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Indoor air polution

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Indoor air pollution has been recognized as a serious health issue. Research has proven that poor air quality in indoor environment can affect us more than the polluted air that we breathe outside. It is a fact that may people spend as much as 90 percent of their time indoors and hence the health risk due to indoor air pollutants is a significant public health concern. The contamination of indoor air can be traced back to biological and non-biological agents within a home, office, or any other indoor environment. It has been estimated that some volatile organic compounds and other agents can reach an indoor level hundreds of times greater than in outdoor air. Inspite of the dangers posed by Indoor air pollution, there is very little awareness regarding the issue.

Indoor air quality refers to the chemical, biological and physical features of air that is present in an indoor environment. Depending on various factors, indoor air quality can be described as good or poor. Deterioration of indoor air quality is due to the contamination of the same by various agents. Indoor air pollution can result from any one of the following:

- Inadequate supply of quality outside air. Contamination arising from sources inside the building (e.g., combustion products including carbon monoxide and tobacco smoke)
- Contamination from outside the building through air intakes, infiltration, open doors, and windows, microbial contamination of ventilation systems or building interiors.

The issue:

The problems associated with indoor air pollution attracts more attention due to the following reasons:

- Use of biomass fuels for cooking in inadequately ventilated indoor environments
- People tend to spend more time indoors and thus the time of exposure is more
- Lack of proper ventilation in homes implies that pollutants concentration can reach dangerous levels
- Low level of awareness on the issue

When compared with pollutants released outside, an indoor air pollutant has more chance of reaching your lungs. It is a foregone conclusion that the chances of Indoor air pollution affecting your health are more than outdoor pollution.

His Excellency Dr. APJ Abdul Kalam, President of India releasing newsletter on “Technologies to Combat Desertification” brought out by ENVIS centre Karnataka on the occasion of World Environment Day on 6 June 2006 at Bangalore.

A baby crawling on the floor inhales the equivalent of 4 cigarettes a day, as a result of the out gassing of carpets, molds, fungi, dust mites, etc: Scientific America

Abhijit Dasgupta I.A.S.,
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Forest, Environment & Ecology Department
Government of Karnataka

26-07-2006

Message

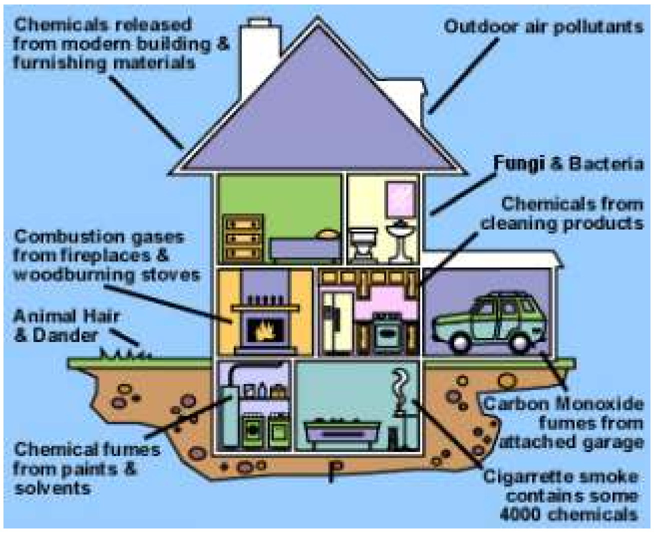
Today "Indoor Air Pollution" is an issue of ever growing interest & concern. Though most people spend a major part of their time indoors, it is the least bothered topic. Case studies in this newsletter substantiate this. There are many reasons for the problems caused by Indoor Air Quality including day to day activities inappropriately done in the areas of sanitation, cooking, paints, pollen grains etc.,. The causes thus vary from non-biological to biological agents. Indoor Air Quality being a major issue in dwellings and offices, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) provide standard design constraints for a building. Unfortunately this is little known in our country and thus not followed.

Seeking appropriate solutions to this problem is the responsibility of every individual citizen. A sum total of every individual's contribution to identify & address the problem would Synergise a social movement, which would cohesively improve our future quality of life. Thus every one should beware of the adverse effects caused by Indoor Air Pollution. The approach in this newsletter is an early attempt to do so and hence need be applauded. I believe that the reader would find sufficient information in this area of concern which if addressed would make our environment a better place. Let's join the movement.

(Abhijit Dasgupta)
Principal Secretary to Government
Forest, Ecology & Environment Department

The sources

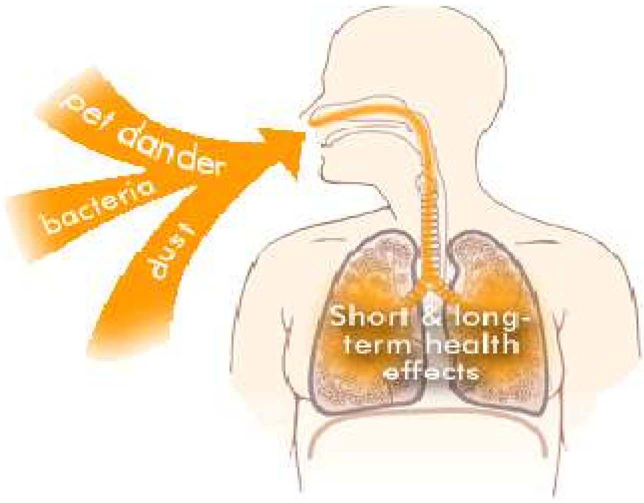
Sources of indoor pollution vary in rural and urban areas. In the former, the contaminants are derived from activities like cooking indoors using bio-mass fuels such as wood and dung. Key pollutants in the urban areas include nitrogen dioxide, carbon monoxide and formaldehyde (from insulation), asbestos, mercury, man-made mineral fibres, personal care products, volatile organic compounds, allergens and tobacco smoke and organisms like bacteria. Due to the increase in air conditioned buildings in India, the level of natural ventilation has come down significantly. Most often, the same pollutants are recirculated indefinitely in buildings and homes.



Sources of indoor air pollution in homes

Agents of Indoor air pollution can be classified into two categories viz., biological and non biological.

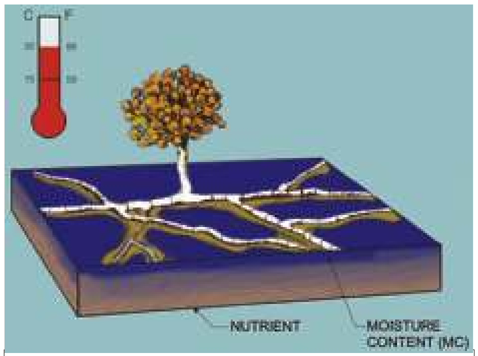
Biological agents: the most prevalent biological forms found in indoor air include viruses, bacteria, fungi, amoebae, algae, pollen grains, dust mites, insects and human and animal dander. Majority of the bacteria encountered in the indoor environment originate from humans. Most fungi and pollens however enter the home through windows and doors from the outdoor air or are brought in via clothing. Understanding the entry routes for biological agents is essential in preventing Indoor air pollution. The following are the common biological agents found in indoor environment:



Viruses and Bacteria: many viruses and bacteria are transmitted with respiratory exhalation. Endotoxins from certain bacteria have been found to contaminate ventilation systems and air-conditioning systems. A toxin produced by them cause upper respiratory inflammation or pneumonitis. In general, the environmental remedy most often chosen to reduce health effects from bacterial contaminants are the same as for dampness in general, plus attention to standing water in humidifying and air conditioning systems.

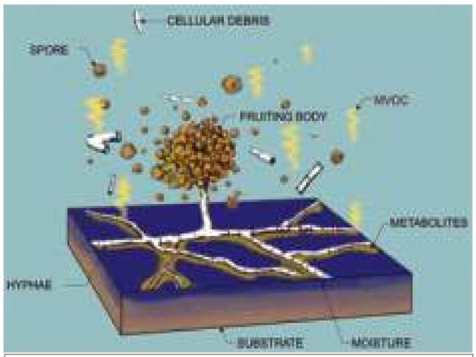
Actinomycosis is an inflammatory bacterial disease of cattle and other animals, sometimes caught by humans; it causes swelling of the abdomen, chest, jaw and symptoms of allergy. This disease is common in many areas with high humidity and in buildings which are air-conditioned or which have humidifying systems. This fungal-like bacterium also causes a non-allergic hypersensitivity pneumonitis

Fungi: Warm indoor environment with humidity greater than 50% is optimum for indoor fungi growth. Fungal colonies can be identified by appearance of dark blanket like growth in damp areas. They may cause true allergy reactions, and a type of toxin released by them known as mycotoxins are believed to have independent toxicity. Fungi thrive in damp, dark surroundings below room temperature. Usual sources of additional moisture such as kitchens and bathrooms have increased mold growth. Fungal spores such as Aspergillus released into air following repairs of old ceilings and wallpapers can pose a risk to certain immuno-compromised individuals. Fungal growth is also associated with production of foul odours, mycotoxins and volatile organic compounds that affect the air quality.



Fungi need a nutrient source, proper temperature and water to grow
Source: www.ebdg.org

Fungi release spores which are carried by winds and accumulate in indoor environment. These spores can cause allergic reaction when inhaled by human beings. Fungi population increases during the monsoon months and during the early months of winter. The best way of dealing with fungi is to control its growth. In addition to improving air circulation, a solution of 1 cup bleaching powder mixed in three 3 litres of water should be used to clean damp areas showing fungal growth.



Fungi gives off spores, cellular debris and MVOCs
Source: www.ebdg.org

During metabolism mold and bacteria create microbiological volatile organic compounds (MVOCs). These are organic compounds that are in a gaseous state within the air of a building. Because they are in this gaseous state they can quickly disseminate throughout a building, even through building components such as wall assemblies. Many of these compounds have a low odor threshold and produce a musty or putrid odor that is quickly detected by occupants. MVOCs from mold and bacteria are obnoxious and can cause complaints about indoor air quality even in low concentrations. However, these appear to be mostly nuisance compounds and are not well linked to actual health effects.

Mold releases spores into the air as a means of reproduction. In addition cellular debris, such as cell wall material, can be released into the building environment from amplification sites. Spores and cellular debris are micro-particulates and, as such, can remain airborne for considerable periods of time traveling freely through tiny cracks, crevices, and holes in building walls, and roofs. Spores, and cellular debris from mold, are allergens and result in reports of symptoms, i.e. itchy eyes, runny noses, headaches, and fatigue. The responses to these allergens differ from person to person so that neighboring building occupants may report very different reactions to mold amplification. Cellular debris from bacteria contains endotoxins which can produce allergic symptoms. At high levels, this material is an irritant and can produce flu-like symptoms. Spores and cellular debris can remain an indoor air quality problem even after active growth of an amplification site is corrected.

Mold and bacteria both produce toxins as by products of metabolism. Some molds, under some circumstances, produce mycotoxins. Bacteria can produce Exotoxins, which are secreted in the environment and endotoxins, as part of cell walls. Some of these are powerful toxins. In general, these compounds consist of large organic molecules that do not diffuse through the air in the same manner as MVOCs. They are found in the air when carried by contaminated dust, debris, spores, or cellular material. This means that exposure to these toxins are most likely when an amplification site is disturbed. Adverse health reactions to mycotoxins from molds such as Stachybotrys Chartarum, have been suspected in buildings with extensive mold growth, but so far have not been documented as a health problem in buildings.

Dust mites: A tiny eight-legged creature related to spiders and ticks. Some mites live freely and some as parasites that can carry disease, attack plants, and cause human allergies. They are too tiny to be visible to the naked eye. Dust mites of 11 species from five different genera may be found indoors. The highest levels are often found in mattresses and pillows, within house dust, and within ventilation systems. Optimum mite growth is seen in climates with average daily temperature between 22-26 degrees Centigrade (72-78 Fahrenheit) and 75+% humidity. Humidity below 50% prevents mite reproduction and reduces mite growth. In order to control mite growth, sprinkle tannic acid and benzyl benzoate powder, which can be purchased from your drugstore, on carpets and furniture.

Pets: Pets including birds, dogs and cats have feathers and dander; excrete proteins in their saliva, urine, and feces that can cause allergy. They may also release other biologic organisms with respiration. Cryptococcus is a fungus that resembles a yeast and causes cryptococcosis. This fungus is transmitted via pigeon droppings and the association of pigeons with high-rise building air-intake vents. Insects like cockroaches and spiders are also responsible for causing allergy in humans.

Pollen: It is a powdery substance produced by flowering plants that contain male reproductive cells. It is carried by wind and insects to other plants, which it fertilizes. Pollens are often a seasonal phenomenon and are often produced in certain months. Pollen from plants like parthenium is known to cause allergy.

Nonbiological Agents

The most important non-biological substances include:

Respirable particles: Fireplaces, wood and coal stoves, unvented kerosene heaters and environmental tobacco smoke are the main source of respirable particles. Many standards exist for particulates. These standards are changing rapidly as the smallest particles have recently been shown to be significantly associated with acute and chronic respiratory illness, pulmonary hypertension, systemic hypertension, and even hospital admission rates for respiratory illnesses.

CO, CO_2, NO, No_2 :The most common sources of the agents are gas stoves, kerosene lanterns on any gas appliance, kerosene stoves and heaters, gasoline engines, some gas furnaces, and environmental tobacco smoke. 25-75 parts per billion of NO and NO_2 is a normal range for homes with gas stoves. Peak values in kitchens with gas stoves may reach 500ppb during meal time. The WHO safety standard is 160ppb per I hour maximum exposure to No_2. A study by the National Institute of Occupational Health, (NIOH), Ahmedabad reported indoor air CO levels of 144,156, 94, 108 and 14 mg/m^3 air during cooking by dung, wood, coal, kerosene and LPG respectively.

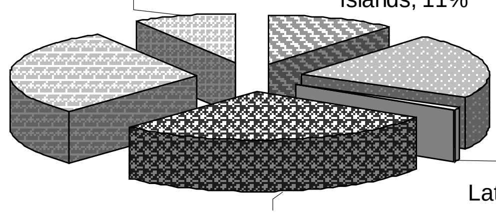
Tobacco smoke, kerosene lanterns and gas stoves and geysers are also important sources of CO. At low levels, inhalation of CO causes fatigue and provokes chest pain in people with ischemic heart disease. High concentrations may impair vision, disturb coordination, cause headaches, dizziness, confusion and nausea. The average level of CO in homes without gas stoves is 0.5-5.0 ppm.

Formaldehyde: Formaldehyde is a volatile organic compound present in urea-formaldehyde foam insulation, glues, adhesives, fiberboard, pressed board, plywood, particle board, carpet backing, and fabrics. Patel and Raiyani measured levels of formaldehyde in indoor environment during cooking by different fuels. The formaldehyde mean levels were 670, 652, 109, 112and 68 µg/m3 of air for cattle dung, wood, coal, kerosene and LPG respectively.. Exposure to high concentrations causes irritation of the eyes and throat, nausea, and difficulty breathing.

"As many as 1.6 million people die every year because more than two billion people in developing countries lack the modern fuels and electricity that help prevent indoor air pollution and its negative health effects...."
Source: UN-Energy, 2005

Freon: the leakage of freon from refrigerators and air conditioning systems is particularly noxious because phosgene gas is generated at ignition points such as electric arcs, cigarettes, kerosene lanterns and candles.

Deaths due to indoor air pollution



Source: ESMAP,World Bank 2000

Asbestos: This has been well studied and well documented to cause respiratory illness. Deteriorating insulation and asbestos plaster are the main sources. Generally, there's no cause for concern being around these products as long as they're in good condition and you don't disturb them or cause them to disintegrate. It's when they are damaged that there's a danger of asbestos fibers being released into the air. If you need repair or removal of an asbestos product, it's best to have it done by a professional. Any and all of these agents can act independently or in numerous combinations to cause or exacerbate respiratory symptoms.

Cooking

Cooking with poorly or improperly designed stoves emit several serious pollutants such as carbon monoxide (CO), methane (CH_4), particulates and other products of incomplete combustion (PIC). While at a global scale these can contribute to global warming, at local scale they cause direct health problems. Women are generally the ones taking care of cooking, so they and their young children can be exposed to smoke for many hours.

Approximately half the world's population and up to 90% of rural households in developing countries still rely on unprocessed biomass fuels such as wood, dung and crop residues. A recent report of the World Health Organization (WHO) asserts the rule of 1000 which states that a pollutant released indoors is one thousand times more likely to reach people's lung than a pollutant released outdoors. It has been estimated that about half a million women and children die each year from indoor air pollution in India. Compared to other countries, India has among the largest burden of disease due to the use of inefficient cooking stoves. It is known fact that it is in this context that the Government has been making a concerted effort during the past two decades to promote 'ASTRA OLEs', Smokeless Chulhas and energy efficient stoves in the rural areas.

Some key findings of Indoor air pollution studies

Exposure to biomass smoke increases the risk of acute respiratory infection (chest infection, coughs, cold and middle ear infections). Children in the Gambia Island found riding on their mother's back, during cooking over smoky stoves were more likely to develop Acute Respiratory Infection (ARI) then unexposed children.

A study in Tanzania reported that the children below five years age died of ARI, were more likely to sleep in a room with an open cook stove than healthy children in the same age group.

Studies in India and Nepal show that non-smoking women who have cooked on biomass stoves exhibit a higher prevalence of chronic lung disease (asthma and chronic bronchitis). The incidence of moderate and severe ailments among two year olds, increased as they spent greater hours near the fire.

Exposure to high indoor smoke levels is associated with pregnancy related problems such as still births and low birth weights. One study in Western India found a 50% increase in stillbirths in women exposed to indoor smoke during pregnancy. Considerable amount of carbon monoxide has been detected in the blood stream of women cooking with biomass.

Other than these four major categories of illness; indoor air pollution is associated with blindness and changes in the immune system. Eighteen percent of blindness may be attributed to the use of biomass fuels. Further, a 1995 study in Eastern India found the immune system of new borns to be depressed due to the presence of indoor air pollution.

Source: ESMAP,World Bank 2000

Biomass fuels are not energy efficient and are not burned completely. Hundreds of harmful chemical substances are emitted during the burning of biomass fuels in the form of gases, aerosols (suspended liquids and solids) and suspended droplets. Smoke from wood-burning stoves has been shown to contain 17 pollutants designated as priority pollutants by the United States Environmental Protection Agency (USEPA,1997) because of their toxicity in animal studies (Cooper 1980; Smith and Liu 1993). These pollutants include carbon monoxide, small amounts of nitrogen dioxide, aerosols (called particulates in the air pollution literature) in the respirable range (0.110 µm in aerodynamic diameter), and other organic matter including polycyclic aromatic hydrocarbons such as benzo pyrene, and other volatile organic compounds such as benzene and formaldehyde. (It is estimated that indoor air pollution (due to burning of unprocessed cooking fuels in homes) in India's rural areas is responsible for at least 5 lakh premature deaths annually, mostly of women, and children under 5. This accounts for 6% - 9% of the total national burden measured in terms of Disease Adjusted Life Years. (MoEF,2005) The incomplete combustion of biomass releases complex mixture of organic compounds, which include suspended particulate matter, carbon monoxide, poly organic materia (POM), poly aromatic hydrocarbons (PAH), formaldehyde,etc. The biomass may also contain intrinsic contaminants such as sulphur, trace metals, etc.

Health effects of indoor air pollution

Indoor air pollution has been shown to cause and/or exacerbate a wide array of health effects like chronic respiratory diseases such as asthma and hypersensitivity pneumonitis. In addition, it can cause headaches, dry eyes, nasal congestion, nausea and fatigue. People who already have respiratory diseases are at greater risk. Infectious diseases caused by bacteria and viruses, such as flu, measles, chicken pox, and tuberculosis, may be spread indoors. Crowded conditions with poor air circulation can promote this spread. Some bacteria and viruses thrive in buildings and circulate through indoor ventilation systems. For example, the bacterium causing Legionnaire's disease, a serious and sometimes lethal infection, and Pontiac Fever, a flu-like illness, have circulated in some large buildings. Health effects from indoor air pollutants may be experienced soon after exposure or, possibly, years later.

Health effects of Ambient Air particulates

- Respiratory Symptoms: The symptoms of the upper respiratory tract include stuffy or runny nose, sinusitis, sore throat, wet cough, hay fever and burning or red eyes. Symptoms of the lower respiratory system include wheezing, dry cough, phlegm, shortness of breath (dysponea), chest discomfort and pain.
- Bronchitis: Increased particulate exposure enhances the incidence of bronchitis in exposed population. Acute bronchitis and bronchiolitis may be misdiagonised as odema, which may get further complicated in the people with myocardial damage and increased left arterial pressure. Bronchiolitis or pneumonia induced by air pollution in the presence of pre-existing heart problems might precipitate congestive heart failure and cardiovascular mortality.
- Pneumoconiosis: Certain respirable dust causes group of lung diseases that lead to appreciable fibrotic changes in the lungs.

Working with paints

Paints contain a variety of chemicals some of which can cause health concerns. Paint vapours can also travel across distance. Ventilation is a must when dealing with paints in addition one should also remember the following:

- ✓ Schedule painting for dry periods in the autumn or spring, when windows are more easily left open for ventilation.
- ✓ Keep windows wide-open, as weather permits, for about 2 to 3 days after painting to avoid unwanted exposure to paint vapors (and to return to acceptable indoor air quality).
- ✓ Use window-mounted box fans to exhaust vapors from the work area. Make sure they cannot fall out of the window. fans cannot be used, make sure that rooms being painted have adequate cross-ventilation.
- ✓ Provide advance notice to neighbors in adjacent units that painting is to begin.
- ✓ Take frequent fresh air breaks while painting. Avoid freshly painted rooms for 2 to 3 days, whenever possible. Keep young children and individuals with breathing problems from freshly painted rooms.
- ✓ Leave painted areas if you experience eye watering,headaches, dizziness, or breathing problems.

Sources and Potential Health Effects of Indoor Air Pollutants		
Pollutant	**Major Indoor Sources**	**Potential Health Effects***
Tobacco Smoke	Cigarettes, cigars, and pipes	Respiratory irritation, bronchitis and pneumonia in children, emphysema, lung cancer, and heart disease
Carbon Monoxide	Unvented or malfunctioning gas appliances, wood stoves, and tobacco smoke	Headache; nausea; angina; impaired vision and mental functioning; fatal at high concentrations
Nitrogen Oxides	Unvented or malfunctioning gas appliances	Eye, nose, and throat irritation; increased respiratory infections in children
Organic Chemicals	Aerosol sprays, solvents, glues, cleaning agents, pesticides, paints, moth repellents, air fresheners, drycleaned clothing, and treated water	Eye, nose, and throat irritation; headaches; loss of coordination; damage to liver, kidney and brain; various types of cancer
Formaldehyde	Pressed wood products such as plywood and particleboard; furnishings; wallpaper; durable press fabrics	Eye, nose, and throat irritation; headache; allergic reactions; cancer
Respirable Particles	Cigarettes, wood stoves, fireplaces, aerosol sprays, and house dust	Eye, nose and throat irritation; increased susceptibility to respiratory infections and bronchitis; lung cancer
Biological Agents (Bacteria, Viruses, Fungi, Animal Dander, Mites)	House dust; pets; bedding; poorly maintained air conditioners, humidifiers and dehumidifiers; wet or moist structures; furnishings	Allergic reactions; asthma; eye, nose, and throat irritation; humidifier fever, influenza, and other infectious diseases
Asbestos	Damaged or deteriorating insulation, fireproofing, and acoustical materials	Asbestosis, lung cancer, mesothelioma, and other cancers
Lead	Sanding or open-flame burning of lead paint; house dust	Nerve and brain damage, particularly in children; anemia; kidney damage; growth retardation

*Depends on factors such as the amount of pollutant inhaled, the duration of exposure and susceptibility of the individual exposed.

Immediate effects may show up after a single exposure or repeated exposures. These include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution, if it can be identified. Symptoms of some diseases, including asthma, hypersensitivity pneumonitis, and humidifier fever, may also show up soon after exposure to some indoor air pollutants.

The likelihood of immediate reactions to indoor air pollutants depends on several factors. Age and preexisting medical conditions are two important influences. In other cases, whether a person reacts to a pollutant depends on individual sensitivity, which varies tremendously from person to person. Some people can become sensitized to biological pollutants after repeated exposures, and it appears that some people can become sensitized to chemical pollutants as well.

Certain immediate effects are similar to those from colds or other viral diseases, so it is often difficult to determine if the symptoms are a result of exposure to indoor air pollution. For this reason, it is important to pay attention to the time and place the symptoms occur. If the symptoms fade or go away when a person is away from the home and return when the person returns, an effort should be made to identify indoor air sources that may be possible causes. Some effects may be made worse by an inadequate supply of outdoor air or from the heating, cooling, or humidity conditions prevalent in the home. Other health effects may show up either years after exposure has occurred or only after long or repeated periods of exposure. These effects, which include some respiratory diseases, heart disease, and cancer, can be severely debilitating or fatal. It is prudent to try to improve the indoor air quality in your home even if symptoms are not noticeable.

Unfortunately, the people who spend the most time indoors, and hence exposed to indoor air pollutants for long periods of time, are often the same people who are most susceptible to their effects. They include the young, elderly, and chronically ill, especially those suffering from respiratory or cardiovascular disease.

Sick building syndrome

The term Sick building syndrome (SBS), was first used in the 1970's to describe a situation in which reported symptoms among a population of building occupants can be temporarily associated with their presence in that building. Generally, a spectrum of specific and non-specific complaints is involved. Typical complaints include lethargy, headache, dizziness, nausea, eye irritation, nasal congestion, and inability to concentrate. SBS should be suspected when a substantial proportion of those spending extended times in a building report or experience acute on-site discomfort.

There has been extensive speculation about the causes of SBS.

Poor design, maintenance, and operation of the structure's ventilation system may be at fault. Another theory suggests that very low levels of specific pollutants may act synergistically to cause health problems. Humidity may also be a factor. While high relative humidity may contribute to biological pollutant problems, an unusually low level (below 20 or 30 percent) may heighten the effects of mucosal irritants and may even prove irritating itself. Other contributing elements may include poor lighting and adverse ergonomic conditions, temperature extremes, noise and psychological stresses that may have both individual and interpersonal impact. The prevalence of the problem is still unknown. A 1984 World Health Organization report suggested that as many as 30 percent of new and remodeled buildings worldwide might generate excessive complaints related to indoor air quality. When SBS is suspected, the individual physician or other health care provider may need to join forces with others to adequately investigate the problem and develop appropriate solutions.

A distinction has to be made between Building Related Illness (BRI) and Sick Building Syndrome (SBS). Morey proposed the use of the term SBS to refer to a constellation of non-specific symptoms experienced by a substantial number of occupants of large buildings (e.g., eye and upper respiratory irritation, headache, fatigue...). The term building-related illness generally is used to describe clinically recognizable disease resulting from exposure to indoor environment. Lung cancer from passive smoking, hypersensitivity pneumonitis caused by a contaminated water spray systems and Legionnaire's disease due to cooling tower drift are all building-related illness (Morey 88).

Managing indoor air pollution

Steps for improving indoor air quality:

Reduce and alter indoor chemical use - pay close attention to the labels on household products. If possible switch to natural products that contain fewer toxic chemicals. When you do need to use a stronger chemical, use it sparingly and follow all the precautions explained on the label.

Air out dry-cleaned items - Don't immediately store dry-cleaned items in a closet. Take the plastic off and allow your clothing to air out for a day or two in a space with good air circulation. Then, recover the items with plastic and store them in a closet.

Install an electronic air cleaner - electronic air cleaners can extract 30 times as much dust as ordinary filters, but they cost a lot more. An air-purifier can be used to remove particulate pollutants up to sub-micron sizes. This machine functions by circulating indoor air with a motor-fan unit and filtering it with the help of special filters. If the price is too steep, one can opt for portable units which cost less. Of course, the smaller units clean just the air in one room-much like a window air conditioner cools only one room. Electronic air cleaners only need to be cleaned once a year or so because they incinerate the trapped dust.

Open the windows Indoor spaces should not be tightly sealed all of the time. It is important to air out the space in homes and offices regularly by opening windows and using fans to draw fresh air inside. Make it a habit to open windows daily atleast for 15-30 minutes. Better still, ensure that your buildings are designed to have natural air circulation and have chimneys designed in an adequate manner and installed at appropriate places. Insist on your architect to test & measure air draughts, air flows & air scavenging processes in your building.

Add plants to your home - plants can do a great job of helping to remove the indoor toxins from home. And some plants are more efficient in this respect than others. A few that has been found to work well: Boston fern, spider plant and areca palm. Another useful leaf plant is the Weeping Fig (Ficus benjamina) which is excellent for getting rid of indoor air pollutants! It can be grown in homes, shops, schools, hospitals and nursing homes. It is very useful for removing formaldehyde. It has bright and dark green leaves and beautiful drooping branches. You can even add money plants to grow along side this plant and you will get even more clean air for your house! And various species of orchids have been found to purify indoor air to a great extent by NASA. A good rule of thumb is two plants per hundred square feet.

In fact, this knowledge of plants serving as purifiers of air has been with us from times immemorial. Perhaps, that was the reason why certain trees have been worshipped like peepal (Ficus religioa), pakur (Ficus infectoria), bel (Aegle marmelos), bargad (Ficus benhalensis), makhan katori (Ficus krishnae), neem (Azdirachta indica), shalmali (Bombax ceiba), kadam (Anthocephalus cadamba), arjuna (Terminalia arjuna), etc. Later on this notion perhaps gave birth to the 'sacred grove' concept' the chief purpose of which was to save the invaluable plants from utter destruction.

Certain other plants like Amaranthus graecizans, Argemone mexicana, Boerhaavia diffusa, Cephalandra indica, Eichhornia crassipes, Eupatorium odoratum, Ipomoea carnea, Lantara, Mikania micrantha, Franax procumbons, etc., also function as bioaccumulators. All these plants are generally weeds; they grow either in the fields or in aquatic habitats where they are not wanted. Moreover, most of these plant species are exotic in origin and have invaded India as alien species.

Today, almost all these plants are associated will various hazards like human diseases, damage to livestock, reduction in crop yield, loss of soil fertility and so on. However, all of these plants have the magical ability to retain numerous noxious pollutants for long periods of time. This has been possible perhaps due to the highly adaptive nature of these plants. Most of these species have adopted several alternative pathways of metabolism for survival while some others are using most efficiently the excess sulphur dioxide and nitrogen oxides of polluted air as sources of sulphur and nitrogen nutrition, respectively. These plants also have a well-developed oxygen radical scavenging system.

Lastly, it needs to be understood and emphasized that plants possess the power to improve the quality of the environment and thereby human health. Certain plants that have the ability to act as sinks for pollutants can be harnessed for the good of mankind.

Case studies in Bangalore:

The Energy and Resources Institute (TERI) has done some of the case studies on Indoor Air quality of buildings located in Bangalore at different areas. Out of all three case studies are shown below.

Before we take up the data let us know about the available standards for Indoor Air quality. As per the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) design considerations, the minimum recommended value of fresh air is 20 cfm (cubic feet per minute) per person.

<u>Case 1: M G road, Bangalore.</u>

Evaluation of Air flow rates:

Airflow rate from the installed air handling units has been carried out as first step. The need for assess the air flow rate is to find out: Choking of filters which may lead to reduction of air flow. Chocking of filters may also increase the growth of microorganisms, which in turn affects the quality of air. Actual airflow rate near air handling units (AHU) should be close to the design airflow rate. [Less air flow rate reduces the number of air recirculations, which may affect the indoor air quality (IAQ)]

Table 1: Measured airflow rates

Location of Air Handling Unit (AHU)	Design flow (cfm)	Measured flow (cfm)	Percentage of design flow
Ground floor (MG Road side)	21000	9843	46.9
Ground floor (Rear side)	21000	10178	48.5
First floor (MG Road side)	21750	14508	66.7
First floor (Rear side)	21750	13622	62.6

The measured airflow rates of each floor AHU is given in the table 1. The measured airflow rate of the AHU's are less than the design flow rates.

Measurements of fresh air:

In-door air quality any occupancy area depends on quantity of fresh airflow (outside air) supplied. To allow the fresh air entry into the occupancy area same quantity of inside air be exhausted. By measuring the air velocity from the fresh air duct, quantity of fresh air has been estimated. The actual fresh air entry in to each AHU is given in the table 2:

Table 2: Measurement of fresh air

Location of Air Handling Unit (AHU)	Design fresh air quantity, cfm	Design fresh air, %	Measured fresh air quantity, cfm	Measured fresh air, %
Ground floor (MG Road side)	1650	7.3	286	2.8
Ground floor (Rear side)	1650	7.3	95	0.9
First floor (MG Road side)	2450	10.1	267	1.8
First floor (Rear side)	2450	10.1	143	1

It may be observed that the measured fresh airflow rate into workstation area is only around 0.9% to 2.8% of the total air flow rate. Further, it may be observed that the air flow rates it self is around 48% to 66% of the design air flow rates indicates that the fresh air entry into the work station areas is negligible. The fresh air entry provision at the AHU rooms is through an opening of 60 cm by 30 cm. More over, the fresh air entry in that opening were also 90% closed using Venetian blind.

The table 3 gives the fresh air quantity per person for both ground and first floor along with the required fresh air quantity as per ASHRAE standards.

Table 3: ASHRAE design considerations

Floor	Number of occupants	Actual fresh air flow, cfm	Required fresh air flow as per ASHRAE standard, cfm	Percentage deviation from standard
Ground floor	20	381	400	4.75
First floor	75	410	1500	72.67

It can be seen from the table 3 that the deviation of fresh air supplied over the ASHRAE standards are as high as 72.67% for the first floor and about 5% for the ground floor. This corroborates with complaints which are more from first floor.

Case 2: Hosur road, Bangalore.

Evaluation of air flow rates:

The measured airflow rates of each floor AHU is given table 4.

Table 4: Measured airflow rates

Location of AHU	Design flow (m^3/h)	Measured flow (m^3/h)	Remarks on measured flow rate
I floor south wing	26520	25920	O.K
I floor north wing	25330	21060	Dip by 17% from the rated value

The measured airflow rate of the I floor south wing is close to the rated value, by the measured air flow rate for the north wing is about 83% of the rated value.

Measurements of fresh air:

The design fresh air quantity and actual fresh air entry in to each wing are given in the table 5.

Table 5: Measurement of fresh air

Location of AHU	Design fresh air flow (m^3/h)	Measured fresh air flow		Deviations from design value, %
		(m^3/h)	% of design flow for fresh air	
I floor south wing	3398	1725	50.8	-49.2
I floor north wing	3398	713	21	-79

The measured fresh air flow rate into workstation area is only around 51% and 21% of the design flow rate for south wing and north wing respectively. The fresh air entry provision at the AHU room is through a duct size of 900 mm X 440 mm.

There is a common fresh air fan-one each for the North Wing and South Wing. The fan is located in the pantry section. A supply fresh air duct is running down to all the floors, from which tapping ducts are drawn into the respective AHU rooms.

As per the ASHRAE design considerations, for 75 persons workstation with a working space of 143 sq. ft for each workstation, this will respectively be at least 1500 cfm, as against of 1725 and 713 cfm in the South and North Wings as assessed. Hence, the present fresh airflow rate is less by at least 79% for North Wing. This corroborates with complaints, which are more from North Wing.

Frequently asked questions:

How do I recognise contamination of indoor air in my home\office?
Signs that can indicate your home may not have enough ventilation include moisture condensation on windows or walls, smelly or stuffy air, dirty central heating and air cooling equipment, and areas where books, shoes, or other items become moldy. To detect odors in your home, step outside for a few minutes, and then upon reentering your home, note whether odors are noticeable.

How do I minimize pollution of air in an indoor environment?

- Eliminate sources of pollution by sealing off insulation, adjusting gas appliances to emit less leakage, ridding your home of chemicals and tobacco smoke, etc.
- Open the windows frequently in order to allow for proper ventilation Maintain extra ventilation while painting, using chemicals, cooking with gas stoves, smoking, etc. by switching on mechanical fans etc.
- Check product labeling to make sure you have the safest products possible for cleaning, personal care, etc.

What are the stipulations for fresh air in an indoor environment?
Usually the fresh air requirements are stipulated as cubic feet per minute (cfm) per person. The recommended cfm in homes should vary between 15 and 20. And in restaurants and other smoke filled places it ought to be up to 30 cfm. On the other hand, cinema halls, stores etc, where smoking is not allowed should have an air flow of about 7.5cfm. Good air circulation can be ensured by installing chimneys to enhance scavenging of hot air and natural in take of fresh air. The health of indoor potted plants is as easy indicated of availability of adequate indoor fresh air.

How do I lookout for biological contaminants?
The golden rule for managing biological contaminants is to prevent build up of humidity\moisture levels. We may see condensation of moisture directly (such as when it builds up on windows) or indirectly (such as mold and mildew). Uncontrolled moisture levels in homes can lead to structural problems. In addition to damaging our homes, uncontrolled moisture levels and lack of sunlight promotes growth of fungi and other microorganisms which can directly affect human health. Moisture should be eliminated from places like bathrooms and kitchens by the use of exhaust fans. Wet clothes should not be hung inside the house for drying.

What are the precautions to be followed before installing an exhaust fan?
Combustion appliances like gas stoves etc need oxygen for maintaining flames. If this air is not provided from outside, air is drawn in from within the premises for combustion and this may lead to the development of negative pressure inside the house. It is to prevent such a situation that an exhaust fan is installed in such areas which require oxygen supply on a regular basis. However, if the exhaust fan is not provided with air for make up for the suction, a negative pressure may still develop. In some homes, a mesh is installed in front of the exhaust fans and this is not cleaned frequently which leads to clogging and consequent reduction in suction from outside. In addition, gas geysers running on LPG should never be installed inside the bathroom as this may lead to build up of carbon monoxide to lethal levels.

What are the features of good indoor air quality?

- introduction and distribution of adequate ventilation air
- control of airborne contaminants
- maintenance of acceptable temperature and relative humidity
- Quality indoor air

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Some of the trees as air purifiers


Peepal Tree (*Ficus Religiosa*) Arali Mara


Bargad (Ficus krishnae) Allada Mara


Billwa Patre Mara (Aegle marmelos)


Neem (Azadirachta indica) Beevina Mara


Shalmali (Bombax ceiba) Bidaru


Arjuna (Terminalia Arjuna) Bilematti Mara

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