So What's Making it Look Brown Outside?

Collecting and Measuring Particulate Matter

Time Needed: Several Days

NOTE: Rainy weather will interfere with the results of this experiment.

Student Outcomes:
Students will:

1. Identify gaseous and solid pollutants in the atmosphere.
2. Observe an experiment that illustrates how to capture particulate pollutants and identify which vehicle gives off more particulates.
3. Conduct an experiment capturing particulate pollutants and determine which locations appear to have more pollution.

Materials Needed:
__Scissors
__Six coffee filters
__Six 3" x 5" index cards
__Microscope or magnifying glass
__Access to six motor vehicles
__The chart provided

Background Information:
Pollutants are generally considered gaseous or solid. There are five major gaseous pollutants in the atmosphere: Sulfur dioxide, carbon monoxide, carbon dioxide, nitrogen oxides and ozone. The solid form of air pollution consists of particulate matter, lead and others. Only small amounts of these gases and solids need be present to pollute the air.

Sulphur dioxide (SO_2) is given off by power plants and factories that burn coal for fuel. SO_2 rises in a cloud from volcanoes and from industrial combustion of fuels containing sulphur. It reacts with oxygen and water in the air to become sulfuric acid, or acid rain. Acid rain can harm animal populations in lakes and rivers as well as trees and other plants by damaging leaves and root systems. It can deteriorate metal and stone on buildings and statues. Acid rain occurs not only at the source of the pollutant, but also many hundreds of miles away due to the movement of air masses.
Carbon dioxide (CO_2) is a normal component of the atmosphere. CO_2 is not really thought of as a major pollutant, but CO_2 levels are increasing. Because of the increased combustion of fossil fuels in the last hundred years (due primarily to increases in population and industrialization) many fear that this CO_2 increase is upsetting the temperature balance within the Earth's atmosphere. This is called global warming.
Carbon monoxide (CO) is a colorless, odorless and tasteless gas that enters the atmosphere when incomplete combustion occurs. The effects of CO are headaches, reduced mental alertness, and heart damage. It may even cause death by reducing the oxygen-carrying capacity of red blood cells.
Nitrogen oxides (NO_2) are mainly composed of nitric oxide (NO) and nitrogen dioxide (NO_2). These are the main components of smog, which is a dangerous vapor that covers cities during a temperature inversion. These nitrogen oxides combine with oxygen and, in the presence of sunlight, form ozone. They can combine with water to make acid rain, react in the air to produce ozone and other pollutants, or are harmful by themselves as a gas in the air.
Ozone (O_3) is a form of oxygen, produced during the interaction of nitrogen oxides, gaseous hydrocarbons, and

sunlight. If the air over a city does not move, pollutants become trapped close to the Earth's surface, reacting and producing smog and ozone. Ozone can cause breathing problems, harm trees and plants, and cause a rapid deterioration of materials such as rubber and fabrics.

Lead (Pb) was more of a problem a few years back when more motor vehicles used gasoline with lead additives. Strict limitations of the level of lead in gasoline has reduced lead emissions by 94 percent and lead in the air by 87 percent. Today, most cars in the USA use unleaded gasoline, but there is still much leaded gas being sold throughout the world. When leaded gasoline is burned, lead is released into the air. When people or animals breathe lead, over a period of time it accumulates in their bodies and can cause brain and kidney damage.

Particulate Matter (PM) consists of soot, dust, tiny droplets of liquid, and other materials. It is sent up into the air primarily by the burning of coal, diesel fuel, and wood. Particulates gradually settle back to the ground and can cause people to cough, get sore throats, or develop other more serious breathing problems. Pollution from particulate matter also causes discoloration of buildings and other structures. Many particulate pollutants are not generated by people, but by nature. Pollen, dust, volcanic ash and desert soils blown by the wind are all forms of particulate pollution.

Problem:

If cars put particulate matter in the atmosphere, how can this particulate matter can be captured and measured?

Hypothesis:

Older vehicles, and those using leaded fuel or diesel fuel, will produce more particulate matter emissions.

Procedure:

1. *Prior to performing this experiment,* find six people who are willing to be interviewed by students and have their automobiles tested (if possible, include a diesel school bus and an older leaded gas vehicle).

2. Divide the class into six groups. Cut the coffee filter into 2"x4" rectangular pieces. Have each group glue one piece of coffee filter to their index card.

3. Allow your students to see the six vehicles you are going to test. Ask them to guess which vehicles will produce the most and least particulate pollution and have them write down why they chose as they did.

4. Assign one vehicle to each student group.

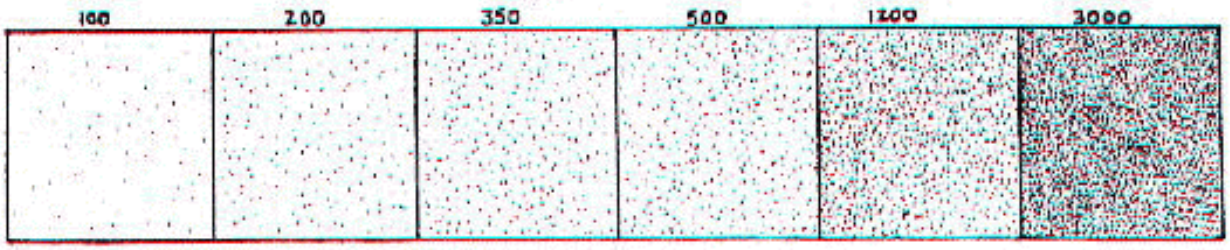
5. Assign one student from each group to interview the vehicle's owner to determine how old the vehicle is, when it was last tuned, what type of fuel it uses, etc. Have another student write the car owner's name, vehicle year and make on the back of the card. When the interviews are complete, have owners start their cars. Have another student from each group hold the index card approximately 6 inches from the automobile exhaust pipe for one minutes.

CAUTION: Do not allow the students to touch the tailpipe and have everyone avoid breathing the fumes. Do this experiment in a well-ventilated area.

6. After each group has tested their vehicle, bring the index cards back to the classroom and look at the cards under a microscope, or with a magnifying glass. Using the particulate scale, have the students estimate the number of particulates per square inch on their card. Have the students write the approximate number of particles per square inch on their card.

7. Have one student from each group bring their card to the board and relay their findings to the class. As a class, display the cards from least amount to greatest amount of particulates.

Conclusion:



Particulate Scale

For use with Student Activity # 3

Based on your observations, do the results of the experiment support or reject your hypothesis? Why or why not?

1. Have the students discuss which cars gave off more particulate pollution; was it older cars, larger cars, diesel-fueled cars, cars that hadn't been tuned in a long time?

2. What conclusion do the students draw from this investigation?

3. Would it matter if the car is regularly tuned up?

4. What other car maintenance factors could influence its emissions?

5. Have the students describe any relationship they see between the answers to the interview questions and the level of particulates on the scale.

6. Have the students graph the age of the automobile versus the number of particulates per square inch.

7. What other ways do vehicles contribute to particulate pollution?

8. Do you think the type of fuel used is also responsible for the amount of particulate emissions?

9. Would you expect solar-, electric-, or compressed natural gas-powered vehicles to have more or less emissions?