Lesson 4- Air Pollution

It's Up In the Air

Background Information

What is air pollution?

Air is never absolutely pollution-free. Particles called particulates are naturally found in our air. The particulates are small suspended solids and liquids from sources such as dust, forest fires, volcanic activity, and plant pollen. These particulates are constantly moving around in the atmosphere. Normally winds and rains would clean the air but today, the amount of some gases and particulates has increased tremendously due to industrial activities. This increase results in unfavorable air quality. We call this condition air pollution.

Particulate matter larger than about ten micrometers (microns) in diameter is filtered out in the nose or caught by mucus in the respiratory tract and propelled up the throat by tiny hairs (cilia). Although the cilia can be damaged by the pollutants, the particulate matter below ten microns (PM-10) in diameter is of greatest concern to human health because it is not filtered and thus reaches the critical areas of the lungs where oxygen exchange takes place and where there in no cilia or mucus to remove it.

Why is this happening?

Our industrialized society adds many pollutants to the air by burning coal, oil, and natural gas. When these fossil fuels are burned, gases such as nitrogen oxides, sulfur dioxide, carbon dioxide, and carbon monoxide are released. Fine particles from smoke are also released. The fossil fuels are coming from factories, power plants, businesses, automobiles, and homes. Toxic chemicals are a major source of air pollutants. Cigarette smoke, the drying of paints, and metal dust from factories also

contribute to air pollution. The burning of vegetation, mostly in tropical regions, releases gases into the air.

Weather is another factor that influences air pollution. Sometimes a mass of warm air moves into a region of cold air. The warm air rises above cooler air near the ground. This traps the cold air beneath it. This condition is called thermal inversion. Pollutants from the earth get trapped. They stay near the air and cannot rise and disperse. This causes poor air quality. A thermal inversion can last several days. Only wind or rain can break up the top layer of warm air.

Another kind of air pollutant is acid rain which is formed when burning fossil fuels releases gases. These gases, sulfur dioxide and nitrogen oxides, mix with water vapor in the air. Sulfuric acid and nitric acid form during a chemical reaction. The resulting rain and snow are acidic.

In many cities, the increasing traffic causes car exhaust to be a major pollution factor. Car exhaust is responsible for about half of the pollutants that cause photochemical smog. Smog is a combination of smoke and fog. Smog is formed when ozone and other pollutants combine in the presence of the sun's light. Ozone is produced when nitrogen oxide and hydrocarbons from a car's exhaust are given off. Ozone is a problem at ground level because it is a toxic gas.

Why is air pollution a problem?

Gases, particulates, and other pollutants do not really disappear. They remain in the air or sink into the soil and water. Pollutants can also settle in our lungs. Exposure to air pollution is associated with numerous effects on human health. These range from itchy eyes and coughing, to asthma and cancer. Americans spend vast sums of money on illnesses caused by air pollution.

Pollutants in the air, including acid rain, can also cause harm to crops, forests, and vegetation. The same pollutants that are harmful to humans have other effects as well. They cause the corrosion of buildings, outdoor works of art, and outdoor equipment.

What about indoor pollution?

Indoor air pollution often goes unnoticed. This is because much of the pollution in houses and buildings is odorless and colorless. Some of the "invisible" pollutants come from insulation, building materials, carpets, cabinets, furniture, gas furnaces, and stoves. Some of the gases given off include carbon monoxide, nitrogen dioxide, methylene chloride, dioxin, mercury vapors, benzene, asbestos, and formaldehyde. Radon gas is another dangerous pollutant that occurs naturally in some kinds of rocks and soil throughout the country but can seep into buildings. Radon found outside is not a problem because it quickly disperses. Radon found inside a building gets trapped and builds up to dangerous levels. Other indoor pollutants are not toxic but can trigger health problems. These are such things as bacteria, mold, mildew, and animal fur. According to the Environmental Protection Agency, inside air can be more polluted than outside air.

How do we know if the air is polluted?

The air is more polluted than ever before. In order to design and evaluate pollution reduction programs, it is necessary to determine which air pollutants are reaching harmful levels. An extensive monitoring and emissions tracking program is in place for ambient carbon monoxide, lead, nitrous oxides, sulfur dioxide, ozone, and PM-10, but there is no similar program for the emissions of 189 hazardous air pollutants considered toxic to people. The EPA's Toxic Release Inventory (TRI) is currently the only database available for assessing trends in the emissions of these air toxics. The TRI requires certain facilities emitting above specified quantities of air toxics to submit annual reports to the EPA on their releases. Some non-manufacturing facilities such as mining, electric utilities, and mobile sources are not required to report. Monitoring equipment is generally expensive and difficult to maintain. Consequently, cost-effective air monitoring devices are needed.

Objectives

After completing the lesson, the students will be able to:

1. Explain the importance of monitoring air pollution
2. Describe various methods that could be used to monitor air pollution.
3. Participate in problem-solving to determine the most effective method for collecting particulate matter.
4. Test for visible and invisible pollutants in the air.
5. Describe the changes that occur to objects and organisms in the environment from air pollution.

Materials Needed

1. Chart paper
2. Index cards
3. Petroleum jelly
4. Masking tape
5. One block of wood for each pair of students (about the same size as the index cards)
6. Measuring cups
7. Three bean plants approximately the same size
8. Vinegar
9. Vinegar-water mixture in 1 to 3 ratio
10. pH paper or indicator
11. School map

Preparation

1. Make an air pollution t-chart with two groups: visible and invisible.

Procedure

1. Using the chart, have the class brainstorm a list of visible and invisible air pollutants.

2. Explain the importance of monitoring to determine if air pollutants are being released.

3. Explain that for the purposes of this activity, the students are to assume that they have to design a monitoring device to collect particulate matter (PM) in the air in the classroom. Ask what would be their first step? Remind them that many pollutants cannot be easily seen or smelled. If necessary, use the following questions as prompts:
What type of particulate matter is likely to be in the classroom?
How is it likely to enter the classroom air- via the ventilation system, windows, peoples' clothing?
Is there likely to be more than one type of particulate matter in the classroom air?
Would it be necessary to monitor them all, or would monitoring one be adequate to draw conclusions about the others?
Could mold, bacteria, and other pollutants affect the monitoring results?
Could the humidity of the air in the room affect the accuracy of the results?
Would it be necessary to control the movement of air through the room? If so, how would you do it?

4. Have the students brainstorm different ideas for collecting particulates (for example, filters, collection dishes, electrostatic materials). Record their ideas. Encourage student to explain how and why their suggestions would work.

5. Poll the rest of the class to see if they agree or disagree with each suggestion. Ask them to explain why. When you have elicited two or three good, supportive alternatives, ask the class to choose the best one.

6. When some consensus has been reached on the best method for collecting particulates, ask if using just one of the chosen monitoring devices would be sufficient to get accurate results. What would be the advantage, if any, in placing monitors in several locations around the classroom? Where should they be placed?

7. Tell the students that the class will be setting up air pollution monitoring devices throughout the school building to test for visible pollutants. (These devices may or may not be similar to the collection devices suggested by the students.) We will also be conducting an experiment to test invisible pollutants.

8. For visible pollutants inside the building, have each pair of students coat an index card with a thin, even coat of petroleum jelly. With masking tape, fasten the square, jelly side up, to the wooden block. Label the devices.

9. Decide on several places around the school where the students think visible pollutants will occur. Each group should have a different area to test. Mark a school map showing where the monitoring devices will be placed. (The outside visible pollutants can be measured by taping a jelly-coated index card to the outside of a classroom window.)

10. Have the students make predictions about which area will have more visible pollutants and why.

11. Place the monitoring devices in the test areas for several days. Have the students check their index cards daily recording observations.

12. Bring the devices back to class for comparison. Observe and rank the cards from the one with the most visible pollutants to the one with the least. Discuss why certain areas have more visible pollutants than others.

13. To test for invisible pollutants, the class will need to be divided into three groups. Each group gets a bean plant.

14. Students determine and compare the pH of the three solutions (tap water, vinegar, and vinegar-water mixture) and predict how the plants will be affected by each solution. Have the students record pH and predictions. (The vinegar represents acid rain which is caused by invisible air pollutants.)

15. The plants will need to be watered every day with 1/8 to ¼ cup of solution: one plant with tap water, one with straight vinegar, and one with vinegar-water mixture. Students record procedure.

16. Observe plants daily. The student will record what happens to the plants. They should sketch their observations.

17. Compare plants and discuss observations at the end of a day, week, two weeks, or until plants die.

18. Using the observations of all the groups, write a class conclusion for this experiment. Help the students understand that this experiment was about acid rain.

Extensions

1. If a light microscope is available and the classroom has an electronic device like a computer or television that is used often, place a glass slide on the electronic device (for example, on top of the computer monitor) for at least three days before the lesson. (Electronic devices tend to attract particulates.) During the lesson, examine the slide under the microscope and discuss the magnification limits of the microscope.

2. Have the students actually build and test their brainstormed monitoring devices. Compare the results with the other monitoring devices.

3. Research the history of acid rain. Include information on the causes of acid rain, when we first became aware of the problem, what problems have been caused by acid rain, what measures have been taken to combat acid rain. Has the situation improved? Make a class mural to show the acid rain cycle.

4. Have the students take a monitoring device home to test the pollution for 24 hours. Students will then report their findings.

Sources

"Air Pollution: Visible and Invisible" *Tulsa Outdoor Air Curriculum*. 2004. www.incog.org/Environmental/AQ%20Curriculum.

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