Indoor Air Quality

Indoor Air Quality: The characteristics (chemical, physical and biological) of air inside a built structure, and the impact of these characteristics on occupants.

What is Indoor Air Quality?

How much time do you spend indoors?

Everyone has the right to healthy indoor air
- World Health Organization, 2000

No matter where we live or what time of year it is, nearly all of us spend a lot more time inside today than our parents, grandparents and great grandparents did when they were our age. During the coldest months of winter, we often try to move as quickly as possible from home, to work or school and back home again. In cities, people can spend up to 90% of their time indoors! It's not surprising, then, that we have become concerned with the quality of air we breathe while inside.

Indoor Air Quality (IAQ) is a measure of how good the air is inside a building.

The air we breathe

How would you know if air quality is good or bad?

To know if air quality – indoor or outdoor - is good or bad, we need to be able to compare it to something. Usually, we compare it to the air in the Earth's atmosphere. The air we breathe is a mixture of the gases, mostly nitrogen and oxygen, as shown in the table below.

Gas	Formula	Abundance percent by volume	Abundance parts per million by volume
Nitrogen	N_2	78.084%	780,840
Oxygen	O_2	20.9476%	209,476
Argon	Ar	0.934%	9,340
Carbon Dioxide	CO_2	0.0314%	314
Neon	Ne	0.001818%	18.18
Helium	He	0.000524%	5.24
Methane	CH_4	0.0002%	2
Krypton	Kr	0.000114%	1.14
Hydrogen	H_2	0.00005%	0.5
Xenon	Xe	0.0000087%	0.087

In large cities, outdoor air can often have high levels of dust (and other particulate matter), carbon monoxide (CO), ground level ozone, nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and/or lead (Pb). Most of these pollutants are found in high concentration near the ground, so air handling systems in large urban buildings are usually placed above ground level where they can take in cleaner air.

Rural and remote communities suffer from air pollution too. In fact, air pollution in the North can get so bad in late winter and early spring that it produces Arctic haze – a phenomenon similar to urban smog.

Do you know what causes smog?

In 1999, this equipment was used to estimate haze in Barrow, Alaska. It measured how much light was being scattered by particles floating in the air.

Source: NOAA, Optical Remote Sensing Division
http://www.etl.noaa.gov/et2/data/data_pages/barrow_haze_mar.html

Sometimes back, the skies on a clear day used to be deep blue all over, even at the horizon. Now you can hardly ever see that anymore, especially on the horizon. It is always pale blue, almost white or even dirty gray. It makes me sad to see what future generations are going to have to put up with.

- Matthew Bean, Yup'ik elder
Betel, Alaska

Haze is caused by particles, like dust, that float in the air. When light hits the particles it gets scattered. We see haze as a lightened colour in the sky, especially at the horizon. In really heavy haze, the horizon will look white, or even grey - not blue.

Do you know where most Arctic air pollution originates?

Scientists and engineers use the natural composition of the atmosphere to develop standards for both indoor and outdoor air quality. For IAQ, the most widely used standards are established by the American Society for Heating, Refrigeration and Air Conditioning Engineers or ASHRAE. ASHRAE Standard 62-2001, *Ventilation for Acceptable Indoor Air Quality*, sets minimum ventilation rates, maximum contaminant concentrations and other requirements for commercial and institutional buildings. For instance, ASHRAE says a school gym should get 566 litres of fresh air per person every minute, while a classroom only needs 425 litres of fresh air per person every minute.

Why would the ventilation rates be different in a gym and class room?

What causes IAQ problems?

Why would air quality be better (or worse) inside a building than outside?

While outdoor air quality can be less than perfect (and genuinely bad in some places), the Earth's natural renewal process – the wind - helps to move and dilute pollutants, and refresh the air outside. Air quality becomes a problem only when people are subjected to high concentrations of pollutants.

Low concentrations of pollutants generally aren't harmful.

High concentrations of pollutants are more likely to be harmful.

High concentrations can build up inside buildings when the source of contamination is located inside and/or when there isn't enough ventilation (air flow and renewal). Physical conditions inside a building, like temperature and humidity, can also impact air quality by providing ideal conditions for the development of some contaminants.

What kind of contaminants do you think can be found in a building?

Pollutants

Contaminants inside a building can be chemical or biological. Many of the contaminants that impact IAQ are naturally occurring, but others are produced by products we bring inside or things we do in everyday living, like cooking and heating. There are hundreds of organisms, chemicals and gases which can cause indoor air quality problems, but they all tend to fall into one of 5 categories.

Radon

Radon is a colourless, odourless, radioactive gas that is given off in the natural breakdown of uranium. It can be found in high concentrations where soils and rocks contain uranium, granite, shale, phosphate or the by-products of uranium or phosphate mining. Radon gas moves up through small spaces in soil and rock, and can enter homes through dirt floors, foundation cracks and other small openings to the ground.

Prolonged exposure to Radon can lead to increased risk of lung cancer, but radon is only a health risk in poorly ventilated, confined spaces where it can accumulate. A Health Canada survey showed that radon levels in certain areas of the country were higher than in others. However, the survey also showed that it is impossible to predict whether any one house will have a high level of radon. Radon testing kits are available for home owners in high risk areas.

Volatile Organic Compounds

Many of the household products we use for cleaning, disinfecting, and hobbies contain volatile organic chemicals (VOC). They are called "volatile" because the chemicals evapourate easily at normal air pressures and temperatures. So, when you use paint, disinfectant, air freshener or even nail polish remover you are releasing pollutants into the air. VOCs are also founding building materials like press wood and carpeting. They cause the "new smell" in newly built homes and cars.

How many of these products do you have in your house?

Gasoline produces a VOC called benzene which is known to cause cancer. Benzene often gets inside a building through an attached garage or when motors are brought inside for repairs and tune-ups.

Biological contaminants

Biological contaminants that can impact IAQ include mold, mildew, animal dander, dust mites and pollen. These naturally occurring organisms may cause allergic reactions or respiratory disease when present in large concentrations.

Mold is a form of fungi, like mushrooms. How do you think mold can grow indoors?

Combustion products

Combustion products are gases given off by the process of burning. They include carbon monoxide, carbon dioxide and nitrogen dioxide. In the home combustion products usually come from burning kerosene, gasoline, heating oil or wood.

Can you think of any other product that is often burned in the home?

It is very important that any kind of wood or gas burning heater, stove or fireplace is properly vented to the outside of the house because some combustion products, particularly carbon monoxide, are very dangerous, even in low concentrations.

Respirable particles

Respirable particles are tiny, lightweight, air-borne particles which can be inhaled. They include dust, pet dander, ash, lead and asbestos fibres. Respirable particles can cause irritation or disease of the respiratory tract. They are especially aggravating for people with asthma.

Health effects

The health effects of poor IAQ depend on the type of pollutant, the concentration of the pollutant in the air and (generally) the length of time a person is exposed to the pollutant.

Who do you think suffers the most from poor IAQ?

CO_2 levels aren't usually a problem in homes. They can be a problem in schools, offices and other buildings where many people work and breathe in the same space.

People give exhale carbon dioxide when they breathe. One common IAQ problem is the build up of carbon dioxide concentration due to poor ventilation and air flow. The result may be building occupants with dry, itchy eyes, sore throats, and fatigue. These symptoms will disappear very quickly after they leave the building. Some VOCs cause similar problems. Again, the symptoms will disappear quickly once a person moves away from the source of the problem.

Other health impacts are more severe. While prolonged exposure to radon and benzene may increase the chance of cancer, there are no clear statistics about how many people will actually develop cancer because of this kind of exposure. More serious are the health impacts of molds and other irritants, especially for people who already have respiratory diseases such as asthma. Molds are a type of fungi, like mushrooms. They occur naturally, and usually grow in warm, damp places. In homes they will often take hold in bathrooms or kitchens, places where moisture occurs in daily activities. Exposure to molds can cause some types of pneumonia or chronic bronchitis.

Mold and First Nations housing

Mold has been identified as a particular problem in First Nations housing. In many communities there is a lack of affordable housing, and so many people may end up living together. According to Indian and Northern Affairs Canada (INAC) about 11 percent of homes in First Nations communities are overcrowded, compared to 1 percent elsewhere in Canada.

When over crowding is combined with inadequate ventilation, smoking, and poor construction or maintenance, the result is often poor indoor air quality and the growth of harmful molds. Mold growth also increases in areas which receive a lot of rain or frequent flooding. INAC, Health Canada, the Assembly of First Nation (AFN) and the Canada Mortgage and Housing Corporation (CMHC) are working together to clean up current mold problems and minimize future mold problems.

Mold will grow just about anywhere, but likes warm, damp environments best. In the left hand photo, mold has started growing on water-damaged gyprock. In the right hand photo, it is growing in wet ceiling tiles. Mold can even grow in hidden places, like behind wall paper.

Source: US EPA

Identifying IAQ problems

Air is transparent.
How do you know when there is an IAQ problem?

A few IAQ problems can be identified visually. For instance, mold growth can be seen as gray-ish, brownish patches on materials like ceiling tiles, on wood or gyprock (although sometimes it is hidden in the spaces between inside and outside walls). Excessive dust is also easy to spot, as is smoke from poorly vented fireplaces. Most IAQ problems, however, are harder to see.

Air is transparent, and so are most of the gases, and chemicals that contribute to poor IAQ. The first signs of a problem are usually headache, dry or itchy eyes, stuffy nose, sore throat and fatigue in occupants; the same type of symptoms people get when they are catching a cold or the flu. The difference is that these symptoms will persist only as long as a person is in the building, they usually disappear quickly when the person goes outside.

Those who design, provide, build, maintain and occupy indoor environments have a duty to do no harm to indoor air quality in that environment.

- WHO
The Right to Healthy Indoor Air
May 15-17, 2000
The Netherlands

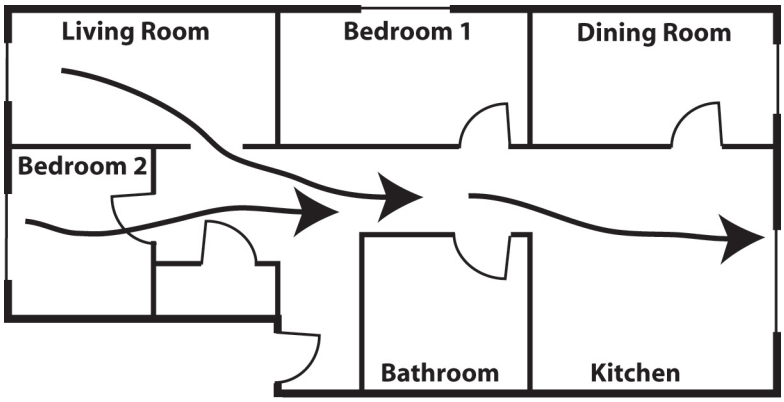
Sometimes a bad or unpleasant smell will be an indication that there is a problem with IAQ.

Building engineers, who study and work to improve IAQ, look at the chemical, biological and physical characteristics of indoor air. They work to fix existing problems. More importantly they work in the planning of new buildings, so that IAQ problems don't become an issue. If a building does have IAQ problems, there are several ways to make improvements.

The first thing an engineer has to do is identify the source of the problem. Is there too much carbon dioxide? Too much dust or pet dander? Is radon or carbon monoxide leaking into a house? In cases where the cause isn't obvious, engineers will use air sampling equipment that lets them test for different contaminants. The tests will also tell them how much of a contaminant is present.

In trying to identify the cause of IAQ problems, engineers will also check building ventilation and air flow. Some of the things they will look at include:

- how much fresh air is available and how it flows through the building,
- if air handling equipment like filters and air conditioning systems are clean and working properly,
- whether there are stagnant air zones being caused by building construction. Sometimes the way a building is constructed traps air in certain place.



In this building, the windows in the living room, bedroom 2 and kitchen are usually open. Air flows through the building as shown. The air in bedroom 1 and the dining room may become stagnant because they are not in the main air flow path. Opening windows and doors in these rooms will help. The bathroom is also a stagnant zone, but it has no window. A fan should be installed to circulate air and keep humidity down.

Solutions

Once the source of the problem is identified, solutions can be examined. While engineers have ways to deal with certain problems, each building is unique, and so each solution is also unique. In general, however:

- Foundation cracks can be sealed to stop radon from getting into a house.
- Polluted outdoor air can filtered so that much less dust, pollen, or car exhaust gets inside.
- Indoor mold can be cleaned up by removal and replacement or disinfecting of contaminated materials.
- Fans and dehumidifiers can be installed to control moisture and help air flow.

In other situations there is no alternative except to remove the source of contamination. Chemical sources such as paint cans, oil cans, cleaners, engine parts etc. should always be removed to storage cupboards, sheds or garages. Pets who are causing allergies and asthma should be kept outside, or at the very least, out of bedrooms.

Ventilation, ventilation, ventilation

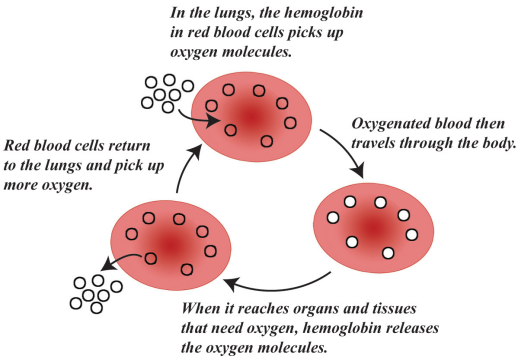
In many cases increasing ventilation, by throwing open the windows or mechanically bringing more fresh air indoors will works wonders. For instance, building materials, carpeting, paint, carpet glue and furniture will give of most of their VOCs when they are new, increased ventilation clears the VOCS more quickly. More fresh air will also ensure no excessive build up of respiratory gasses like carbon dioxide.

When might it be difficult to bring more fresh air into a building?

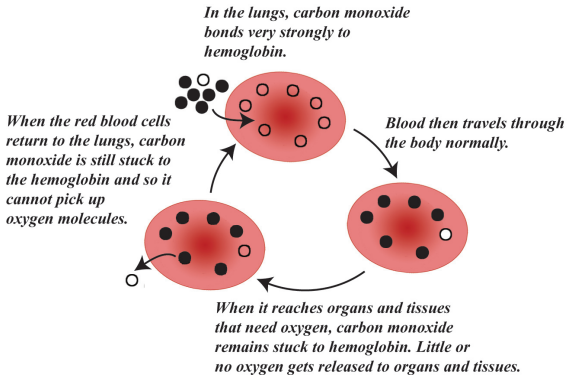
Good ventilation is especially important in homes and buildings with fireplaces, wood-burning or kerosene stoves, oil heaters, gas ovens and attached garages. Carbon-based fuels provide lots of heat and energy, but also give off carbon monoxide. In the air, carbon monoxide is a colourless, odourless gas. It is also extremely dangerous. It enters the body through breathing, and bonds very strongly with hemoglobin, the oxygen receptors on red blood cells.

Hemoglobin is the part of blood that carries oxygen to all the organs of the body. Oxygen bonds very loosely with hemoglobin. When blood travels to a part of the body which needs oxygen, the hemoglobin releases oxygen easily. Carbon monoxide, on the other hand, sticks to the hemoglobin and does not get easily released. So, if a person breathes carbon monoxide for an extended period of time, eventually all the oxygen carrying capacity of his or her blood is taken up by carbon monoxide. This leads to sleepiness, headache, and, if the person doesn't get fresh air, death. Carbon monoxide poisoning usually occurs in winter, when people seal there homes tightly to keep warm.

Breathing regular air



Breathing air with high concentrations of CO



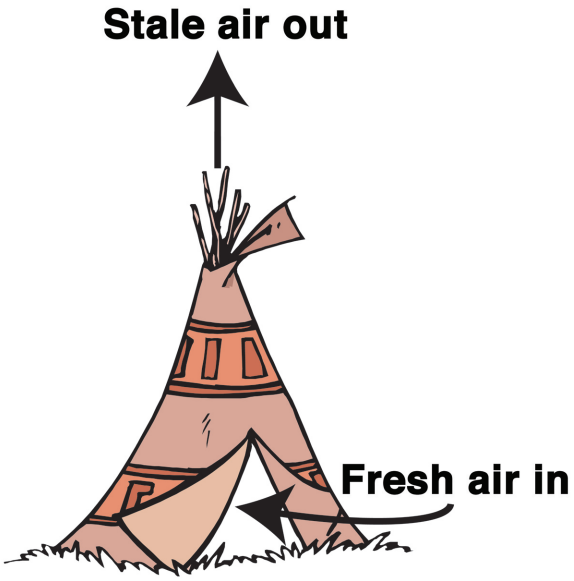
Fire pits were common in many types of traditional housing.
How did Aboriginal peoples make sure that indoor fires did not harm building occupants?

Aboriginal engineers, traditional housing and the stack effect

Aboriginal engineers have understood the importance of ventilation for thousands of years. Many traditional types of housing - iglus, longhouses, tipis etc. – contained fire pits for cooking. These same houses had openings built into the roof of the structure. They also had door openings at or near ground level.

Which is heavier, hot or cold air?

Hot air is less dense, and therefore lighter than cold air. Hot air therefore rises to the top of any closed room. If there is an opening high in the room (or building) and another low in the room (or building), a natural flow occurs. Hot air rises and is vented out of the top opening, while being replaced with cooler air which enters from outside through the lower opening. Scientists refer to this phenomenom as the Stack Effect. Aboriginal engineers used the stack effect to make sure IAQ remained safe in traditional structures.



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Connecting to Math

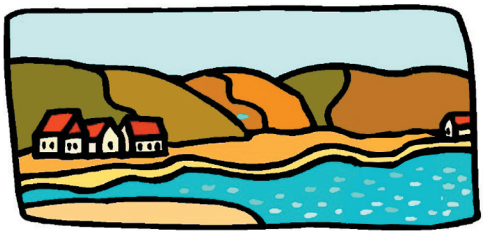
1. You are the town's Building Engineer. The Council Office Manager calls you one morning with a problem. Council meetings have been running long, and she has noticed that people tend to get sleepy somewhere between the third and fourth hour. She tells you there are between 35 and 50 people at each meeting – usually more than less – and asks you to check the fresh air supply in the room.

   You suspect that there might be a build up of carbon dioxide in the room over time, You go to your ASHRAE Handbook and find out that meeting rooms need 566 litres of fresh air per minute per person in the room. You then use monitoring equipment to see how much fresh air is actually getting into the room. You equipment tells you that 1,500,000 litres of fresh air enters the room each hour.

   a) Is this enough air for the number of people at the meetings?
   b) How many people can comfortably use the room?

2. Your town is right by a river that floods every 3-5 years. There are 644 houses in town. Since the last flood, 48 new homes have been built using mold resistant methods and materials. You know about 15% of the older houses are suffering from mold problems and need to be fixed. The repairs will cost about $2400 per house. You are meeting with Chief and Council this evening to discuss the project.

   a) Approximately how many homes will require repairs?
   b) How much do you tell Chief and Council the repairs will cost?



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