

## LAB: Temperature Inversion - Pollution Simulation

### Purpose

To learn about the relationship of temperature and air masses which can be responsible for the build-up of smog and industrial pollution in large urban areas.

### Overview

Students will create a temperature inversion in a long aquarium or gallon jar (both set-ups will be described). Incense will be used to simulate industrial pollution, demonstrating how smog builds up in a temperature inversion when no mixing of air masses occurs.

### Time

1 class period

### Key Concepts

Air masses move in relation to temperature - warm air (being lighter) rises as colder air (being heavier) sinks.

Pollution carried in the air is actually tiny particles of impurities carried between air molecules, making the air masses more dense, and therefore, heavier.

Air pollution, such as smog, tends to travel in cold air masses.

### Skills

Making observations

Collecting data

Making predictions

Testing hypotheses

Communicating observations and interpretations orally, in writing and graphically

### Background

Air masses move in relation to temperature: warm air (being lighter) rises as colder air (being heavier) sinks. Pollution carried in the air is actually tiny particles of impurities carried between air molecules, making the air masses more dense, and therefore, heavier. Air pollution, such as smog, tends to travel in cold air masses.

Sometimes when South Florida and other locations experience a cold front, the air is yellow and dirty as the cold front first arrives. Look at a map. The cold air pushes past cities that burn their garbage and vent the smoke through tall stacks that keeps their city's air clean, but the stacks' nasty fumes are picked up and pushed in other directions depending on the wind and/or front direction, somewhat like a gutter emptying into a river.

### Aquarium Set-Up Materials

A long rectangular aquarium

Hot water bottle, filled or 2 plastic soda bottles, filled with hot water

Zip-lock bag of ice

Sand to cover the hot water bottle and zip-lock bag

Incense sticks

Matches

Solid cover for the aquarium (could be made of any material)

### **Aquarium Procedure**

1. Fill the aquarium with four inches of sand.
2. Bury the hot water on one end.
3. Bury the zip-lock bag of ice at the other end of the aquarium.
4. Place a stick of incense near the cold source and have the class observe the behavior of the smoke.
5. Place a stick of incense near the hot source, and have the class observe the behavior of the smoke.
6. Make sure the cold and hot sources are still cold and hot. Then place a stick of incense in the middle of the aquarium between the two temperature sources and observe the air movement.

### **Gallon Jar Set-Up Materials**

One-gallon jar  
Sand  
Zip-lock bags  
Ice  
Hot water  
Incense stick  
Matches  
Tape

### **Gallon Jar Procedure**

1. Place about two inches of sand in the bottom of the jar. Place the zip-lock bag of ice on the sand.
2. Pour hot water into several zip-lock bags. Tape these to the top of the jar on the inside.
3. Rest a funnel, delivery end down, on the top of the jar.
4. Light an incense stick and insert it into the jar, stopping so that the smoking portion is midway in the jar.
5. Ask the class to make predictions or hypotheses as to what they think the smoke will do. (Some hypotheses might be: it will come out of the top of the funnel, it will mix in the jar, it will lie on the bottom of the jar due to the iced zip-lock bag.)
6. As the students see that the smoke stays close to the bottom of the jar, ask them why this is happening.
7. Ask students to describe what they saw happening in the aquarium or gallon jar. What has this got to do with air pollution? Could the hot area be the Equator and the cold area be the Poles? Where would all the pollution end up? Does this explain how gases released over the United States are found in concentrated amounts at the Poles? Do polar bears burn fossil fuels? Do they barbecue meat? Do they use air conditioners and refrigerators? How does all this stuff we put into the atmosphere get there? Should we worry about this?
8. Ask students when they feel would be the most likely time of year that we would have a temperature inversion? Why?
9. Students should draw a picture of the temperature inversion simulation and label the hot and cold air masses. A description of what is happening should accompany the sketch.

10. Have students explain the saying, "Everybody's downstream." as it relates to what you have just observed. Polar bears, seals, and the Native Peoples of the Arctic do not use PCBs, yet they have high levels of this cancer-causing toxin in their bodies. How might PCBs get to the Arctic and then into the food chain? Have students use sketches, labeling their work. Students can also provide answers in an essay format

**Further Investigation**

1. Have students investigate air quality for the cities of Los Angeles, California and Mexico City, Mexico. How are these cities similar? What causes their smog and temperature inversions? What is the source of the pollution in each city - do they have the same problems? Does your city have any of the factors that might cause temperature inversion? Smog?
2. Acid rain caused by factories in the northeast United States is killing lakes and forests in Canada. How is this possible? What can be done to stop it?
3. How do PCBs show up in seals and native peoples of the Arctic if they don't use those chemicals? What effect do PCBs have on organisms? Is there a safer alternative to PCBs? Is the alternative cost effective?

**Ethics Activities:**

1. Now that students know more about air pollution and how it spreads, have students describe what they think polluting industry in this country should do to rectify the situation. Should the companies be held responsible for the damage to the quality of the air or should this responsibility be passed on to all of us to deal with? What is the responsibility of individuals and what can they do?
2. How close to the pollution do you have to be to really care about the damage to the environment and health of the cities? If you were directly affected by the pollution, would you feel differently?
3. You live on the outskirts of town, lots of open space and nature. The city landfill is three miles away, but you never notice it except for a few days in the summer when the wind blows out of the north. Everything has been fine until the city decided to build a large incinerator for garbage because the landfill was almost full. That was six months ago. Now, every time they burn garbage, the ashes fall on your property and the smell of burning garbage is present too often. Your dad has a cough all the time now. Moving is not an option. What would you do? Write an action plan that you think will get results.

**Student Assessment**

1. Did the students actively participate in class discussions including forming hypotheses and then discussing why these hypotheses are borne out by the experiments or not?
2. Did the students address specific issues listed above in short answer and/or essay format as well as in drawings?