INDOOR AIR POLLUTION

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INTRODUCTION

The mention of indoor air pollution often provokes reaction of disbelief or humour or both. Although many questions remain to be answered, scientists are becoming increasingly convinced that indoor air pollution is a serious health problem The existence of this problem have been recognized since early 1970s.

INDOOR AIR POLLUTANTS

The indoor air pollutants currently being studied are:

- 1. Radon and its decay;
- 2. Chemical products of combustion such as nitrogen oxides and carbon monoxide;
- 3. Formaldehyde;
- 4. Asbestos;
- 5. Residues from consumer products;
- 6. Allergens (substances inducing an allergic state or reaction) and micro-organisms; and
- 7. Tobacco smoke.

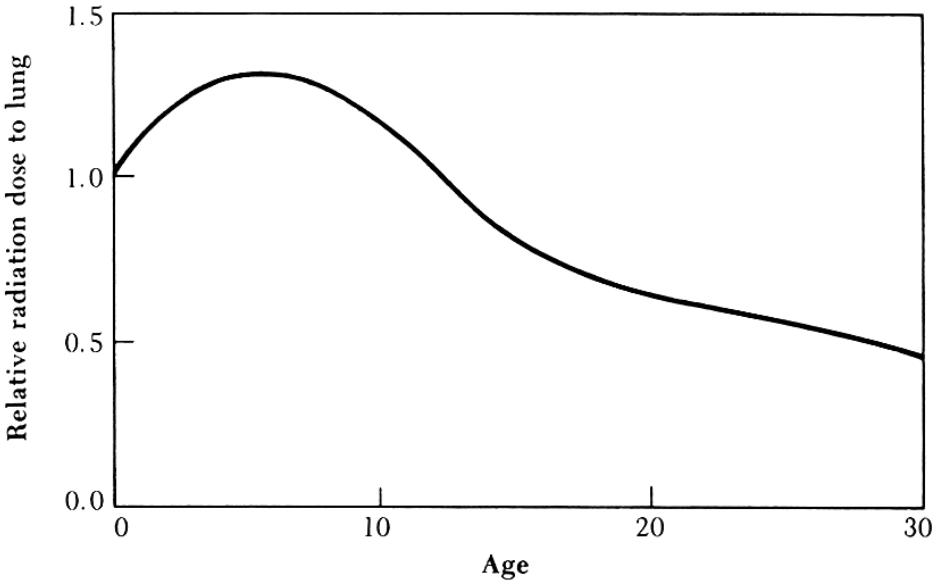
These pollutants can cause:

- 1. Respiratory diseases;
- 2. Cancer; and
- 3. even Death.

While many of these pollutants are found in offices, factories, and office buildings, for our purpose we define "indoor air pollution" as pollution that is found within residential buildings at levels that affect human health.

Indoor air pollution may, in fact, pose an even greater threat to health than outdoor air pollution. Contrary to common assumption, air pollutant concentrations behind the closed doors of homes and other buildings are often higher than corresponding concentrations outdoors. This is particularly true of pollutants such as formaldehyde that are released primarily indoors, but it can also be true of pollutants such as nitrogen oxides that are released both indoors and outdoors.

Primarily most people spend most of their time indoors, hence even if pollutant concentrations in some cases are lower indoors than outdoors, indoor exposures are more prolonged and frequent. Consequently, health effects are more severe. Although indoor air pollution affects all groups of people, it particularly threatens the young, the old, and the ill. These groups are both more susceptible to the effects of pollution and more likely to be indoors. Children are affected the most by the amount of radiation from outside air reaching their lungs, mainly because the shape of a child's lung is very different from that of an adult. In addition, children's breathing patterns are different from those of adults. The crying of a newborn or the attempts of a baby to crawl are hard work. The figure bellow shows the relative doses to the lung (from the same amount of radon in the air) for children and adults. From example, the radiation dose to a five-year-old child's bronchial tree is almost three times the dose to an adult breathing in the same amount of radon.



The relative radiation dose deposited in the lungs of people of different ages, breathing in the same amount of radon daughter products. The different shape of children's lungs results in children receiving a higher radiation dose than do adults.

Secondly, indoor air pollution may be becoming worse because of certain recent initiatives to conserve energy. One common method is to make buildings more energy-efficient to "weatherize" them by sealing them off, as tightly as possible, from the outside. One experimental energy-efficient house, for example, has been described as a "veritable (actual) fortress against the loss of energy. There are leakproof triple-glazed windows, a weather-stripped magnetically sealed front door, and plastic sheets in the walls, floors, and ceilings that keep the home's living space as airtight as the inside of a sandwich bag".

Weatherization reduces the ventilation rate - the rate at which outdoor air replaces indoor air. In conventional homes, for example, outdoor air replaces the entire volume of indoor air about once every hour. In some energy-efficient homes, however, outdoor air replaces indoor air only about once every five hours. Preliminary research suggests that concentrations of at least some indoor air pollutants vary proportionately with the ventilation rate; thus, decreasing the ventilation rate by a factor of five may increase concentrations of indoor air pollutants by the same factor. Because of these increased concentrations, the current trend towards sealing off homes to conserve energy may have serious health consequences.

What Are the Air Pollutants?

(1) Radon and its Decay Products

Radon is a radioactive gas that occurs naturally at trace levels. Like any radioactive element, its nuclear structure is unstable, and hence, it undergoes radioactive decay. Radioactive decay is the process by which a nucleus undergoes spontaneous transformation into a different nucleus or into different energy state of the same nucleus. The process results in a decrease, with time, of the number of the original radioactive atoms in a sample. It involves the emission from the nucleus of alpha particles (positively charged nuclei of Helium), beta particles (electrons), or gamma rays (very short wavelength electromagnetic waves).

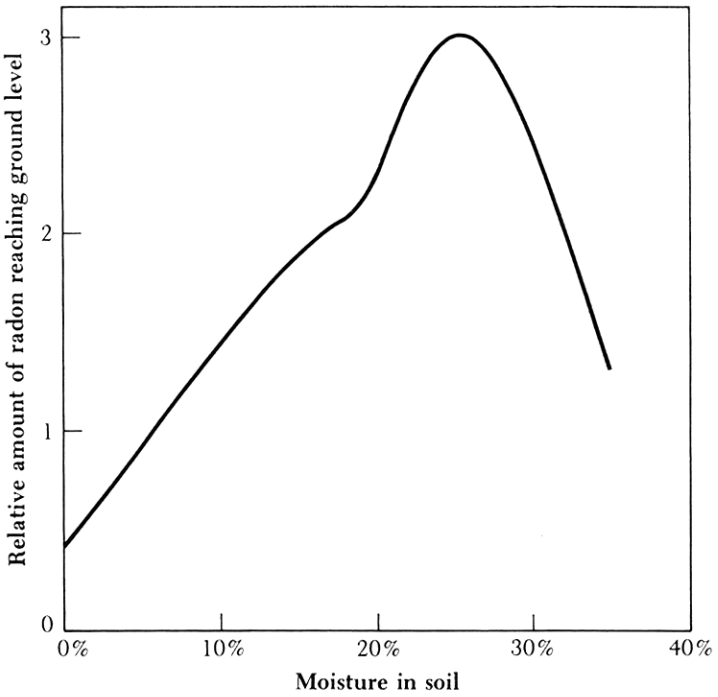
Some of the many forms of radon, ranging from Radon-198 to Radon-227, exist only for fractions of a second. Radon-222 and Radon-227 are formed as intermediate products of the decay series.

Radon-222 is not itself hazardous it does not spend enough time in the lung, to decay and emit alpha particle. Its daughter products, Polonium-218 and Polonium-214, attach themselves to dust particles (aerosols) that may be inhaled and settled on the surface of the lung. The alpha particles emitted by Polonium-218 and Polonium-214 may damage radiation-sensitive cells near the surface of the lung, causing DNA damage, which can lead to cancer.

Radon-220 atoms have half-life of less than a minute, which is not enough time for them to escape from the ground in large quantities. The danger from Radon-220 is probably much lower than that from Radon-222.

There are several sources of radon found within homes:

- 1. Radon is present in most homes and may seep into homes from below. It can diffuse, both directly through the foundation and through cracks or penetrations in the foundations;



The amount of radon gas emerging from the ground changes as the soil gets wetter. When the soil dampens, the amount of radon reaching the surface goes up, but if the soil is very wet, much less radon reaches the ground.

- 2. Radon also may be present in the several tons of concrete and brick used to build homes, because these materials are made from rock and soil.
- 3. Both water and natural gas used in the house may contain radon if they pass through underground areas that contain the element. Even if the soil in one area is not rich in radon, groundwater flowing through the soil can carry radon with it from adjacent areas. High level of radon is water have been correlated with indoor levels of the substance.
- 4. Homes with certain type of solar heating systems may manifest elevated radon concentrations because the rocks used to store heat in such systems contain and emit radon. Radiation exposures from radon indoors are in addition to radiation exposures outdoors, in the workplace, and from substances within the body. Our bodies contain radioactive material e.g. K40 and C14.

Houses built over phosphate deposits or uranium mill tailings have significantly higher radon concentrations than houses in other areas.

Radon concentrations can be two to five times higher in energy-efficient homes than in conventional homes. The cause of these increased radon concentrations appears to be decreased ventilation rates.

Although radon levels are higher in the basement and groundfloor levels of apartment buildings, no clear relationship has been found between levels of radon and its daughter products and height above the first floor. Thus, apartments dwellers on the tenth floor of a building are not necessarily exposed to lower concentration of radon than are those on the third floor.

Because radon occurs naturally in the soil, it is not possible to ban radon or to ban products containing radon. There are, however, several ways to control indoor exposure to radon.

- 1. Reduce radon levels in building materials.
- 2. Seal building materials from which radon emanates.
- 3. Use air filters or other means to remove radon from indoor air.
- 4. Mixing indoor air to facilitate deposition of the radon decay products on solid substances and introducing charged ions into the air to link up with radon decay products, thereby removing them from the atmosphere.
- 5. Diluting indoor air with air from outside can appreciably reduce indoor radon levels.

(2) Products of Combustion

Combustion generates:

- 1. Carbon monoxide (CO);
- 2. Nitrogen oxides (NOx) and other gaseous pollutants;
- 3. Particulates.

The above overall pollutants are produced within the home by combustion in gas stoves, waterheaters, heating furnaces, kerosene space heaters, wood stoves, gas clothes dryers, wood stoves, fireplaces, and garages adjoining or underneath the living area.

Carbon monoxide, when inhaled, binds with hemoglobin in the blood, blocking the distribution of oxygen to the body's cells. If enough CO is inhaled, suffocation results. Because CO builds up in the blood, prolonged exposure at low concentrations may also have health effects, such as decreased stamina and coordination.

Nitrogen oxides also bind with hemoglobin, producing effects similar to those CO. Exposures to NO2 may impair breathing, damage airways and tissue, and lead to chronic bronchitis and emphysema. Nitrogen oxides may also have behaviourial and psychological effects, such as lengthening reaction times or causing depression. Carbon monoxide and nitrogen oxides may affect the young, the old, and the sick more severely than other groups.

There are several ways to control concentrations of combustion products in residential buildings:

- 1. Remove sources of combustion products;
- 2. Complete elimination of gas stoves;
- 3. Design sources of combustion products to operate more efficiently so that they create less pollution;
- 4. Increase general ventilation;
- 5. Direct ventilation of individual combustion sources can serve to reduce both overall levels and peak concentrations.

(3) Formaldehydes

Formadehydes, H2C=O, is both, a byproduct of combustion and a widely used chemical present in many manufactured products. It is a serious respiratory and skin irritant, and perhaps a carcinogen. The main sources of formaldehyde in indoor air appear to be:

- 1. Urea formaldehyde insulation;
- 2. Particleboard (synthetic resins);
- 3. Plywood (synthetic resins);
- 4. Released by combustion appliances, cigarettes, paper products, floor covering, textiles, disinfectants, toothpastes, shampoos, cosmetics, and some medicines.

Formaldehyde is added in some products because it kills bacteria, fungi, and viruses. Studies have shown that indoor concentrations often exceed 1 ppm and even the 3 ppm occupational exposure limit. At levels ranging upwards from 0.05, formaldehyde exposure leads to rashes, irritation of respiratory tract, nausea, headaches, dizziness, lethargy, and aggravation of bronchial asthma. All of these effects appear at lower concentrations in people who have been exposed to the substance for long periods of time.

(4) Asbestos

Asbestos is the name of a group of substances that are:

- 1. Fibrous;
- 2. Flexible;
- 3. Incombustible; and
- 4. Durable.

Asbestos fibers remain airborne for long periods of time, are small enough to be inhaled deep into the lungs, and durable even within human tissue. Asbestos causes several forms of cancer and mesothelioma, yet an estimated 2000 to 3000 products contain asbestos. Many of these products, such as roofing and

flooring materials, textiles, papers, filters and gaskets, cement, pipes, coating materials, and thermal and acoustic insulation, are found in homes. Asbestos found in residences does not present a health problem until the fibers become detached and float freely through air.

Ways to reducing asbestos concentrations in indoor air are:

- 1. Eliminate products containing asbestos from buildings;
- 2. Removing building materials that contain asbestos from existing buildings.
- 3. Limit exposure to asbestos by preventing the disturbance of materials that contain asbestos.

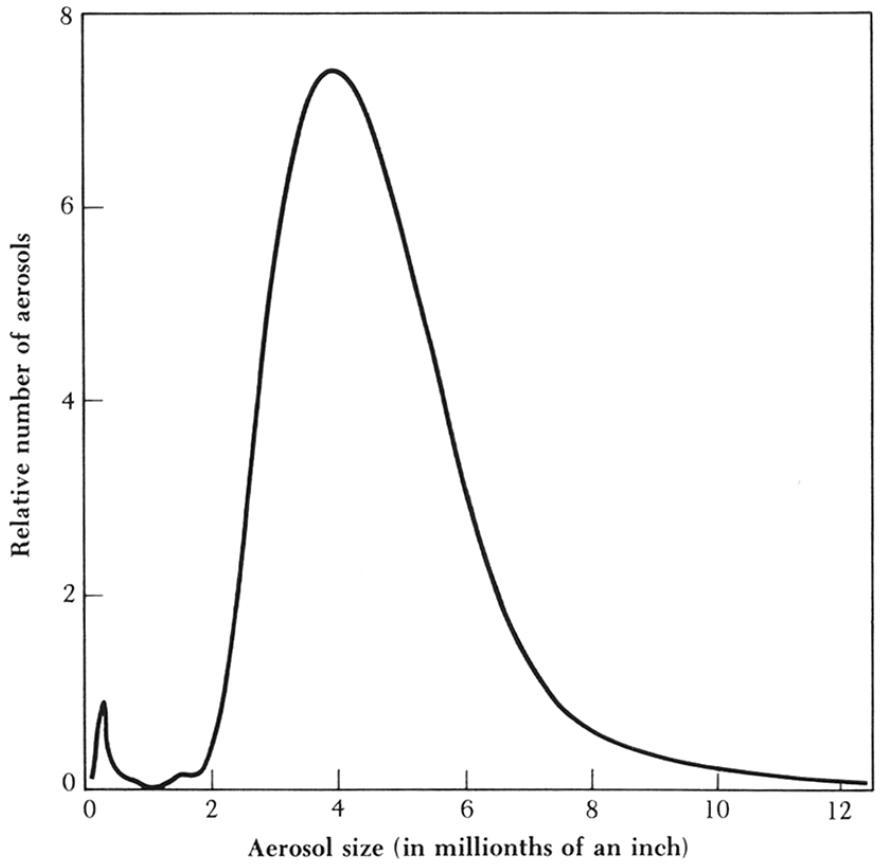
(5) Chemical Fumes and Particles

Many consumer products used in homes release particles or chemical fumes. These fumes and particulates may be trapped indoors and concentrated to the extent that they affect human health. A number of aerosol products found in most homes contain indoor air pollutants. The average contains an estimated 45 aerosol spray products. These aerosol items include:

- 1. Hair spray,
- 2. Frying-pan spray,
- 3. Insect repellant,
- 4. Room freshener,
- 5. Furniture polish,
- 6. Bathroom cleaners, among others.

The active substances in aerosols include:

- 1. Sodium or potassium hydroxide (oven cleaners),
- 2. Ammonium hydroxide (window cleaners),
- 3. Morpholine (furniture polish),
- 4. Tetrachloroethylene (spot removers),
- 5. Toluene,
- 6. Xylene (spot removers),
- 7. Methylchloride (spot removers),
- 8. Pigments (paints),
- 9. Hydrated aluminum chloride (deodorants),
- 10. Vinyl acetate copolymer resins (hair sprays),
- 11. Dichlorvos and chlordane (pesticides),



Relative numbers of different-sized aerosols present in a typical house in New York. Most of the particles are around 4 millionth of an inch, but there is significant number of smaller aerosols.

Aerosol propellants include:

- 1. Dichlorodifluomethane and trichlorofluoromethane, (Commonly known as flurocarbons now banned from consumer products),
- 2. Vinyl chloride (now banned from consumer products),
- 3. Propane,
- 4. Butane,
- 5. Nitrous oxide, and
- 6. Methylene chloride.

Grinding, sanding, cleaning, and other activities also release potentially hazardous chemicals into the air. Plastics, paints, solvents, artificial fiber textiles, cleaners, bleaches, disinfectants, deodorizers, and other substances all emit pollutants either through evaporation or "outpassing" that is, the release of gaseous chemicals from solid substances, such as:

- 1. Methylene chloride from paint remover,
- 2. Mercury compounds in latex paints,
- 3. Various breakdown products from pesticides.

Dust and particles, which may be by-products of hobby and craft materials and processes (for example, lead glazes, solder and flux from stainless glass and jewelry making, and woodworking) are resuspended whenever the area is cleaned.

The health effects of pollutants from consumer products are:

- 1. Respiratory effects,
- 2. Nasal cancer,
- 3. Birth defects.

Product restrictions or bans may be the only way to control the danger created by products that are hazardous even when used properly.

(6) Other Indoor Pollutants

The other air pollutants that threaten the indoor air quality that should be considered are: Airborne bacteria, viruses, and fungi, and ozone.

Many of these microorganisms carry infectious diseases, such as: Influenza, Legionnaire's disease, Tuberculosis, Measles, Mumps, Chicken pox, and Rubella.

Air-cleaning filters, Heat exchangers, humidifying systems, and Air Conditioners, if not properly looked after also cause infections.

If sources of Ozone, such as electrostatic air filters, are located indoors, indoor concentrations of ozone can exceed outdoor concentrations, and may cause respiratory irritation and drowsiness.

Plants that remove toxic chemicals from the air

An interesting study by National Aeronautics and Space Administration (NASA) has shown the ability of indoor plants to remove toxic chemicals from the air.

The study showed that many of the plants we use quite commonly as decorative indoor plants are quite efficient at removing the harmful gases when used in conjunction with activated charcoal in the soil.

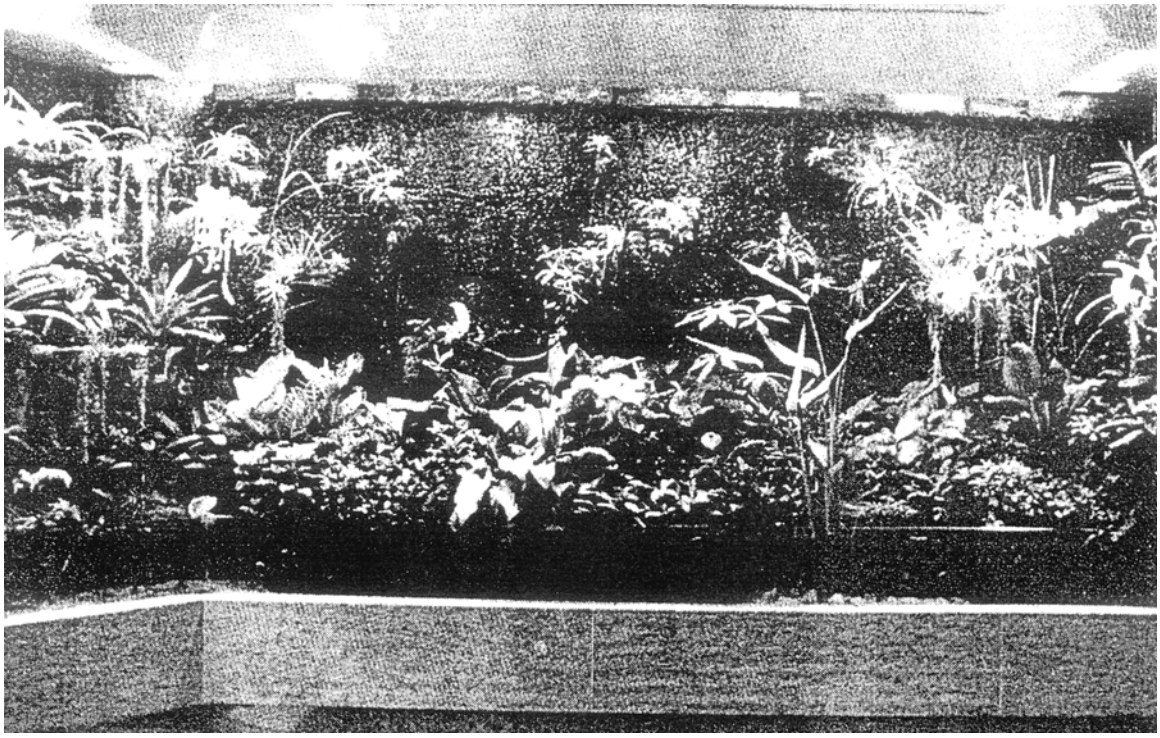
Benzene, for example, a common ingredient in paints, plastics, rubber, inks, and oils was removed quite effectively (from about 50 to 90 per cent) by plants like English ivy, Scindapsus (Pothoc), Chinese evergreen, and Dracaena. Up to 70 per cent of Formaldehyde was removed by similar plants. The third chemical tested was Trichloroethylene. Plants were not as effective in removing this one, ranging from about 9 per cent for scindapsus to 23 per cent for Spathephyllum, the peace lily.

The root-soil zone appears the most efficient area for removal of the toxic, volatile organic chemicals. To quote the authors, :maximising air exposure to the plant root-soil area should be considered when placing plants in buildings for air filtration".

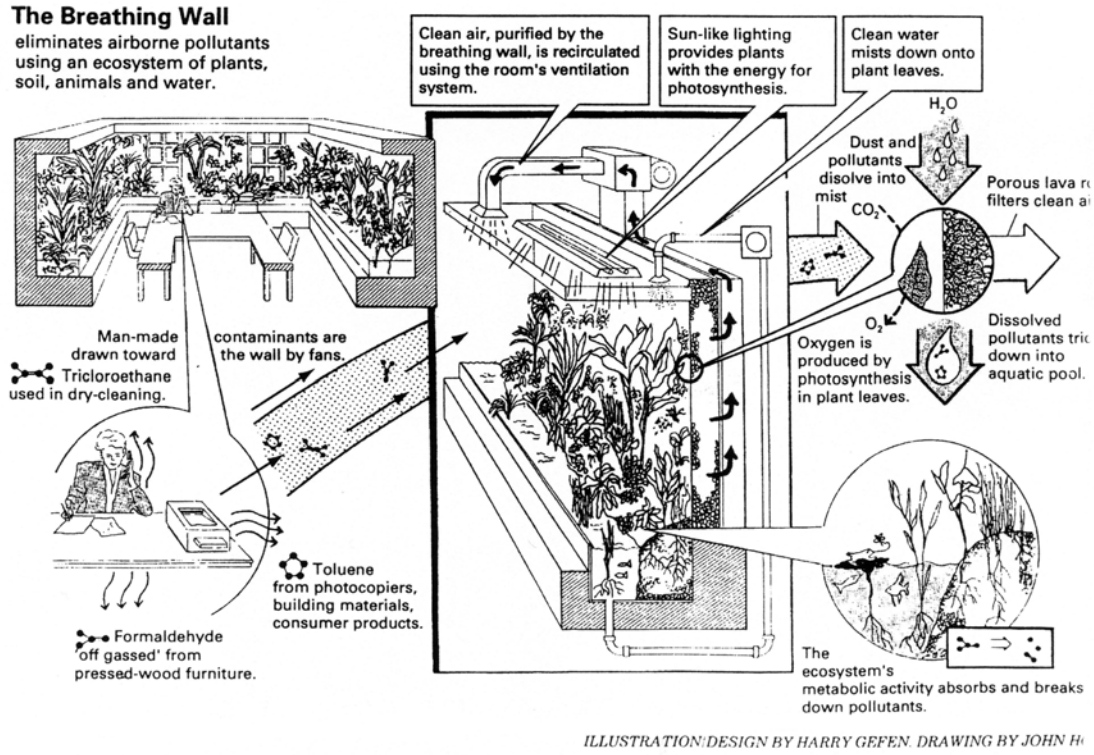
What can be done to diminish health hazards due to indoor pollution?

- 1. Accelerate scientific research and technical research in the area of pollution control.
- 2. Mandatory testing of the quality of indoor air in the private homes and public buildings. This will be one of the basic and important aspect of National Preventive Medicine Plan.
- 3. Citizens should put pressure on regulators to set new regulations and revise the old ones immediately.
- 4. Prohibit altogether or set limits on the manufacture, processing, or distribution of a chemical.
- 5. Prohibit or set limits on the manufacture, processing, or distribution of these substances for certain uses.
- 6. Require manufacturers to label their products or provide instructions for their use.
- 7. Prohibit or regulate "any manner or method of commercial use".
- 8. Require manufacturers to give notice of potential health risks to purchasers or general public, or even to replace or repurchase the substances.
- 9. Order manufacturers to improve quality control standards.
- 10. Make an effort to recycle. Buy products packaged in biodegradable wrapping. Ask for groceries to be bagged in paper.
- 11. Change the lifestyle !
- 12. Use indoor plants to diminish the concentration of toxic gases from the indoor air.

THE FOLLOWING IS A SCHEMATIC DIAGRAM OF AN EXPERIMENT IN A TORONTO OFFICE BUILDING.
Taken from Evelyn Chau's article in The Globe & Mail.



The Breathing Wall is a three-sided surface of vertical lava-rock surface that is home to 800 species of plants, 50 aquatic species in an aquarium and an indeterminate number of insects.



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