one in five Canadians now has some form of respiratory problem and 5 to 10 percent of Canadian children have childhood asthma.

Exposure to ozone can irritate the nose and throat and cause chest tightness, coughing and wheezing. Increases in ozone levels in Canada have been linked to increased mortality, emergency hospital visits and admissions for respiratory problems. In sensitive people, the stress of ozone exposure can be particularly damaging. There is also evidence that ozone heightens the sensitivity of asthmatics to allergens. Other studies on animals have indicated that ozone exposure decreases the lungs' ability to ward off disease. The effects also include decreased lung capacity, which can impair performance in athletes.

Students can simulate the experience of those with asthma and other respiratory problems with Activity 4 in the Activities section.

Many of the adverse health effects resulting from exposure to particulate matter are similar to those for ozone, and are specific to the cardio-respiratory (heart-lung) system. When we inhale particulate matter, the particles can penetrate deep into the lungs. The smaller the particle, the deeper into the lungs it can penetrate. Recent studies have identified strong links between high levels of airborne particles and increased hospital admissions for heart and respiratory problems, as well as higher death rates from these ailments.

According to a report commissioned by the Ontario Medial Association (OMA), air pollution costs Ontario citizens more than $1 billion a year in hospital admissions, emergency room visits and absenteeism. Approximately 1900 premature deaths occur per year in Ontario as a result of air pollution.

Other Effects of Pollution

Plants also require air to grow. Ozone interferes with the ability of plants to produce and store food, threatening their growth and making them more susceptible to disease and pests. Some estimate that the provinces of British Columbia and Ontario each lose millions of dollars per year because of lower crop productivity due to high levels of ground-level ozone. Ozone damage can be seen on the foliage of some potato varieties in Atlantic Canada. Beans, tomatoes, potatoes, soya beans and wheat are all crops which are sensitive to ozone. Trees, which live longer than the plants above, are exposed to ozone year after year. If the effects of exposure add up over many years, which is believed to happen, entire forests can be affected. This means that other living things, like the plants and animals that depend on the trees to provide shelter, are also affected by prolonged exposure to ground-level ozone.

Rural pollution can be just as bad as urban pollution, depending on a combination of local weather conditions, topography, or the amount of pollution due to long-range transport.

Other materials you use in everyday life can be weakened by exposure to high levels of ozone. Rubber, textile dyes and fabrics, and certain types of paints and other coatings are either damaged or weakened by ozone exposure. Synthetic elastic materials can become brittle and crack, while the textiles and dyes fade faster than usual.

To demonstrate the effect of pollution on rubber, try Activity 5 in the Activities section.

AIR QUALITY PREDICTION

As Sky Watchers, you have learned how Environment Canada meteorologists predict what the weather is going to be like where you live. You also know they predict how strong the UV radiation is going to be for the day. This is done so Canadians can be better prepared for any kind of weather, or can wear sunscreen and protective clothing to prevent sunburns. Environment Canada and your provincial, regional and local governments are also concerned about the air you breathe and the quality of that air. They want people to be able to make informed decisions and plan their activities around the quality of the air. In some cities, like Vancouver and Montreal, the local municipal governments are responsible for issuing the smog information for the local area. Just like you wouldn't plan to have a picnic in the rain, or fly a kite in the middle of a thunder and lightning storm, it is better to avoid strenuous outdoor activities when pollution levels are high. Generally, the highest levels of ozone are in the mid-to-late afternoon. If you want to have a game of soccer, where you will be running around a lot and breathing in a lot more air, depending on the specific conditions for the day, you should try and play in the morning, when the air quality is generally better. The forecast tells you when the air quality will be good or bad, so you can plan your outdoor activities around it.

TIPS

For more information on Air Quality Forecasts and Services in your area, log on to the following URL and select your region from the map:

http://www.msc-smc.ec.gc.ca/aq_smog/index_e.cfm

Smog Alerts
Federal, provincial, regional and local governments are working together to keep Canadians informed about the level of air pollution in their communities, and to educate them about how to reduce smog and limit their exposure. Listen for the following:

Smog or Air Quality Advisories:	Environment Canada, in partnership with provincial & municipal agencies, issue advisories in smog-prone communities across the country. These advisories, usually issued the day before high levels of ozone are expected, encourage people and industries to take action to reduce air pollution. Information is also provides about the effects of smog on the environment and human health.
Air Quality Index:	In some areas, an Air Quality Index (AQI) is issued by the province or local municipality to provide daily information on various air pollutants. Some provinces also use this as a basis to predict air quality. Contact your provincial or local government for more details.
Smog Forecast:	In 1997, a pilot project forecasting smog levels on a daily basis was launched in Saint John, NB. This initiative, which was very successful, was developed in partnership with the provincial government and health organizations. Environment Canada has now expanded this service across NB, NS, and PEI and is working to involve other provinces by building on existing programs and partnerships.

To reduce your exposure to smog, listen for Smog Advisories and other air quality information. Avoid vigorous outdoor exercise when levels of ground-level ozone and airborne particles are high. People with heart and lung disease, especially asthma, should stay indoors if possible.

Smog Forecasts

The categories for the smog forecasts range from good to very poor. In Atlantic Canada and the greater Vancouver area for instance, the categories are good, fair, poor and very poor. In Ontario, the lower categories are further divided into very good, good and moderate. When the forecast is fair, health officials recommend that people who are sensitive to pollution should try to restrict their activity and stay indoors.

Saint John, NB was the first city in Canada to have a daily smog forecast. The forecast has been operating since 1997.

Most smog forecast programs operate between May and October. The concentrations of ground-level ozone are usually higher during this period due to warmer weather conditions. The number of times each summer that the higher levels are reached depends on where you live, weather conditions and can vary from year to year. If the summer is cool and wet, there will be fewer days with high smog levels. On the other hand, a hot and dry summer can result in additional days with high concentrations.

Try combining the weather forecasts your class can attempt in Chapter 5 of the Sky Watchers: Guide to Weather with a smog forecast. Activity 6 in the Activities section lists some helpful questions, and answers, along with an answer chart.

Smog Advisories

The Smog Advisory Program, developed in 1993 by Environment Canada, alerts citizens when ground-level ozone concentrations (smog) are expected to exceed the national standard. Smog Advisories are similar to weather warnings, in that they are only issued when conditions are expected to meet specific criteria. In Atlantic Canada, Health Advisories are also issued along with Smog Advisories, recommending that people with sensitivities to pollution consult their physicians. The key difference between Smog Forecasts and Smog Advisories is that the latter are only issued when smog levels threaten to become detrimental to the health of the general population. This occurs when levels are expected to reach the poor category.

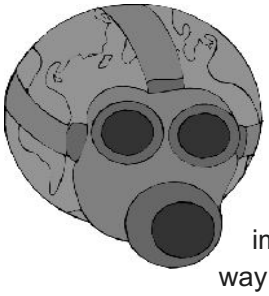
WHAT CAN WE DO TO REDUCE POLLUTION?

It is important for the future of our planet, and the health of all living things, that we do what we can to reduce air pollution. Some simple solutions are using a fan instead of air conditioning whenever possible and not letting your car idle unnecessarily. However, by attempting to find alternatives, such as using public transportation or car-pooling, we can lessen our impact on the environment. In the future, it may be that we will be able to utilize other methods to provide us with energy. Solar energy and wind energy are both in use at present and may become more widely used as the technology improves. On the following page, there are some simple tips that you can copy to send home with the students. Encourage them to talk to their parents about trying to work for cleaner air.

TIPS

Ask your students to think about all the things they do in a day that contribute to smog formation. Encourage them to keep track of environmentally-friendly choices so they can see the difference they are making.

Activity:
Ask your students about what can be done to improve the impact we are having on the environment. Have them do research on alternative energy sources such as solar and wind energy.



Tips for Reducing Air Pollution

Many of the choices that we make every day have a direct impact on the amount of pollution that goes into our air from the way we get to work and school in the morning to the way we heat and cool our homes. Since burning fuel is an important part of smog formation, reducing energy use and making wise decisions about the products we use are important steps toward cleaner air. Learn as much as possible about alternative energy sources, and discuss your concerns about smog with other people, including your parents. The following are some simple tips to pass along.

Go public. Use public transportation or car-pool instead of using your car; after all, one bus-load of passengers saves nine tonnes of air pollution each year. If smog levels are not too high, try using your bike or walking.

Turn it off. Idling your car engine for even one minute uses more fuel than turning it off and re-starting it. Most cars and trucks require only 15 to 30 seconds of idling before being driven, even in winter.

Be fuel efficient. Make fuel efficiency a prime factor in your choice of vehicle. Conserve air conditioning, which burns more gas; buy a smaller vehicle to reduce pollution and save on travel costs; and consider alternatives to gasoline such as propane, natural gas and ethanol.

Say good-bye to gas. Swap gasoline-powered vehicles and other machinery, such as motorboats, motorbikes and gas lawnmowers, for human-powered versions like canoes and sailboats, bicycles, and electric or push lawnmowers.

Drive smart. Differences in driving style can lead to a 20 percent variation in fuel consumption. Driving at moderate speeds and avoiding quick starts and stops uses less fuel.

Stay tuned. Keeping your car engine tuned and your tires properly inflated increases fuel efficiency.

Use air with care. Save fuel by using air conditioning only when needed for comfort and health. Fans use much less energy.

Say no to solvents. The evaporation of solvents found in household cleaners (e.g. mineral spirits) and surface coatings (e.g. oil-based paint) is a major source of pollutants which later form ozone. Use alternative products where possible and dispose of solvent-based products properly.

Tight is right. Save fuel by upgrading and maintaining your home heating system, insulation and windows.

Think R-2000. When buying a new house or renovating, make energy-efficient choices. R-2000 homes are better sealed and insulated, and therefore use less energy.

Environment Canada Smog Fact Sheet - July 1999

Activity number 1 - a demonstration

Purpose - To illustrate the difference between visible and invisible air pollution.

ACTIVITIES

Materials

- Clear glass bowl or large clear plastic glasses
- Tablespoon of milk
- Teaspoon of pepper
- Water
- spoon to stir with

If done as a demonstration, it may help to have a white piece of paper behind the bowl for easier observation.

Method

1. Fill bowl or cup half full of water.
2. Add one tablespoon of milk to water, stir.
3. Add teaspoon of pepper to water, stir.
4. Observe the differences between the milk and pepper.

Discussion Points

Ask before the experiment:

- What is the water a model of? (Air)
- What are the milk and pepper supposed to represent? (Milk is gaseous air pollution, pepper is particulate air pollution)

Ask after the experiment:

- What kind of pollutants did the the milk act like in the water? (Gases)
- What kind of pollutants did the pepper act like in the water? (Particulates)
- What would be easier to get out of the water? (Pepper)
- Would it be easier to remove gases or particulates out of the air? (In a controlled area, particulates can be removed by filtering the air. To remove gases from the air is more difficult.)
- How can we measure the gases in the air when we can't see them? (Air samples can be taken for a lab analysis, there are also monitors that can measure some gases like ozone in the air.)

Activity number 2A - a graphing exercise

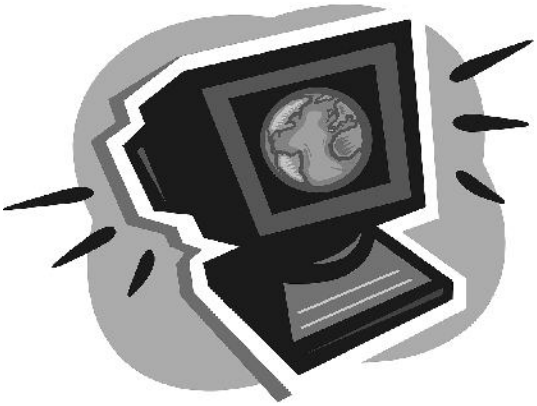
Purpose - To allow students to measure the ground-level ozone in their area, and to examine the trend over a specific length of time.

Materials:

- local ground-level ozone readings from the internet or local smog/air quality forecast
- graph paper

Method:

1. Obtain the local ozone reading for each day.
2. Have the students graph the ozone readings for the week and go over the discussion points.



Discussion Points:

- What does your graph tell you about the ozone level in your area?
- During what part of the day is the ozone level highest? Why do you think that is?
- What contributes to the ozone level in your area?
- What is being done to decrease harmful ground-level ozone? (Possible answers-smokestacks and cars now have better pollution controls. People are becoming more conscious of conserving energy.)
- Have the students record their observations.
- Keep a log of the dates and measurements for next year's students to compare their measurements with. It would be a good idea to keep a record of temperatures and cloud cover with this for the students to observe the trends together.

Activity number 2B - a graphing exercise (optional)

Purpose - To allow students to measure the ground-level ozone in their area, and to examine the trend over a specific length of time.

Materials:

- one week supply of EcoBadges
- EcoBadge instructions
- graph paper

Note: To obtain a supply of EcoBadges, order directly from Vistanomics at www.vistanomics.com or contact your regional Sky Watchers coordinator.

Method:

1. Go over the instructions the EcoBadge instructions with the students.
2. Divide the class into groups of 4 or 5 and give each student a test card.
3. Each student in the group will wear the badge for 8 hours and the group should record their ozone readings for the 4 or 5 days.
4. Have the students graph their results for the week and go over the discussion points.

Discussion Points:

- What does your graph tell you about the ozone level in your area?
- During what part of the day is the ozone level highest? Why do you think that is?
- What contributes to the ozone level in your area?
- What is being done to decrease harmful ground-level ozone? (Possible answers-smokestacks and cars now have better pollution controls. People are becoming more conscious of conserving energy.)
- Have the students record their observations.
- Keep a log of the dates and measurements for next year's students to compare their measurements with. It would be a good idea to keep a record of temperatures and cloud cover with this for the students to observe the trends together.

Activity number 3- The Clean Air Game

Purpose - To familiarize students with air pollution vocabulary and concepts

Materials:

- board game on page 13
- one die
- playing pieces for each student
- paper and pencil for keeping score

Method:

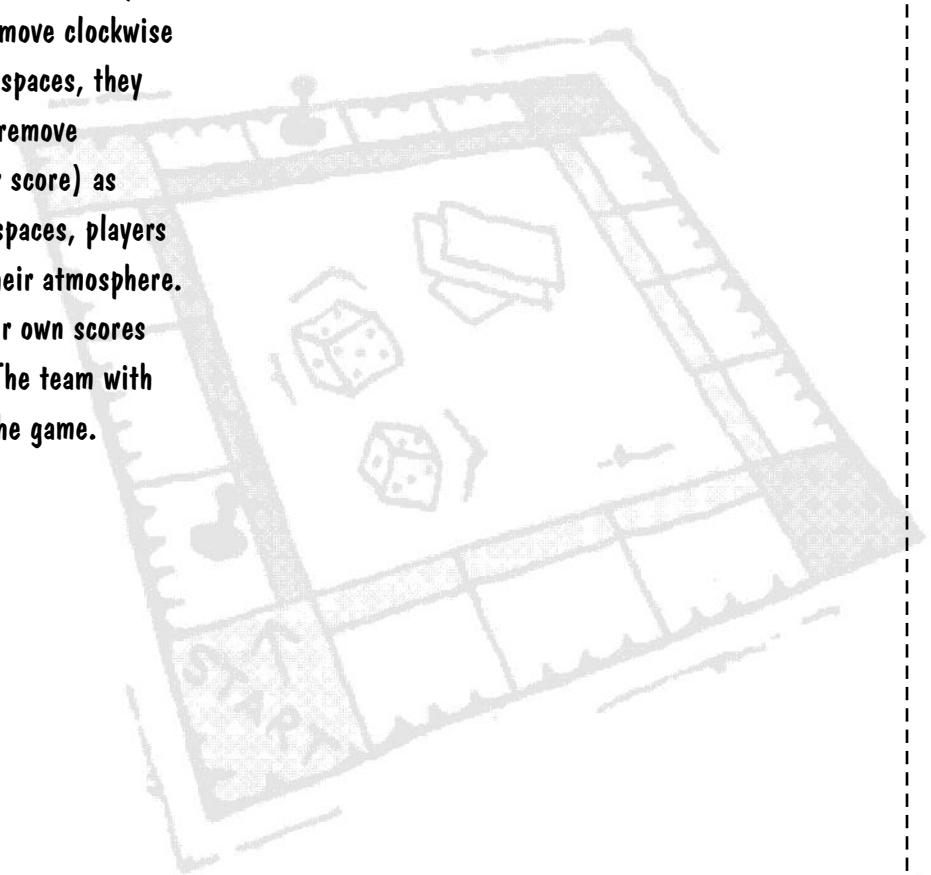
Suggested play time is 20 to 30 minutes.

To play the game:

Form teams of four or five students. Each student has a playing piece and each team has a die. Players start on one of the Green Spaces and move clockwise around the board. As players land on spaces, they read aloud the description and add or remove pollutants from their 'atmosphere' (or score) as directed. When landing on pollutant spaces, players must add one of those pollutants to their atmosphere. Players may wish to keep track of their own scores but the team score is what matters. The team with the lowest score (cleanest air) wins the game.

Scoring

Scoring can be done on score sheets or by using manipulatives, such as cheerios and fruit loops, to represent the pollution. When using the cereal, each student starts with 15 pieces of cereal and a handful in the centre of the game. To remove pollutants, players eat the cereal pieces. To add pollutants, they take pieces from the centre of the board and add them to their own pile. Depending on your class, students can keep track of the six individual pollutants and a general pollution score or just the general pollution.



Activity number 4 - Breathing troubles

Purpose - To simulate the breathing troubles of children with asthma and other breathing problems

Have the students without asthma try the following to understand how it can feel.

Materials:

- juice box straw for each student

Method:

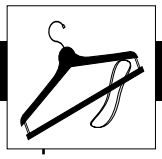
1. Have the students take ten regular deep breaths. This is how normal people breathe when there is no air pollution.

2. Give each student a straw. Have them put the straws in their mouths and plug their noses. Now have them take the ten deep breaths again.

Tip: Be sure the students take only ten breaths. They may get dizzy or hyperventilate if they attempt more than ten.

Discussion Points:

- Did you notice a difference between breathing normally and through the straw?
- How would it feel to breathe like this all the time? Can you imagine playing sports or running if you could only breathe through the straw?



Activity number 5 - The Rubber Band Test

Purpose - To demonstrate the effect air pollution can have on rubber

Materials:

- 4 small rubber bands
- 1 wire clothes hanger
- Magnifying glass

Method:

1. Bend the hanger so that when you stretch the rubber bands over the hanger, they are tight.

2. Hang the hanger outdoors in a shady place so it's out of the sun and leave it there for two weeks.

3. After the two weeks, look at the rubber bands. Do they look the way they did before, or are they cracked? Check with the magnifying glass too!

4. Touch the rubber bands. Do they feel the way they did before, or are they hard? If they look and feel the way they did before, then the air is quite clean. If they look cracked and feel hard, then the air is polluted. You may want to stretch one of the rubber bands from outside and an identical new band that was not outside to see how far each can be stretched before it breaks.

5. Leave the rubber bands out for a few more weeks. Observe any further changes in the rubber bands.

Discussion Points:

- Discuss causes and effects of air pollution before the experiment.

- Discuss the observations and inferences from the results of the observations.

Activity number 6 - Smog prediction

Purpose - To allow students to apply what they have learned to predicting smog levels in their area.

Materials:

- Required from Tomorrow's Forecast:
  - Temperature
  - Wind speed and direction
  - Precipitation forecast
  - Sky cover
- Today's Air Quality Reading
- Answer Chart (included on page 18)

Method:

Have students answer the following questions and make a prediction about tomorrow's ground-level ozone readings. They should be able to determine if the reading will be higher or lower than today's based on what the weather forecast for tomorrow is.

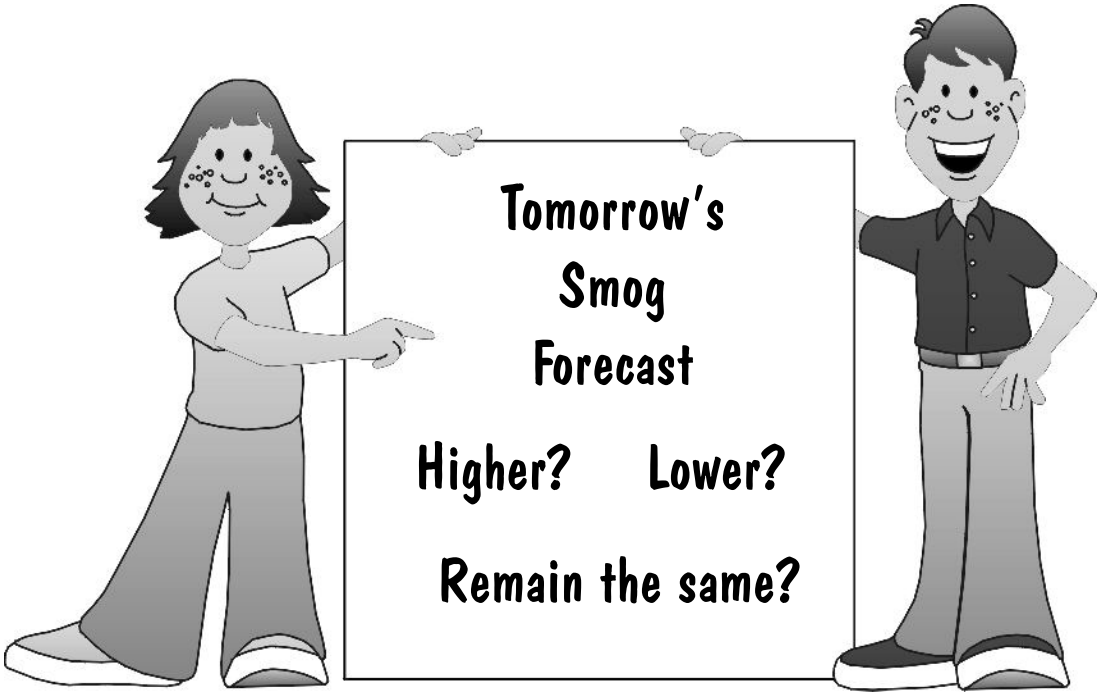
Things to Think About:

- **Is the afternoon temperature expected to be greater than 20°C?** Ozone formation occurs more readily at these higher temperatures.
- **Are the winds going to be light, moderate or strong?** Light winds usually correspond to increased smog levels since there is limited mixing in the lower atmosphere.
- **What direction is the wind coming from?** Central and Eastern Canada: A southwesterly wind will typically increase smog levels, especially in areas influenced by long-range transport. On the other hand, a northerly wind can decrease smog levels by bringing a cleaner "brand" of air into the area. Southern British Columbia: Winds from the Pacific Ocean and Strait of Georgia push pollutants inland up the Fraser Valley e.g. towards the Abbotsford and Chilliwack regions. When this is combined with a strong temperature inversion, local and regional air quality will deteriorate. Improvement is usually not expected until there is a significant wind shift or precipitation event. (For example, wind becoming moderate to strong northwesterly after a frontal passage.) Hint: Check the latest Environment Canada weather forecast for your area to see if/when any significant changes in wind direction and/or speed are expected.
- **Is it supposed to be sunny or cloudy?** A sunny day provides the energy from the sun required to interact with pollutants and lead to higher ground-level ozone concentrations.
- **Will there be any precipitation?** In most cases, precipitation will remove pollutants from the air, leading to an improvement in the air quality.
- **What day of the week is it?** Pollutants have a tendency to build up in the air. Over the weekend, there is typically less traffic and other pollution-causing activities so pollutant concentrations are lower. Because of this, at the beginning of the week, smog levels can be lower. At the end of the week, the concentration of pollutants have had a chance to build up through the week and this can lead to higher smog levels.
- **Are you outside a major city or other industrial center?** If there is such a source of pollutants nearby, check the wind direction to see if the wind is coming from that direction. The increased number of people, cars and industry in major cities all contribute to increased levels of smog.

Based on your answers to the above questions, will the smog concentrations be higher or lower or remain the same tomorrow?

ANSWER CHART

Question	Smog Level Higher	Smog Level Lower
Afternoon temperature above 20^{o}C?		
Wind-light, moderate or strong?		
Wind direction?		
Sunny or Cloudy?		
Rainy?		
Day of the Week?		
Pollution source nearby?		



POLLUTION GLOSSARY

A

Acid rain - Acid rain is more properly called acid precipitation. It occurs when sulphur dioxide and nitrogen oxide emissions convert into such pollutants as sulphuric acid and nitric acid. Both dissolve easily in air-born water droplets.

Air mass - An air mass is a large body of air, sometimes extending thousands of kilometres, which has relatively uniform characteristics of temperature and moisture.

Air pollution - the degradation of air quality by contaminants to the point that they may injure health, property, plant or animal life, or prevent the use and enjoyment of the outdoors.

Air Quality Advisories - (See **Smog Advisories**)

Air Quality Index (AQI) - provides information on the adverse effects of the more common air pollutants. It is designed to identify the worst effects that may result from the mixture of pollutants currently being measured and to describe the prevailing air quality.

Airborne particles - (See **Particulate matter**)

Ambient air - outdoor air.

Atmosphere - the envelope of air which surrounds the earth and is bound to it by gravity.

B

Benzene - a colourless, hazardous hyrocarbon emitted during gasoline storage and transfer and from refining processes.

Breeze - a breeze is a light wind.

C

Carbon dioxide - (chemical formula : CO_2) a colourless, odourless gas formed during breathing, combustion, and decaying that adds to the greenhouse effect.

Carbon monoxide - (chemical formula : CO) a colourless, odourless, poisonous gas produced when carbon-containing substances such as coal, oil, gasoline, wood, or natural gas do not burn completely.

Cardio-respiratory system - the heart and lung system in the body.

Catalytic converter - an air pollution control device that uses a chemical reaction to reduce emissions from motor vehicles.

Coarse particles - category of **particulate matter** with particles having a diameter of between 10 and 2.5 micrometres, referred to as PM_{10}.

Cold Front - When a cold air mass is coming in and pushing out a warmer air mass, the boundary between the two air masses is called a cold front. (See also **Front** and **Warm front**)

Combustion - burning or the production of heat and light energy through a chemical process.

Contaminant - unwanted chemicals and other materials in the air.

D

Dispersion - the process of reducing high concentrations of air pollutants through atmospheric motion.

E

Emission - a discharge or release of pollutants into the air, such as from a smokestack or automobile engine.

Environment - the combination of all external conditions and influences relating to the life, development, and survival of all living things.

F

Fine particles - category of **particulate matter** with particles having a diameter of less than 2.5 micrometres, referred to as $PM_{2.5}$.

Fossil fuels - coal, oil, and natural gas formed from the remains of ancient plant and animal life.

Front - the boundary of transition zone between two different air masses. (See also **Cold front** and **Warm front**)his is caused by atmospheric gases, such as water vapour, carbon dioxide, and methane containing the heat from the earth's surface. The

G

Greenhouse Effect - This term describes the warming of the lower atmosphere. This is caused by atmospheric gases, such as water vapour, carbon dioxide, and methane containing the heat from the earth's surface. The natural greenhouse effect keeps the surface temperature of the earth warmer than it would be if all the radiation from the sun escaped immediately.

Ground-level ozone - Ozone is produced at ground level when some of the chemical components of vehicle exhaust and industrial emissions react with sunlight. At ground level, ozone is a powerful and irritating pollutant. In fact, it is the main component of smog. (See also **Ozone**, **Stratospheric ozone**)

H

Hazardous air pollutant - a contaminant that may cause an increase in rates of death or serious illness.

Haze - the term haze is used when pollutants, fine dust or salt particles or moisture in the air reduce visibility. Haze usually has a yellow or bluish tinge.

Health Advisory - issued in some regions along with **Smog Advisories**, recommending that people with certain health considerations consult their physicians.

Hydrocarbons - compounds found in fossil fuels, glues, paints, and solvents that can react with other pollutants to cause smog. (Also referred to as **Volatile Organic Compounds** (VOC's))

I

Inversion - see **Temperature Inversion**

L

Lake breeze - This is the breeze which blows from the sea or large lake to the land. A lake breeze is instigated when the temperature of the land is higher than the temperature of the water. The land heats the air above, which rises and is replaced by the cooler air from over the water. (Also called **sea breeze**)

Long-range transport - the movement of pollutants with the wind from one region to another.

M

Meteorology - the study of the atmosphere and the changes which take place within it

N

Nitrogen oxides - (designated NO_x) gases that form when nitrogen and oxygen in the atmosphere are burned with fossil fuels at high temperatures.

O

Ozone - (chemical formula : O_3) Ozone is a pungent-smelling, slightly bluish gas which is a close chemical cousin to oxygen. About 90 percent of the earth's ozone is located in a natural layer high above the surface of the globe in a region of the atmosphere called the stratosphere. (see **Stratospheric ozone**) Ironically, while high-level ozone is beneficial to the environment, ground-level ozone is not. (see **Ground-level ozone**)

P

Particulate matter - Particulate matter (PM) is made up of very tiny solid or liquid particles that are small enough to remain suspended in the air. These include dust, smoke, fumes, spray and mist.

Photochemical process - the chemical changes resulting in smog brought about by the energy of the sun acting on air pollutants, such as nitrogen oxides and volatile organic compounds.

Plume - the visible emission from a smokestack or chimney.

Pollution - impurities in air, water and land that create an unclean environment.

Prevailing winds - This is the direction from which the winds blow most frequently during a given period of time. For example, the prevailing winds in Canada come from the west.

R

Respiratory - anything having to do with breathing and taking in oxygen and releasing carbon dioxide.

Ridge - The term refers to an elongated area of high atmospheric pressure (as in a ridge of high pressure) which extends from the centre of high pressure. A ridge is the opposite of a **trough**.

S

Sea breeze - see **Lake breeze**.

Secondary pollutant - an air pollutant formed in the atmosphere from other pollutants instead of being emitted directly by a source.

Smog - a combination of **particulate matter**, **ground-level ozone** and other chemical pollutants which can reduce visibility and have other harmful effects.

Smog Advisory - alerts citizens when ground-level ozone concentrations are expected to exceed the national standard (poor category).

Smog Forecast - a prediction of expected levels of ground-level ozone issued by Environment Canada or other local or regional governmental departments.

Smoke - the gaseous products and small carbon particles resulting from incomplete combustion.

Solar energy - energy converted from sunshine.

Stomata - tiny openings on the underside of leaves through which a plant takes in carbon dioxide.

Stratosphere - the layer of air that extends from about 11 to 50 kilometres above the earth's surface. For more information see page 12 in Sky Watchers Guide to Weather.

Stratospheric ozone - The natural layer of the earth's ozone located in the stratosphere. Here, it protects the earth and all that lies within it from the harmful effects of the sun's ultraviolet radiation by absorbing much of it. (See also **Ozone**, **Ground-level ozone**)

T

Temperature inversion - In the **troposphere**, temperatures usually decrease the higher you go. With an inversion, the temperature increases with altitude.

Topography - the physical and natural features of a region.

Toxic - something that can be poisonous or deadly if eaten, touched or inhaled in large enough amounts.

Troposphere - layer of air closest to the earth. It ranges from 6 to 7 kilometres above the surface at the poles to 20 kilometres in the tropics. For more information, see page 12 in the Sky Watchers Guide to Weather.

Trough - A trough is an elongated area of low atmospheric pressure which extends from a centre of low pressure. (see **Ridge**)

V

Volatile organic compounds (VOC's) - contaminants that can help form ozone near the ground and can be harmful to health. (see also **Hydrocarbons**)

W

Warm front - This is the boundary or transition zone which separates a warm and cold air mass when the cold air mass is retreating, allowing the warm air mass to move in. (See also **Front** and **Cold front**)

Wind energy - energy converted from wind.

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