

Health Impacts of Indoor Air Pollution

Air pollution, both indoor and outdoor, is a major environmental health problem affecting developed and developing countries alike. It comes from sources of dust, gases and smoke, and is generated mainly by human activities but also naturally. While the problem regarding outdoor air pollution has been well publicised for several decades, it is indoor air pollution that is causing the most recent concerns for obvious reasons:

Exposure to Indoor Air Pollution

People's exposure to indoor air pollution is determined by the concentrations of pollutants in the indoor environment and, most importantly, by the time individuals spend in polluted environments. Most people spend a large amount of their time indoors, which makes indoor spaces important micro-environments when addressing risks from air pollution. Most of a person's daily exposure to many air pollutants comes through inhalation of indoor air, both because of the amount of time spent indoors and because of the higher pollution levels indoors.

The air quality inside buildings is affected by many factors. In an effort to conserve energy, modern building design has favoured tighter structures with lower rates of ventilation. By contrast, in some areas of the world only natural ventilation is used; in other areas mechanical ventilation is common. Factors that can have a negative effect on health and comfort in buildings range from chemical and biological pollutants to occupant perceptions of specific stresses such as temperature, humidity, artificial light, noise and vibration.

Sources of Indoor Air Pollution

Important sources of indoor pollutants include outdoor air, the human body and human activities, emissions from building materials, furnishings and appliances and use of consumer products. Microbial contamination is mostly related to the presence of humidity. The heating, ventilating and air conditioning (HVAC) system can also act as a pollutant source, especially when it is not properly maintained. For example, improper maintenance of HVAC equipment can lead to re-emission of particulate contaminants. Biological contamination can proliferate in moist components of the system and be distributed throughout the building.

Health Effects of Specific Air Pollutants

Most indoor air pollutants directly affect the respiratory and cardiovascular systems. Sometimes the brain and general nervous system are also affected. The direct human health effects of indoor air pollution on the respiratory system vary according to both the intensity and the duration of exposure, and also with the health status of the population exposed. Certain parts of the population may be at greater risk, for example, the very young and elderly, those already suffering from respiratory disease, hyper-responders and people exercising.

Allergens

Allergens such as pollen, house dust mites' faeces and moulds in indoor environments of high humidity can cause allergic asthma (reversible narrowing of lower airways), allergic rhinoconjunctivitis in children and young adults, and recurrent bouts of pneumonia or milder attacks of breathlessness.

Asbestos

Asbestos and other mineral fibres may be a cause of an increased incidence of lung cancer. Acute exposure to asbestos and glass fibres can cause severe skin irritation.

Carbon Monoxide (CO)

Carbon Monoxide results from burning of gasoline, natural gas, coal, oil etc. Breathing CO reduces the ability of blood to transport oxygen to body cells and tissues; cells and tissues need oxygen to work. It may be particularly hazardous to people who have heart or circulatory (blood vessel) problems and people who have a damaged lung or respiratory tract.

Formaldehyde (HCHO)

The main acute effects of formaldehyde include odour perception and irritation of eyes, nose and throat. Discomfort, lacrimation, sneezing, coughing, nausea and dyspnea have also been observed, depending on the concentration. Formaldehyde is also a well known carcinogenic.

Infectious Microorganisms

Inhalation of infectious microorganisms discharged by people and animals is a primary mechanism of contagion for most acute respiratory infections. In indoor environments characterised by reduced ventilation and increased use of untreated recirculated air concentrations of microorganisms may increase.

Nitrogen Oxides (NO_x)

Nitrogen oxides are smog-forming chemicals, created by the burning of gasoline, natural gas, coal, oil etc. Cars are a major source of NO₂. Health effects include lung damage and illnesses of the respiratory organs.

Ozone (O₃)

This chemical is the principal component of smog. It is created by a chemical reaction of various pollutants, such as VOCs and NO_x. Indoor sources of ozone include outdoor ozone, office equipment (e.g. printers, photocopiers), as well as ozone generators. Some ionising air cleaners also produce ozone. Health effects include: breathing problems, reduced lung function, asthma, irritation of eyes, stuffy nose, reduced resistance to colds and other infections. Ozone may also speed up aging of lung tissue.

Particulate Matter (PM)

In addition to smoke and soot generated by burning of fossil fuels, tobacco smoke, by industrial processes, agriculture, wild fires etc., particulate matter consists of tiny aerosol particles formed from gaseous emissions of sulfur dioxide and VOCs. Particulate pollution is classified by size, with finer particles (PM_{2.5}, i.e. particles of 2.5 microns size and less) considered to be more dangerous than coarser material (PM₁₀) because they are small enough to evade the body's respiratory defence mechanisms and lodge deep in lung tissue. For that reason, these tiny particles appear to have the greatest health-damaging potential. Many scientific studies have linked breathing PM to a series of significant health problems, including:

- nose and throat irritation
- increases in respiratory symptoms (like coughing and difficult or painful breathing)
- aggravated asthma
- decreased lung function
- lung damage
- bronchitis
- early death

Sulfur Dioxide (SO₂)

This chemical is generated by the burning of coal and oil, and other industrial processes and can cause breathing problems and permanent damage to the lungs.

Tobacco and Biomass Smoke

Smoke contains a variety of health-damaging pollutants, including particles, carbon monoxide, nitrous oxides, sulphur oxides (mainly from coal), formaldehyde and many carcinogens (chemical substances known to increase the risk of cancer) such as benzene. The active and passive inhalation of smoke can lead to a reduction of pulmonary function, to an increased incidence of respiratory symptoms and infections, to an increased incidence of lung cancer and early death. There is consistent evidence that exposure to smoke increases the risk of acute lower respiratory infections in childhood, particularly pneumonia. Globally, acute lower respiratory infections represent the single most important cause of death in children under 5 years and account for at least 2 million deaths annually in this age group.

Volatile organic compounds (VOCs)

VOCs are released from burning fuel (gasoline, oil, coal, natural gas, etc.), solvents, paints, glues and other products used at work or at home. Cars are also an important source of VOCs. VOCs include chemicals such as benzene, toluene, methylene chloride and methyl chloroform. Health effects reported for VOCs range from sensory irritation to behavioural, neurotoxic, hepatotoxic and genotoxic effects. Long-term exposure is suspected to cause damage to the liver and other parts of the body. Exposure to mixtures of VOCs may be an important cause of Sick Building Syndrome.

Other Health Effects Associated with Indoor Air Pollution

Sick Building Syndrome (SBS)

SBS is the occurrence of specific symptoms with unspecified aetiology. SBS is experienced by people while working or living in a particular building, but which disappear after they leave it. Symptoms include mucous membrane, skin and eye irritation, chest tightness, fatigue, headache, malaise, lethargy, lack of concentration, odour annoyance and influenza symptoms. It is assumed that the interaction of several factors, involving different reaction mechanisms, cause the syndrome, but there is yet no clear evidence of any exposure-effect relationship.

Building Related Illness (BRI)

BRI is an illness related to indoor exposures to biological and chemical substances (e.g. fungi, bacteria, endotoxins, mycotoxins, radon, CO, HCHO). It is experienced by some people working or living in a particular building and it does not disappear after leaving it. Illnesses include respiratory tract infections and diseases, legionnaires' disease, cardiovascular diseases and lung cancer.

Further Information

For many years, the *World Health Organisation (WHO)* and the *US Environmental Protection Agency (EPA)* have studied the health effects of air pollution and have produced numerous publications on this topic. There is consistent evidence that exposure to indoor and outdoor air pollution can lead to severe acute and chronic health problems. For the latest information please refer to the websites of the WHO (www.who.int) and the EPA (www.epa.gov).