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Indoor Air Quality in Homes

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Abstract

Indoor air pollution is an international health concern because people spend a majority of their time indoors. Children are at a higher risk of health problems from pollutant exposure, especially because air in the child breathing zone is more polluted than it is in the adult breathing zone. Pollutants of concern include biological contaminants, combustion pollutants, volatile organic compounds, and radon and other soil gases. Humans have a history with lead and asbestos that goes back thousands of years to the ancient Romans and Egyptians. These two pollutants are still problems in older homes and apartments. All of these toxicants can be minimized or abated. Awareness of these issues is a critical first step in improving air quality in places where people live. These factors are of particular concern when examining indoor air quality because most people in the U.S. spend about 90% of their time indoors with some groups such as infants, the elderly, and infirm persons spending nearly all of their time indoors [1]. A number of conditions contribute to typically higher levels of indoor pollutants than corresponding levels outdoors [2]. The U.S. Environmental Protection Agency has reported that pollutant levels can be higher indoors than outdoors. By one estimate, pollutant levels can be 10 to 100 times higher inside than outside [3].

Introduction

Biological contaminants in homes include viruses, bacteria, mold, dust mites, animal dander, and pollen. The latter four of these are known asthma triggers. An estimated 300 million people worldwide suffer from asthma, and this number increases by 50% every ten years [4]. This illness is a growing concern for children. In the United States alone it is responsible for 14 million missed school days annually, is the third-ranking cause of hospitalization of children under 15 years of age, and entails an estimated $3.2 billion per year in costs of treating children under 18 years of age [5].

Volatile organic compounds (VOCs) are emitted from certain building materials, pesticides, paints, paint strippers, solvents, and hobby supplies and can include benzene, styrene, xylene, methylene chloride, tetrachloro-ethylene, and formaldehyde, among others. Many of these are known or suspected human carcinogens [5].

Radon is a colorless, odorless, and tasteless radioactive gas. It is a decay product of uranium, which is present in trace amounts in soils all over the world. Uranium decays to radium-both of these are solid elements. But radium decays to radon, which is a gas. It then moves easily through soils, especially porous, sandy, or gravelly soils. Radon pathways into buildings include cracks in basement floors and foundation walls. Radon is the second leading cause of lung cancer. In the U.S. radon is estimated to be responsible for 21,000 deaths every year [6]. Combustion Products are another category of indoor environmental pollutants. They consist of nitrogen oxides, sulfur dioxide, carbon monoxide, respirable particles and water. Nitrogen oxides and sulfur dioxides are lung irritants, but carbon monoxide can kill. Combustion pollutants enter the indoor environment when they leak from home appliances and equipment that burn gas, oil, kerosene, or wood. Human exposure to low levels of carbon monoxide results in symptoms that mimic those of influenza. Exposure to higher levels can kill [7].

Lead, which is related to a variety of disorders and is particularly dangerous to children, can be a common component of house dust. While lead poisoning through ingestion has received substantial attention, airborne lead is an often-overlooked source of exposure. In homes painted before 1978, lead-based paint was commonly used on double-hung windows, which shed the paint as dust when the sashes rub against each other [8]. Asbestos was used as insulation on heating systems and heating ducts. In some older homes, it actually covers entire boilers. Exposure to asbestos causes asbestosis, a type of lung cancer, mesothelioma, which is cancer of the chest lining, and lung cancer. Abatement of both lead and asbestos are not do-it-yourself activities. The removal of these elements is regulated in the U.S. and must be performed by certified abatement contractors [9].

The most effective strategy for controlling indoor air pollution is to control the problem at its source. Ventilation is also important, especially in the case of moisture. Expel moisture to the outside through exhaust fans that are vented to the outdoors. In the case of combustion pollutants, regular servicing of heating systems and other appliances

that are combustion based is necessary. Radon gas can be controlled through mitigation in existing homes and with radon-resistant construction techniques in new homes. Exposure to some VOCs can be hazardous to human health. Adequate ventilation should be provided when using these materials. Low- or no-VOC emitting products are now available and should be considered as safer alternatives. Lead and asbestos are present in older homes and apartments and pose considerable health risks to humans. Only trained professionals should perform abatement or encapsulation of both materials.

Numerous studies have documented the incidences of indoor air pollution and its negative impacts on children, especially with respect to lead, pesticides, radon, and asthma triggers [3]. For physiological and behavioral reasons, children are at higher risk than adults for both exposure to environmental toxicants and for adverse health effects from those toxicants [5]. Children are more highly exposed to environmental pollutants than adults because they breathe more air per pound of body weight and chew or suck on toys and hands that have been in contact with pollutants [1]. In addition, air in the child breathing zone is more polluted than it is in the adult breathing zone [10]. The child breathing zone is defined as being from the floor to three feet in height. The adult breathing zone is above that. Awareness of these issues is a critical first step in improving air quality in homes and apartments.

Concerns about indoor air quality have led to indoor air management becoming a new consumer skill. Steps involved in this process include identifying a pollutant of concern, controlling it at its source, and if that fails, mitigation. Table 1 lists potential indoor environmental toxicants in homes.

Table 1: Residential Indoor Environmental Toxicants.

Pollutant	Health Impacts
Biological Contaminants: mold, viruses, bacteria, dust mites, pollen, animal dander	Upper respiratory tract symptoms, coughing, wheezing, asthma symptoms, hypersensitivity pneumonitis
Volatile Organic Compounds (VOCs)	Eye, nose, throat irritation; headaches; nausea; coordination problems; liver, kidney, brain damage; cancer; child development problems
Radon	Lung cancer
Combustion pollutants	Eye, nose, throat irritation; fatigue; headaches; dizziness; confusion; death
Lead	Reduced IQ; learning disabilities; impaired hearing; reduced attention spans; behavioral problems; anemia; kidney damage; central nervous system damage; coma; convulsions; death
Asbestos	Mesothelioma; asbestosis; lung cancer

Discussion

Biological Contaminants

Biological contaminants include mold, viruses, bacteria, and dust mites. The term also applies to animal dander and pollen. Exposure to mold can cause allergic reactions, asthma, and other respiratory problems [10]. Mold spores are ubiquitous in indoor and outdoor air. The most practical way to prevent spores from colonizing in homes is to control moisture levels. Maintaining relative humidity to between 30 and 60 percent will minimize problems with mold [5]. This can be accomplished through adequate ventilation: exhaust fans ducted to the outdoors in bathrooms, an exhaust fan ducted to the outdoors over the kitchen range, and a clothes dryer that is vented according to the manufacturer's instructions. Preventing moisture entry from external sources is also important in preventing mold growth. This means quick repairs of leaks in roofs, siding, and other building components and maintaining dry basements and crawl spaces. Dust mites, pollen, and dander can be controlled in houses through regular cleaning [5].

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are carbon-based molecular compounds that evaporate at room temperature. In homes VOCs are emitted from certain building materials, paints, paint strippers, solvents, hobby supplies, air fresheners, and from smoking. They are also brought into a house from outdoor air [5] Some VOCs are known and suspected human carcinogens and include acetone, benzene, ethylene glycol, formaldehyde, methylene chloride, perchloroethylene, toluene, and xylene [12]. Adequate ventilation should be provided when using VOC- containing products. Low- or no-VOC products are increasingly becoming available.

Radon

Radon is a colorless, odorless, and tasteless radioactive gas. It comes from the decay of uranium, which is present in trace amounts in soils all over the world. Uranium decays to radium-both of these are solid elements. But radium decays to radon, which is a gas. Radon moves easily through soils, especially porous, sandy or gravelly soils. Radon can enter a house through foundation cracks and other openings. Once inside a house, radon decays to solid elements: lead, polonium and bismuth. These elements attach themselves to particles in the air. House occupants then inhale the particles into their lungs where they emit radiation, which eventually leads to lung cancer. Radon is the second-leading cause of lung cancer after cigarette smoking [13].

Radon's presence can only be confirmed through the use of short- or long-term radon detectors. The U.S Environmental Protection Agency (EPA) recommends that mitigation systems be installed at or above the Action Level of 4 picoCuries per Liter (pCi/L) of air. In EPA-designated Zone 1 counties, or counties in which indoor radon levels are expected to be 4 PCi/L or higher, Radon-Resistant Construction Techniques are recommended for new homes [13].

Combustion Pollutants

Combustion Pollutants comprise another category of indoor air pollutants. They consist of nitrogen oxides, sulfur dioxide, carbon monoxide, respirable particulates, and water. Nitrogen oxides and sulfur dioxides are lung irritants, and carbon monoxide can kill. Recommendations for avoiding combustion pollutants include avoiding the use of unvented fuel-fired space heaters in homes, regular maintenance of fuel-fired heating systems and water heaters, the placement of an exterior-vented exhaust fan over a gas cooking range, and the avoidance of smoking indoors. In addition, every home should have a smoke detector and at least one carbon monoxide detector.

Conclusion

As a public policy issue, human exposure to indoor environmental pollutants should be recognized for costs such exposure imposes on society. Fisk [14] demonstrated that indoor environmental improve-

ments in the U.S. would reduce health care costs and improve human productivity substantially. He estimated savings of $6 to $14 billion from reductions in respiratory disease and $1 to $4 billion from decreases in allergies and asthma. Other social costs to consider are those imposed by intelligence losses and behavioral problems from lead exposure. These costs justify policy interventions that could range from public education about indoor environmental quality to financial assistance for pollutant mitigation for limited-resource households.

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