ZA 101.01
IAQ Basics

20 minutes

Estimated duration to complete this Learning Segment

Zehnder Academy Learning Path

This segment is part of the training for:

Zehnder America Certified Comfosystems **SPECIFIER**

Zehnder America Certified Comfosystems **INSTALLER**

Zehnder America Authorized Comfosystems **TECHNICIAN**

Zehnder America Authorized Comfosystems **DEALER**

Zehnder America Authorized Comfosystems **DISTRIBUTOR**

Knowledge Level:

Introductory

Recommended prerequisites:

- None

LEARNING OBJECTIVE(S)

1. Understand what affects Indoor Air Quality (IAQ) in buildings.
2. Identify some of the basic types of indoor pollution.
3. Review the common ways people try to fix IAQ issues.

Learning Objective #1

Understand what affects Indoor Air Quality (IAQ) in buildings.

“Indoor” Air Quality (IAQ)

For thousands of years, “indoors” basically meant shelter and security.

However, today, “indoors” is where we live most of our lives and store all our possessions.

The EPA says Americans spend an average of 90% of their time indoors.

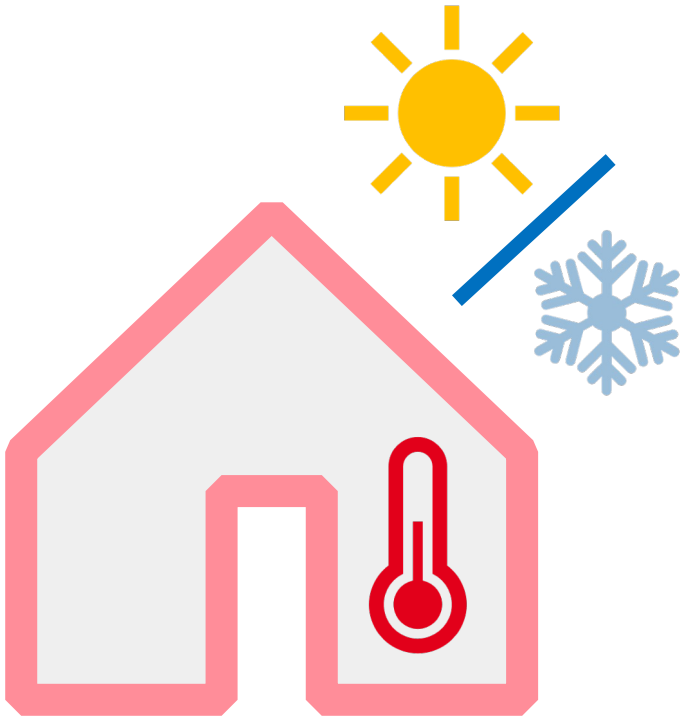
U.S. Environmental Protection Agency. 1989. Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C. Washington, DC.

Basic Building Factors Affecting IAQ

"Indoors" is separated from "Outdoors" by one or more barriers, including…

- Weather barrier
  - "Shelter 1.0"
  - Keeps out bulk moisture and direct wind.

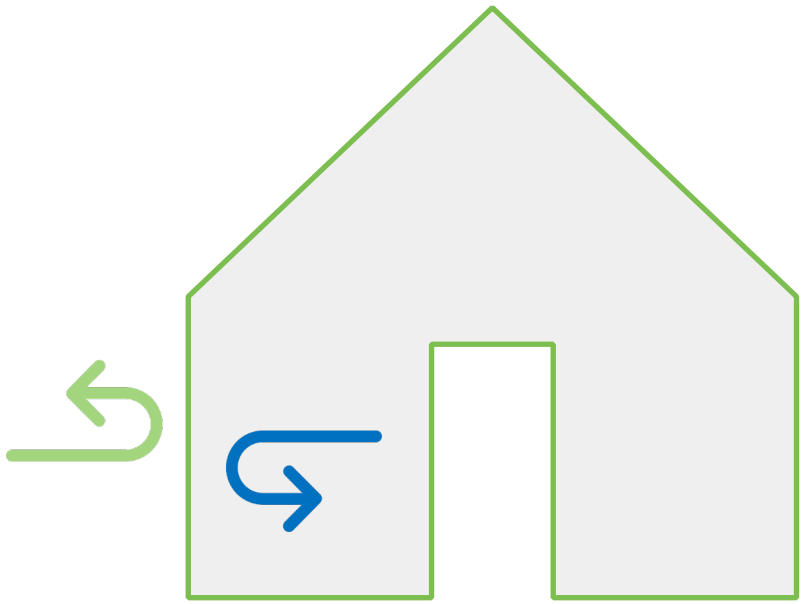
Basic Building Factors Affecting IAQ



"Indoors" is separated from "Outdoors" by one or more barriers, including…

- Weather barrier
- Thermal barrier
  - Insulates interior from exterior temperature extremes
  - One of the main advancements in the construction industry in the last 50 years

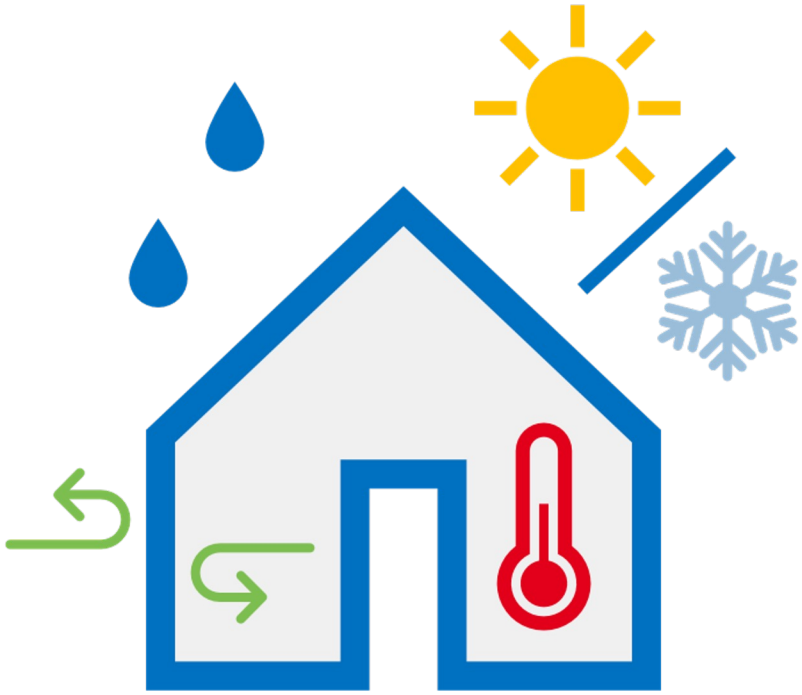
Basic Building Factors Affecting IAQ



"Indoors" is separated from "Outdoors" by one or more barriers, including…

- Weather barrier
- Thermal barrier
- Air barrier
  - Reduces airflow in and out of the house (infiltration & exfiltration)
  - A more recent emphasis in the industry (last 10-20 years)

Basic Building Factors Affecting IAQ



When done properly, this combination of barriers is effective at…

- Improving occupant comfort
- Improving building durability
- Saving heating/cooling costs

It also…

- Restricts natural airflow
- **Traps pollution inside!**

Basic Building Factors Affecting IAQ

…as a result, “indoors” is not only a place to live and store our stuff…

Increasingly, it is a place where we collect air pollutants!

In fact, the EPA says indoor air can be up to 5x more polluted than outdoor air.

U.S. Environmental Protection Agency. 1987. The total exposure assessment methodology (TEAM) study: Summary and analysis. EPA/600/6-87/002a. Washington, DC.

Check Your Knowledge

Learning Objective:

Understand what affects Indoor Air Quality (IAQ) in buildings

Based on the previous review of "barriers" in the building, which of the following is most likely to affect Indoor Air Quality?

A. Window glazing coatings
B. Solar orientation
C. Building wrap and tape
D. Shower tile selection

Check Your Knowledge

Learning Objective:

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Learning Objective #2

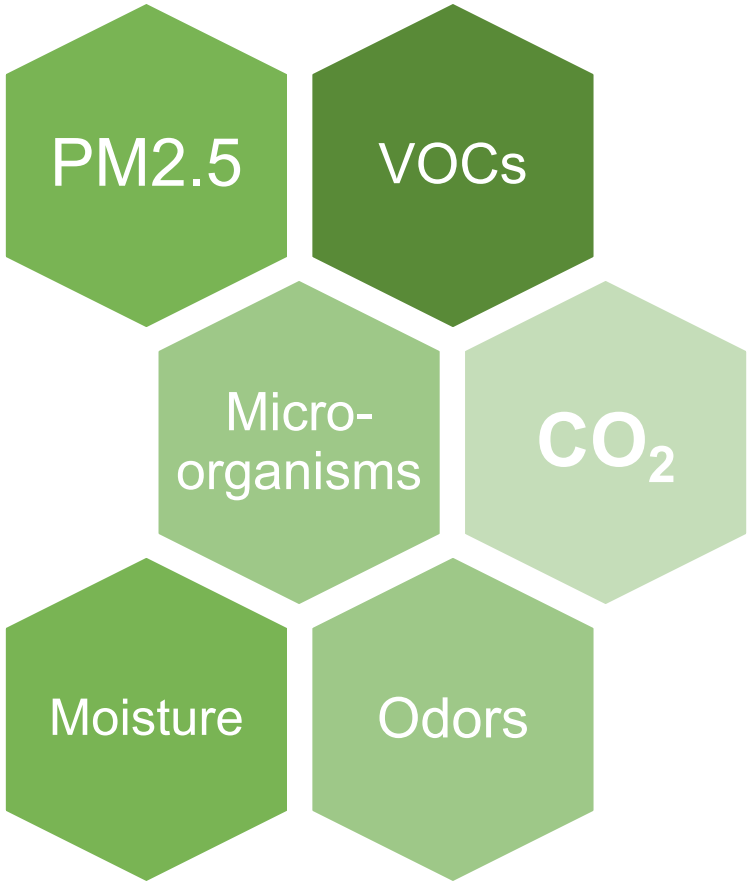
Identify some of the basic types of indoor pollution.

Typical Indoor Air Quality Contaminants

Most buildings are affected by very common Indoor Air Quality issues.

Knowing about these contaminants can help us understand the best ways to deal with them.

Let's look at some the most typical categories, one by one…



Volatile Organic Compounds (VOCs)

EPA:

"Volatile organic compounds, or VOCs are organic chemical compounds whose composition makes it possible for them to evaporate under normal indoor atmospheric conditions of temperature and pressure."

https://www.epa.gov/indoor-air-quality-iaq/technical-overview-volatile-organic-compounds

In other words…VOCs "off-gas" at normal room temperature.

Common indoor sources of VOCs

- Building materials
- Adhesives and finishes
- Flooring materials and furniture
- Cleaners and disinfectants
- Air fresheners
- Cosmetics and deodorants
- Dry-cleaned clothing
- Printers and copiers

The American Lung Association says breathing in VOCs…

- Can irritate the eyes, nose and throat
- Can cause difficulty breathing and nausea
- Can damage the central nervous system as well as other organs

Some VOCs can cause cancer.

Not all VOCs have all these health effects, though many have several.

https://www.lung.org/our-initiatives/healthy-air/indoor/indoor-air-pollutants/volatile-organic-compounds.html

Check Your Knowledge

Learning Objective:

Identify some of the basic types of indoor pollution.

Which of the following is probably NOT a big source of VOCs?

A. Air freshener sprays
B. Cotton bath towels
C. Nail polish
D. Glued wooden beams

Check Your Knowledge

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Particulate Matter (PM)

Particulate Matter is airborne pollution including…

- Solid particles
- Liquid droplets
- Or a combination of solid & liquid

Some can be seen, but a lot of it is too small to be seen without magnification.

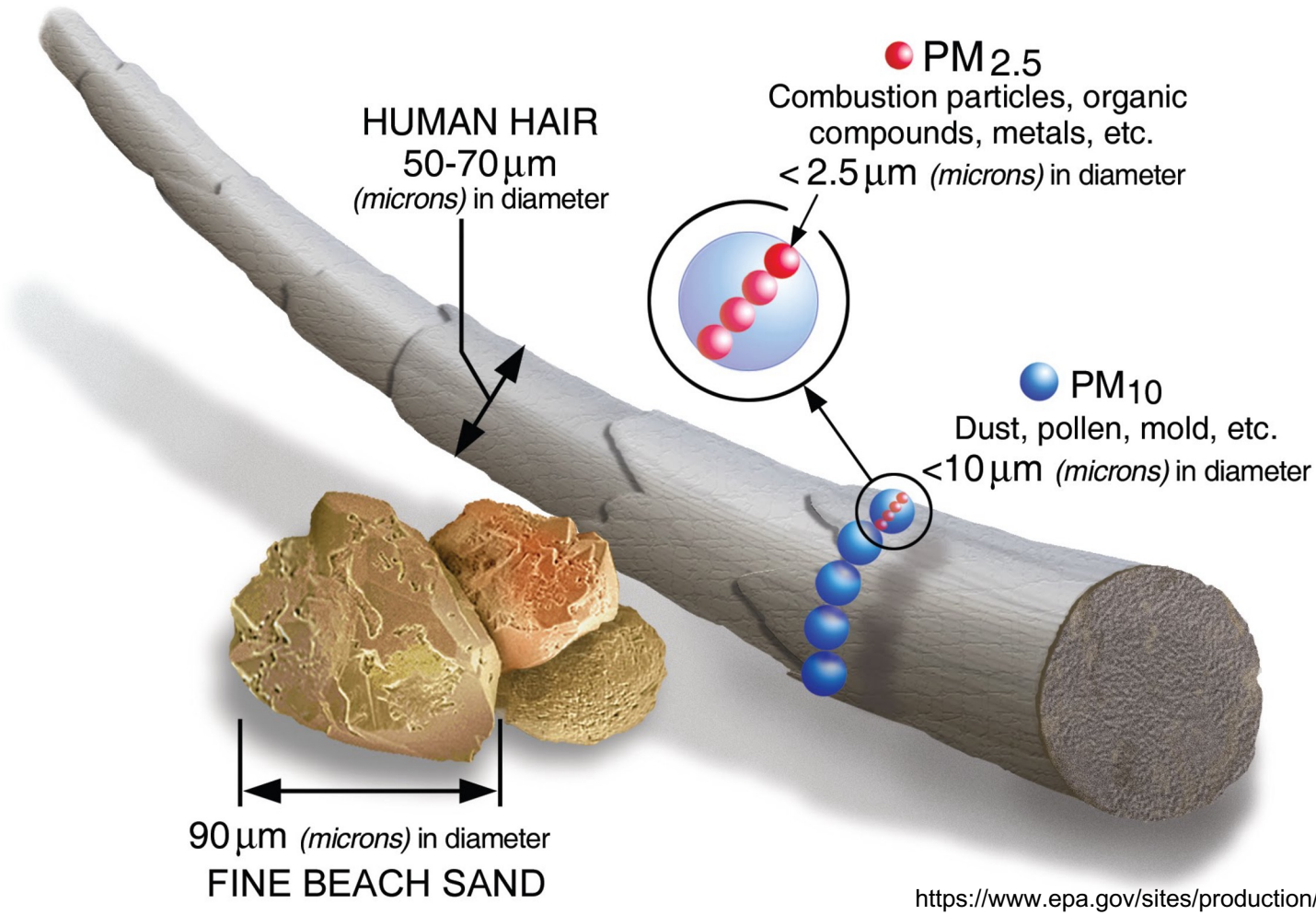
Size of Particulate Matter (PM)

PM10

- 10 microns and smaller
- Inhalable particles that can get deep into the lungs

PM2.5

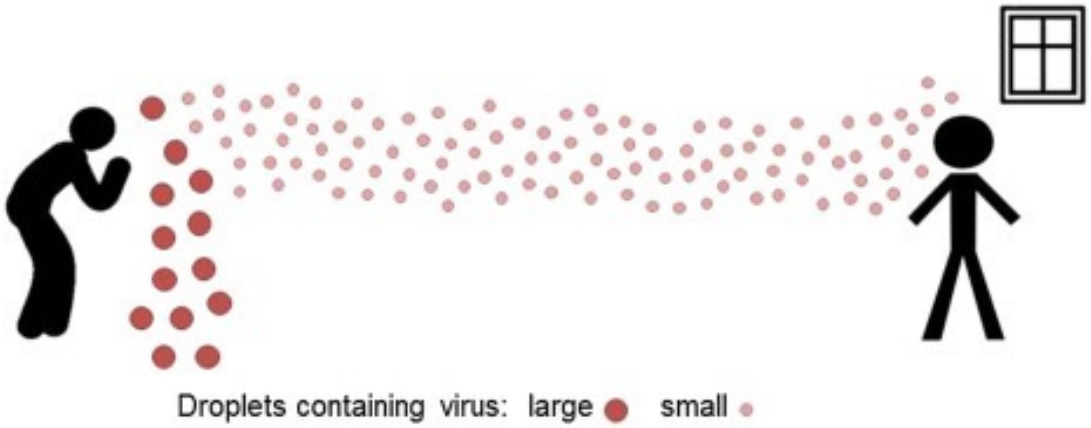
- 2.5 microns and smaller
- Fine inhalable particles that can pass through the lungs into the bloodstream
- PM2.5 pose the greatest risk to health

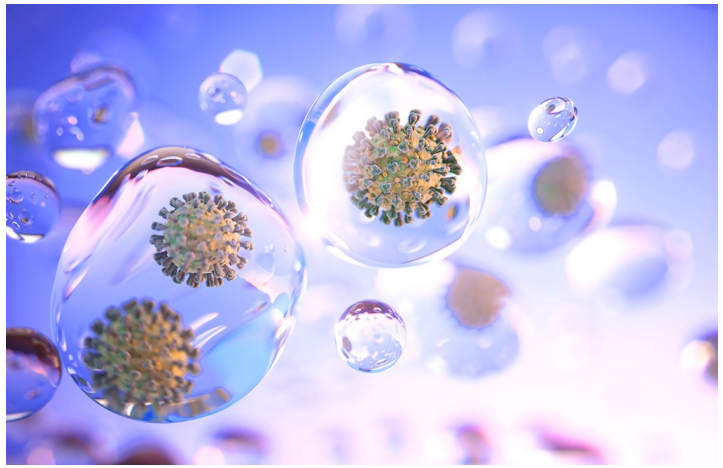


https://www.epa.gov/sites/production/files/2016-09/pm2.5_scale_graphic-color_2.jpg

Particulate Matter and Infectious Disease

- Virus is often spread through airborne respiratory droplets.
- Larger droplets fall quickly, but smaller droplets may evaporate into droplet nuclei and stay suspended longer and travel further.

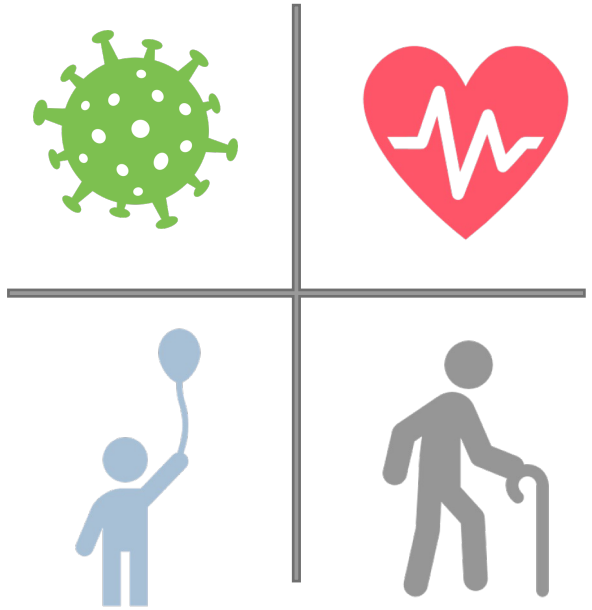




Health Risks Associated with Particulate Matter

Numerous scientific studies have linked particle pollution exposure to a variety of problems, including…

- Premature death in people with heart or lung disease
- Nonfatal heart attacks
- Irregular heartbeat
- Aggravated asthma
- Decreased lung function
- Increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing



People with heart or lung diseases, children, and older adults are the most likely to be affected by particle pollution exposure.

https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm

Check Your Knowledge

Learning Objective:

Identify some of the basic types of indoor pollution

Which of the following is a serious concern about airborne particulate matter?

A. PM2.5 can enter the blood.
B. PM10 can obscure eyesight.
C. PM2.5 can cause vomiting.
D. PM10 makes walking surfaces slippery.

Check Your Knowledge

Learning Objective:

Identify some of the basic types of indoor pollution

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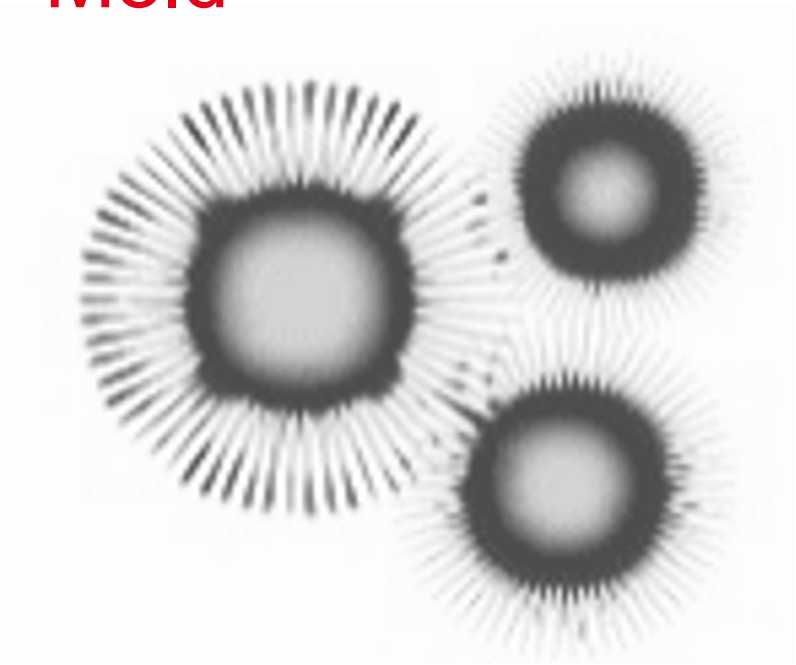
High Humidity and Micro-organisms:

Dust Mites

- Dust mites eat dead skin particles as food
- Dust mites thrive when humidity levels are higher (50% RH or more)
- Most humans are allergic to the digestive enzymes of dust mites
- Each dust mite lives for about 10 weeks
- Each dust mite will create thousands of allergenic fecal and enzyme-coated particles during its short life

High Humidity and Micro-organisms:

Mold



- Molds eat all kinds of organic matter as food (including fabrics and paper)
- Mold thrives when humidity levels are higher (75% RH or more; some species thrive at even lower RH)
- Molds release “mycotoxins” gases as part of their feeding process (possibly to weaken host organisms)
- “The adverse health effects of mycotoxins range from acute poisoning to long-term effects such as immune deficiency and cancer.” – World Health Organization

Check Your Knowledge

Learning Objective:

Identify some of the basic types of indoor pollution

What is the most serious concern about high indoor humidity?

A. It causes frizzy hair.
B. It takes laundry longer to dry.
C. It causes moisture on mirrors.
D. It encourages the growth of biological irritants and toxins.

Check Your Knowledge

Learning Objective:

Identify some of the basic types of indoor pollution

What is the most serious concern about high indoor humidity?

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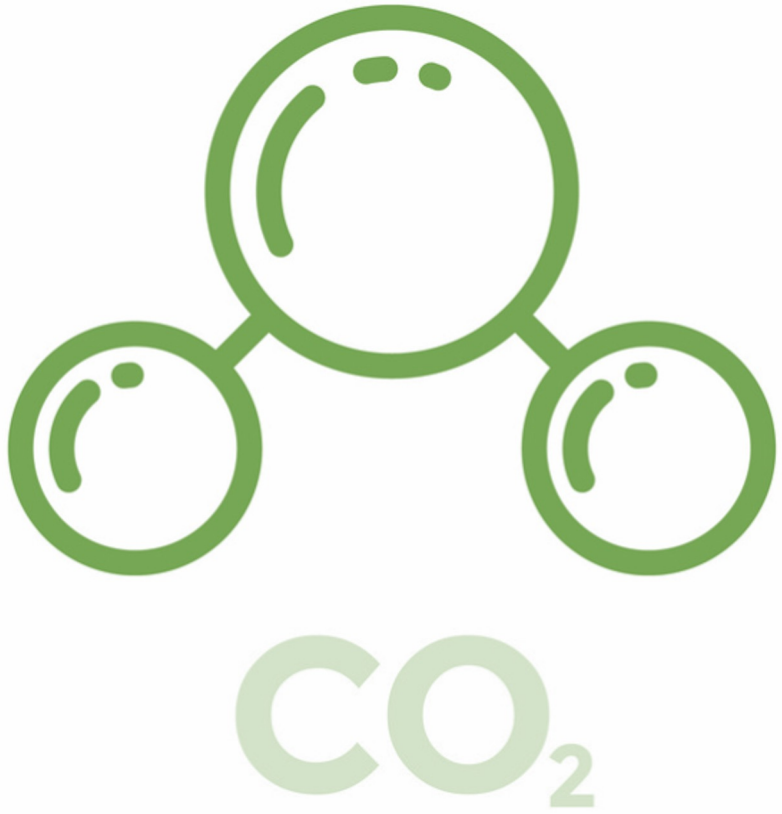
Carbon Dioxide (CO_2)

Carbon Dioxide is one of the waste products of cellular respiration in animals (including humans).

- People and pets give off CO_2 when they breathe.

CO_2 is also a waste product of combustion.

- Fuel-burning appliances like furnaces and stoves give off CO_2 when they burn.



Carbon Dioxide Concentrations in Air

The average outdoor concentration of CO_2 is

= ($^{+}$/-) 400 ppm

The **recommended** indoor concentration of CO_2 is

< 1,000 ppm

(ppm = parts per million)

Cognitive function decreases temporarily when CO_2 increases

Harvard study on CO_2 in offices

Even a moderate 400 ppm increase in CO2 levels resulted in a 21% decrease in cognitive scores.

http://nrs.harvard.edu/urn-3:HUL.InstRepos:27662232

Danish study on CO_2 in student dorm rooms

Following nights with average CO2 concentrations of 2,395 ppm students' subjective self-assessment and objective cognitive scores were degraded compared to nights with average concentrations of only 835 ppm.

Strøm-Tejsen, P., D. Zukowska., P. Wargocki, D.P. Wyon. 2016. "The effects of bedroom air quality on sleep and next-day performance." Indoor Air, 26(5)

CO_2 concentrations in homes can regularly exceed 1,000 ppm.

This study monitored CO2 levels in the Master Bedrooms of 22 homes in Vermont during heating season.

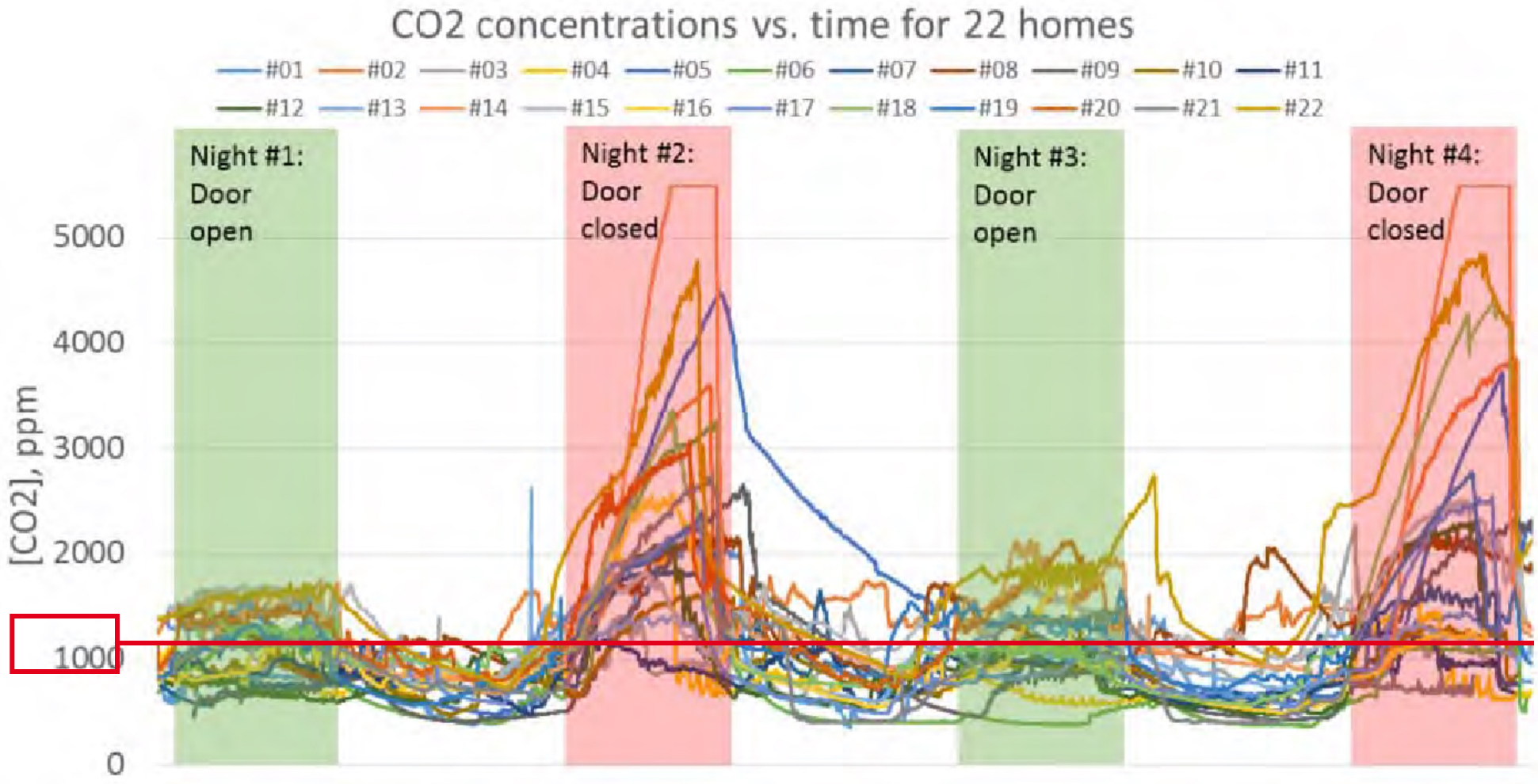


Image Credit: Brian Just, Efficiency Vermont, “The drawbacks of breathing: Nighttime carbon dioxide (CO2) levels in bedrooms in 22 Vermont homes”, 2018

Carbon Dioxide in Context

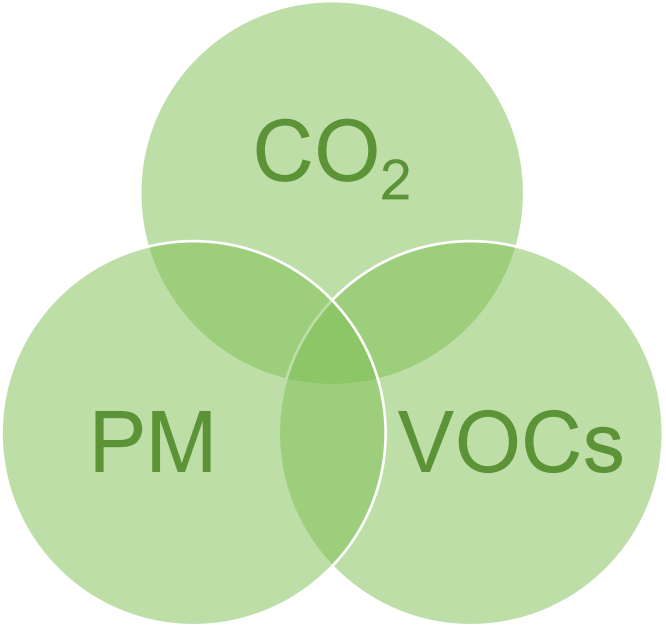
Moderately elevated CO_2 can temporarily reduce cognitive function. It's not a long-term health hazard except in very high concentrations greater than 5,000 ppm (rarely seen in homes).

Question:

Then why be so concerned about CO_2 levels?

Answers:

- *Because reducing CO_2 improves well-being and productivity.*
- *Because reducing CO_2 often means you're also reducing other pollutants at the same time.*



CO_2 levels in excess of 1,000 ppm often correlate with high levels of contaminants which may have GREATER long-term health risks.

Historically, CO_2 sensors are more accessible, affordable and reliable than many other IAQ contaminant sensors.

Check Your Knowledge

Learning Objective:

Identify some of the basic types of indoor pollution

Which one of the following statements is NOT true?

A. CO_2 is normally found in the air we breathe.

B. CO_2 levels in homes don't matter.

C. CO_2 levels can be monitored with sensors.

D. CO_2 can affect brain function at higher levels.

Check Your Knowledge

Learning Objective:

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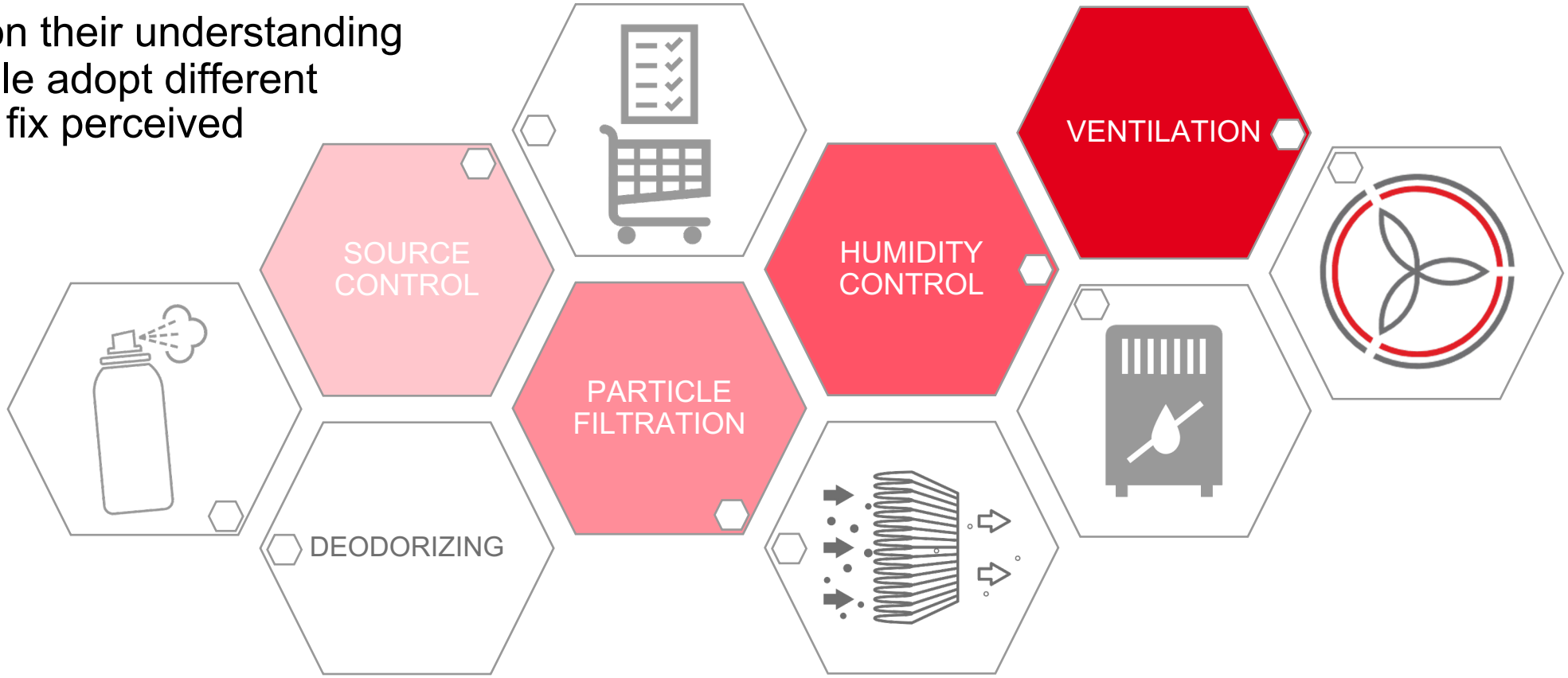
Learning Objective #3

Review the common ways people try to fix IAQ issues

Common Approaches to “IAQ”

Depending on their understanding of IAQ, people adopt different strategies to fix perceived problems.



Deodorizing

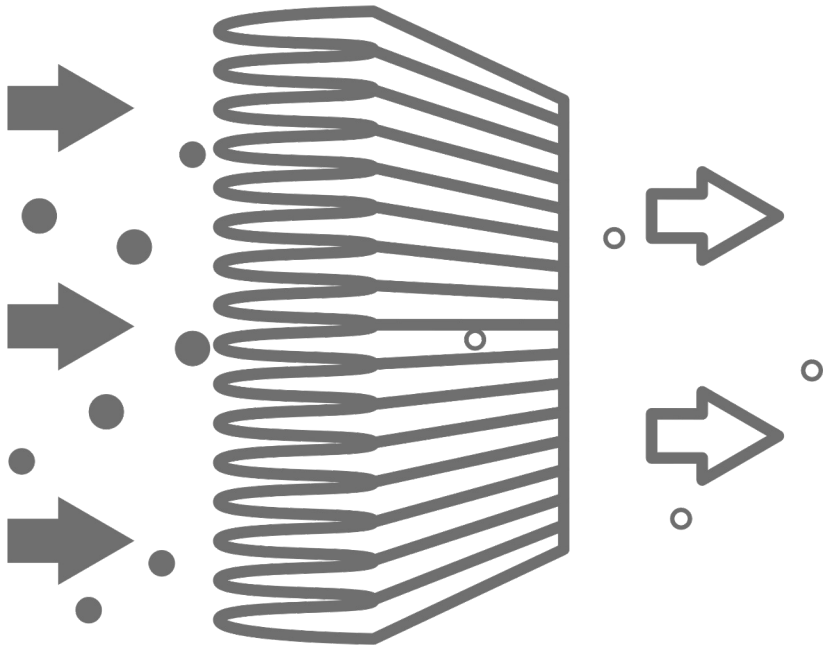
Advantages:

- May reduce the perception of unpleasant odors

Disadvantages and/or limitations:

- Unable to change the underlying causes of Indoor Air Quality issues (only masks them)
- Usually adds more pollution in the form of VOCs

Particle Filtration



Advantages:

- Can be effective at removing Particulate Matter
- May take advantage of existing air handling equipment

Disadvantages and/or limitations:

- Filters can be expensive to replace
- Filters designed for removal of finer particles reduce air flow from the air handler
- Deferred maintenance of filters can create even more Indoor Air Quality issues
- Limited impact: doesn't effectively treat elevated VOC, CO_2 or humidity levels

Source Control

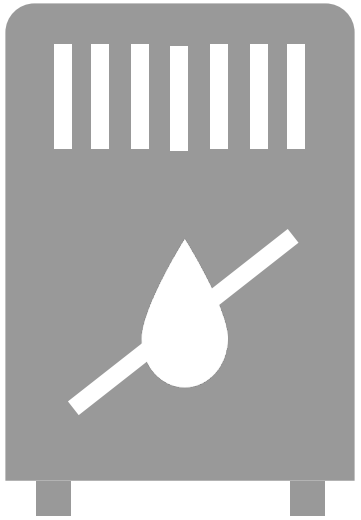
Advantages:

- Many manufacturers of building products, furnishings and personal/home care products are offering less toxic alternatives, which can help reduce levels of some VOCs and PM inside the home

Disadvantages and/or limitations:

- It is difficult for consumers to avoid all sources of toxic VOCs
- While some particulates can be avoided, many are produced inside the house with normal living
- Source control has little impact on CO2 and humidity levels that are caused by people

Dehumidification



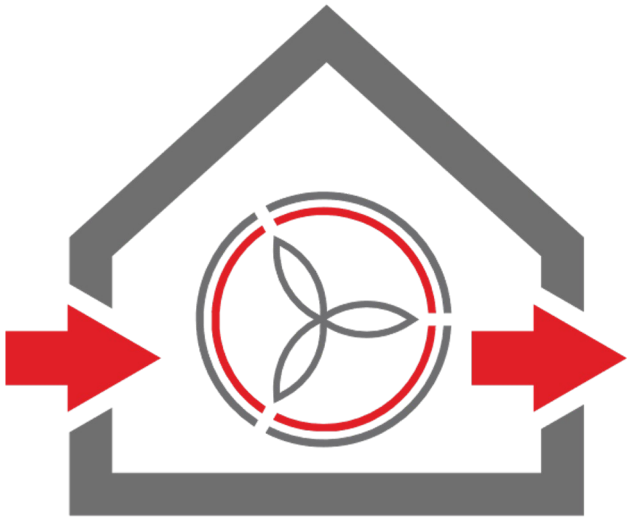
Advantages:

- Removes the conditions that nurture dust mites and mold growth
- Can help reduce the release of some VOCs
- Improves comfort during times of high humidity

Disadvantages and/or limitations:

- Very limited particle filtration, depending on filter media included, rate of air recirculation, and air distribution
- Limited effect on VOCs
- No impact on CO_2 levels
- High operating cost (electricity)

Ventilation



Advantages:

- Effectively dilutes VOC levels
- Effectively dilutes particulate levels
- Effectively reduces indoor humidity levels in many instances (depending on outdoor conditions)
- Effectively dilutes CO_2 levels

Disadvantages and/or limitations:

- Outdoor air may need to be conditioned, depending on outdoor conditions and whether energy recovery is used and how effective it is

Ventilation is a highly effective IAQ tool.

Continue with Zehnder Academy to learn more about its proper application.

Check Your Knowledge

Learning Objective:

Review the common ways people try to fix IAQ issues

Which of the following approaches is the most effective at improving the majority of Indoor Air Quality issues?

A. Deodorizing
B. Particle filtration
C. Material selection
D. Ventilation

Check Your Knowledge

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Thank you for taking this Learning Segment. We hope you found it informative.

Please explore Zehnder Academy's other course offerings and continue to grow your professional expertise.