



Indoor Environment – Indoor Air Quality

Purpose:

To increase the students' awareness of the sources of indoor pollutants and pathways

Time estimate:

- ½ to 1 hour

Module Objectives:

1. Understand the basics of airflow as related to pressure
2. Understand how HVAC and exhaust fans affect the building's air pressure
3. Understand potential indoor pollutant sources: VOCs, particulates, animal dander, insects, mold
4. Understand the principles of source removal, dilution, and air filters/purifiers
5. Understand how radon from the soil can be drawn into the house
6. Understand that most vacuums cleaner blow dust back into the room
7. Understand that mold is everywhere, but requires moisture to grow in the house

Vocabulary:

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|-------------------|-------------------------------------|
| ▪ Carbon Dioxide | ▪ Pollutant |
| ▪ Carbon Monoxide | ▪ Radon |
| ▪ Formaldehyde | ▪ Respiration |
| ▪ Humidity | ▪ Secondhand smoke |
| ▪ Mold | ▪ Ventilation |
| ▪ Particulates | ▪ Volatile Organic Compounds (VOCs) |

Supplies:

Model house	Smoke tube
Balloon (3)	Candle
Air freshener, Bounce™	Can of paint/varnish
Dust buster™ (dust sample)	Car deodorizer – preferably new car smell
Radioactive meter (Radon test kit)	Moldy – agar plate
Psychrometer/Moisture meter	CO ₂ meter
Air filter – dirty/clean	Matchbox car
Tile cleaner/Pesticide	Differential manometer
Wet wood/dry wood	Wet carpet/dry carpet
Flashlight	

Student handouts:

- Vocabulary (combined with the Electromagnetic Radiation module)
- Room-to-room inspection (combined with the Electromagnetic Radiation module)

Overview:

- Step 1: Sources of pollutants
Step 2: Pollutant pathways
Step 3: Mitigation of sources



Step 1: Sources of pollutants

Explanation:

Does anyone know anyone with allergies? How about asthma? Do you know that there are 10 times as many kids with asthma today than there were when your grandparents were in the 4th grade? Do you realize that asthma is the leading cause of hospitalization and absenteeism for children? What's going on?

You've probably heard about how cars and some industries cause air pollution, but believe it or not, that isn't the primary cause for the *respiration* or breathing problems. According to research (EPA), it is because we spend over 90% of our time indoors and that our homes can be 6 times more polluted than outdoors, and over 95% of the homes inspected have pollution. And now, almost 18% of the population is sensitized. The problem is sometimes people will get sick immediately from indoor pollutants, but sometimes it will take weeks, months or years of exposure to become sensitive. This makes it very difficult to determine when someone is sick because of bad indoor air.

What is a *pollutant* and from where does it come?

A pollutant is anything in the environment that causes problems for people or animals; pollutants are unwanted chemicals or other materials found in the air, such as gases, vapors, dust, smoke, or soot. Some of the problems that people experience are:

- * Itchy eyes
- * Breathing difficulty
- * Muscle cramps
- * Asthma
- * Runny nose
- * Headaches
- * Sleeping problems
- * Allergies

I know you have studied about the effects of *secondhand smoke* that there are over 2000 known pollutants in smoke - some can cause lung cancer. Therefore, you should never have someone smoke in your house. But what other sources might be in your home? I've got several examples up here – *candles, air fresheners, cleaners, ...*

There are some specific sources that cause some people to have:

Have you ever smelled the "new" smell - perhaps in a car, in a clothing store, with new carpet, or new furniture, paint or varnish? This "new" smell is really the material releasing *formaldehyde* into the air. Formaldehyde is a strong-smelling chemical, which is part of the group called *Volatile Organic Compounds* - Volatile because they release into the air, and Organic because they contain carbon. These are usually referred to as VOCs and can be found in *paint, varnish, household cleaners, air fresheners, fabric softener, ...* Anything that has an odor is a VOC.

Another indoor pollutant is *Carbon Monoxide*. Do you know what produces carbon monoxide? CO is a very dangerous (toxic) gas found near chimneys, furnaces, idling cars or other engines. It is colorless and odorless. Cars are a primary source, but so is anything that burns, such as a gas stove, water heater, or fire in a fireplace. There are alarms you can use to detect carbon monoxide.

Animals can also be sources of indoor pollutants, both their hair and their dander, or oil from their skin. Dust and insects can also cause health problems for some individuals. Do you realize that most vacuum cleaners work like this Dust Buster, and will blow dust back into the house? This dust is usually the smaller *particulates* that we can breathe into our lungs. Look at the dust that collects on this paper.

And finally, when moisture develops in a home, *mold* can grow. Mold is natural, and quite common; it can be found everywhere outside in soil and plants. But it shouldn't be allowed to grow inside. Mold will grow anywhere it stays damp – under the house, in the basement, under a leaky sink, in the bathroom, or in a dark, damp closet. *Show the mold sample.*

And finally, a very common source of indoor pollutant is *Carbon Dioxide*. Do you know where it comes from? CO₂ is a by-product of human respiration and if high may be an indication of poor



ventilation. From us, during respiration we breathe in oxygen and breathe out carbon dioxide. Thus, if we have a lot of people in a room without fresh air, we can actually pollute the room.

Step 2: Pollutant pathways

Explanation:

So what if there is a pollutant source in the basement or under the house, you don't go there very often, right?

Air pressure

To understand how pollutants move through a house, it is important to understand air pressure. *Get a balloon.* Why isn't the balloon inflated? Does it need air? *Open up the neck as if allowing air to flow in.* Now it is open, why isn't the air flowing in? *Blow up the balloon.* It will only fill if I force air into the balloon; I have to push air in under pressure. Now what would happen if I punctured the balloon? Why? The air in the balloon is under force, or pressure, it is at a higher pressure than the air outside of the balloon, and therefore wants to escape and escape quickly. *Use the differential manometer and measure the pressures.* *Let the air out.* Air will always flow from an area of higher pressure to an area of lower pressure.

Positive pressure

Set up the model house, exterior door closed, window closed, and interior door open. Have you ever held your hand over an air conditioning vent, or in front of a fan? They create a positive pressure to force air from one place to another, moving air throughout the room or house. In the model house, there is an external fan (*in the green box*) that when it is running it forces air through the tube throughout the house, like an air conditioning unit, creating a positive pressure in the house. *Turn on the fan. Use the differential manometer.* Look at what happens if there is a source of pollution just outside of the house, it blows throughout the house. *Inject the smoke into the green box. Use the flashlight to trace the smoke.* Let's focus on the kitchen. Right now the "pollutant" comes in and disappears fairly quickly. What would happen if we close the door to the living room? *Close the door and window.* Now, what about opening the window. What would be the effect of people in the house, if a car were left running near the exterior fan? *Put the matchbox car near the exterior fan.* What about someone painting nearby or mold growing? *Move the demo products near the fan.* Do you see how pollutants from outside can get into your house, or how pollutants from one part of the house will actually blow into other parts?

Negative pressure

Set up the model house, exterior door closed, window closed, and interior door open. There is probably an exhaust fan in your bathroom and your kitchen; do you know what they do? They create a negative pressure in the room, so that all of the moisture and odors are drawn out of the room to the outside. Do you remember why we want to keep the moisture out of the house? To keep mold from growing, you should always use the exhaust fan in the bathroom and in the kitchen.

Look at this house, like some houses; it has an exhaust fan in the attic. When the exhaust fan is on, the house will have a negative pressure, so the air will flow from within the house to the outside. *Turn on the exhaust fan. Use the differential manometer.* When the air inside the house is cleaner, this is a good thing since the house will be filled up with the clean outside air. However, look what happens when there is a source of pollution from under the house. *Inject the smoke under the middle of the house. Use the flashlight to trace the smoke.* Notice how it seeps up into the house, travels up the stairs, and goes out the attic. Do you see that a problem under the house from VOCs, mold, or perhaps the common pollutant for this area called *Radon*, will spread throughout the house? Radon is a radioactive gas that you cannot see or smell that comes from deep within the ground. Here in Middle Tennessee radon is a problem, and according to the EPA, it is the second leading cause of lung cancer because the small radioactive particles cling to dust and can be inhaled deep into the lungs. *Show and describe the radon test kit.*

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through a healthy indoor environment*



What would happen to this source under the house in a positive pressure house? *Use the exterior fan and inject the smoke beneath the house.* The pollutant from the basement should not enter the house.

Step 3: Mitigation of sources

Explanation:

So what do you do if you think you have polluted air? The first step is to find out the possible sources, and then get rid of the source. Some sources are obvious: cars, paint, household cleaning elements, etc.

Mold

But there are some less obvious, like mold. *Get the Psychrometer and the Moisture meter.* This instrument, called a Psychrometer measures the humidity in the area. Humidity is the amount of water vapor in the air. Why would be concerned about moisture in the air? With a lot of moisture we might have mold growth. Humidity can be different at different places around the room, but for right now, who wants to tell me what the humidity is right here? *Use a volunteer.* This instrument, called a Moisture meter, tells you whether a material is wet. There are two pieces of wood here; who can tell me which one is wet? *Use a volunteer.* If you have high humidity or moisture, it is likely that mold will grow.

Carbon Dioxide/VOC's

Finally, let's check the room for carbon dioxide. *Use a volunteer.* What happens to the instrument you "breathe" directly into it? What could we do to reduce the carbon dioxide? Opening the window to increase *ventilation* will dilute the carbon dioxide and also carbon monoxide.

What could you do for VOC's? Increase ventilation. *Ask a volunteer to smell the VOCs.*

Dust/Animals

One of the best things to do to reduce problems from dust and animals is to use a good filter in the air conditioner. Filters trap the dust and animal hair, but must be replaced or cleaned to work well. *Show the dirty filter next to the clean filter.*

Radon

Show the radon test kit. Radon can be tested using a test kit available at most building supply stores, or by measuring for radioactive materials. *Show the Radioactive meter. Use a volunteer.*