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ISSUES IN ENVIRONMENTAL HEALTH: INDOOR AIR POLLUTION*

I. INTRODUCTION

As an emerging public health issue of the 1980s, indoor air pollution in non-occupational settings has been receiving increased attention in the media and the scientific communities. Homeowners and office workers have also become aware that the indoor environment may be a source of chemical compounds that can be hazardous to their health. It is likely that recent changes in our housing and our daily activities have caused increases in indoor air pollution which have resulted in this greater awareness of the problem.

Beginning in the early 1970s, increases in energy prices have caused changes in the way we construct and treat our indoor environments. Energy saving measures such as construction of superinsulated homes and use of energy-saving air handling units in office buildings have become common practices. Renovations to existing homes and offices have also served to increase the energy efficiency of those structures. The approaches utilized to achieve these energy savings include reducing the air exchanges, increasing insulation, and switching to alternative fuels. All three of these procedures can have an adverse effect on the indoor air quality. In new homes which have been heavily insulated and weatherized, fresh air exchange rates can be reduced to a level as low as 0.1 air changes per hour. Offices with automated air handling units can reduce the amount of fresh air being brought into the building to levels below one percent. The exclusion of incoming fresh air is one of the main causes for the increased occurrence of indoor air pollution episodes.

II. SOURCES

Several types of chemicals and materials have been identified in the indoor air as possible causes of adverse health effects. The sources of these chemicals and materials vary. However, most of them fall into but a few categories. Combustion is a common source of many indoor air pollutants. Combustion sources include cigarettes; furnaces burning oil, gas, or coal; unvented kerosene heaters; gas ovens; and wood burning stoves. Many consumer products (eg, carpeting, upholstery, particle board, cleaning compounds, new and recently dry-cleaned clothes, plastic products, and furniture) give off some chemical components at varying rates. Insulation products such as urea-formaldehyde foam insulation, polyurethane, and asbestos have all been identified as sources of indoor air problems. Another important source of indoor air contamination problems is the general lack of ventilation found in many of the indoor environments with the concomitant increase in all the indoor air contaminants including odors and carbon dioxide.

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*Adapted from: State of Connecticut Department of Health Services. Issues in environmental health. Connecticut Epidemiologist 1985; 4:19-20.

III. POLLUTANTS

Carbon monoxide is one of the most acutely toxic indoor air pollutants. It is a by-product of combustion which is colorless and odorless. The most common sources of carbon monoxide are unvented kerosene heaters, improperly functioning furnaces, wood burning stoves, and tobacco smoke.

Other sources of carbon monoxide include automobile exhaust which, for several reasons, enters an indoor environment. Effects of carbon monoxide can be seen at fairly low levels due to its ability to bind to hemoglobin and form carboxy hemoglobin which inhibits the uptake of oxygen in the blood. Early symptoms of carbon monoxide exposure include dizziness, headache, and loss of coordination. Continued exposure to high levels of carbon monoxide can and has resulted in death.

Nitrogen oxides and **sulfur dioxide** are two common indoor air contaminants. The major indoor source for these two compounds is unvented kerosene heaters. In addition, gas burning ovens can produce high levels of nitrogen oxides. Both of these compounds have irritant effects on the respiratory system and may increase one's susceptibility to infectious diseases.

Pesticides are often found in the indoor environment. Application of pesticides both inside and outside the home can result in significant levels of pesticide in the air within the house. Improper applications of compounds such as chlordane have resulted in indoor levels high enough to cause adverse health effects. Pesticides often have a distinctive odor which may act as a warning signal to the residents. Health effects seen with pesticides often involve the central nervous system, liver, and kidney.

Formaldehyde is one of the more publicized indoor air contaminants. The formaldehyde source of greatest concern recently is urea-formaldehyde foam insulation. This product was blown into homes during the middle to late 1970s. Problems arose shortly after application of the insulation when free formaldehyde was released in significant quantities from the insulation into the indoor air. Levels as high as 5 ppm were found in homes soon after the application of the insulation. The US Consumer Product Safety Commission banned the use of urea-formaldehyde foam insulation in 1981. The ban was later overturned in court. However, the insulation already in place in many homes can continue to give off formaldehyde for many years after application. Air levels of formaldehyde in homes insulated with urea-formaldehyde foam insulation during the 1970s are usually quite low today. However, there are still occasional instances of levels which can cause adverse health effects.

Formaldehyde is a common compound found in many consumer products. Some major sources of formaldehyde are particle board, pressed wood, and plywood. These products are of special concern in mobile homes which have a large amount of these wood products in them and in homes that are built very tightly. Formaldehyde is an upper respiratory tract irritant and can also cause eye and skin irritation. There are animal data indicating that formaldehyde may also be a carcinogen. Human epidemiological studies on its carcinogenicity are still not conclusive.

Radon is a naturally occurring radioactive element found in the earth's crust. Recent studies indicate that high levels of radon can be found inside some homes. This is a concern because the radioactive decay of radon after it has been inhaled has been shown to increase the risk of lung cancer. It has been estimated that anywhere from 20% to 100% of all lung cancers not associated with cigarette smoking may be caused by radon exposure. Radon enters the home from the ground through either well water or cracks in the the foundation. The gas is odorless and colorless and can only be measured by use of special detectors. Measures to reduce the amount of radon in homes include sealing the basement foundation, treating the well water before it enters the home, and ventilating the basement.

Tobacco smoke is often disregarded as an indoor air pollutant. However, epidemiological studies have shown that second-hand cigarette smoke may be one of the biggest health risks

associated with indoor air pollution. Children whose parents smoke have been shown to have higher rates of respiratory illness than children whose parents do not smoke. More than 2,000 compounds have been identified in cigarette smoke. Some of the compounds found in higher concentrations include carbon monoxide, carbon dioxide, polyaromatic hydrocarbons, and respirable particles.

Improper ventilation in large buildings can cause unacceptable odors and increased levels of carbon dioxide and other compounds. These odors are due to a concentration of chemicals and particles being released into the indoor environment. Increased building occupancy and cigarette smoking can add to odor and health problems. One method for estimating the general indoor air quality is by monitoring carbon dioxide levels. Increased carbon dioxide levels above background indicate inadequate ventilation and an accumulation of other indoor air contaminants. Outdoor air levels of carbon dioxide usually range from 300 to 400 ppm. Indoor levels of carbon dioxide greater than 1,000 ppm indicate that ventilation is inadequate. Health effects due to improper ventilation include respiratory irritation, skin irritation, headache, nausea, and many other vague complaints. This set of symptoms has sometimes been referred to as "tight building syndrome."

Asbestos-containing materials are found in many public buildings and homes. Disturbance of these materials or "asbestos fallout" from these materials can result in significant air levels of asbestos fibers. The significance of these levels of asbestos is still unclear because the number of fibers found in the indoor environment is relatively low compared to the number of fibers found in occupational settings where the adverse effects of asbestos have been proven. Removal or encapsulation of asbestos material can reduce or remove the exposure hazard. However, improper asbestos abatement procedures can result in exposures much higher than those which existed previously.

IV. INVESTIGATIONAL PROCEDURES

Investigation of all indoor air pollution episodes can be broken down into five basic steps.

1. The first and most important step in the investigation should be a thorough visual inspection of the entire building in question. This inspection is intended to identify any obvious sources of air pollution and importantly includes a careful inspection of the ventilation system. In many cases inspection and repair of the ventilation system will solve the problem by simply providing adequate fresh air.

2. Although rarely used in most indoor air investigations, air sampling can sometimes provide useful information if visual inspection and ventilation adjustments fail to improve air quality. Air sampling for contaminants is a very specific process. Different sampling procedures and laboratory analysis may be required for each suspect compound. Data obtained from air monitoring are difficult to interpret, because suspect compounds are usually found in low levels, and "background" compounds are present in large numbers. Indoor air monitoring can be a very time-consuming and costly procedure if the suspect compound cannot be identified.

3. Epidemiological methods have been used to investigate indoor air problems and occasionally may be useful in guiding interventions when initial measures fail to solve the problem. Unfortunately, the symptoms described in indoor air pollution episodes are often too vague and are masked by too many other underlying conditions to provide useful information.

4. With indoor air complaints in office or public buildings, other factors need to be investigated. The conditions under which the office workers must function play an important part in the workers' impressions of their environment. Improper lighting, high noise levels, and improper temperature control can all increase discomfort levels experienced by the workers and can increase the number of complaints.

5. Once an investigation has identified a potential source, remediation measures should be taken. The success or failure of remediation in terms of alleviating the complaints is often used as positive identification of the pollution source. Increased ventilation should be the first measure tried. Other measures include source removal, enclosure, and treatment of the source.

PDN Editorial Note: There are currently very few federal or state standards for acceptable levels of indoor air pollution. The Texas Department of Health sponsored the introduction of an Indoor Air Quality Act in the 69th Texas legislature. This legislation would have empowered the Department to establish and enforce indoor air quality and ventilation standards in public buildings. Although it was not adopted, similar legislation may be presented in the next session.

The Texas Department of Health receives over 1,000 calls or complaints on indoor pollution every year. More than 50% of the calls concern asbestos or formaldehyde. Over 10,000 bulk samples have been examined for asbestos content, and more than 1,400 on-site surveys for formaldehyde have been made. Other surveys have involved a great variety of indoor air pollutants.

If you have questions concerning indoor pollution, call your local health department or the Occupational Health Program, Texas Department of Health, 512/458-7254.

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