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AUTHOR	Grubb, Deborah
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ABSTRACT

Health problems related to school buildings can be categorized in five major areas: sick-building syndrome; health-threatening building materials; environmental hazards such as radon gas and asbestos; lead poisoning; and poor indoor air quality due to smoke, chemicals, and other pollutants. This paper provides an overview of these areas, describing the extent of the problem, sources of the problem, and control/regulation of the problem. The term "sick-building syndrome" refers to a host of mysterious illnesses thought to result from tightly sealed, poorly ventilated buildings. In addition, the rapid proliferation of new building materials makes monitoring more difficult. The House of Representatives Committee on Energy and Commerce, Subcommittee on Health and Environment (1993) determined that serious environmental threats exist in the air of American schools. Comparative risk studies conducted by the Environmental Protection Agency in 1990 concluded that indoor air pollution is among the top four environmental risks to public health. Solutions depend upon the specific contaminant. Most, however, can be controlled by installing and using appropriate HVAC systems. (Contains 19 references.) (Author/LMI)

Healthy Buildings?

Deborah Grubb

Morehead State University

Abstract

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Health problems with school buildings can be broken into five major areas: sick-building syndrome, health-threatening building materials, environmental hazards such as radon gas and asbestos, lead poisoning, and poor general indoor air quality due to smoke, chemicals, and other pollutants.

The term sick building syndrome has been given to a host of mysterious illnesses thought to result from tightly sealed, poorly ventilated buildings. The problem appears to be, in part, a result of the energy crisis of the 1970s when efforts were made to make buildings as air-tight as possible to cut energy costs. In addition, new developments in the building industry have resulted in a multiplicity of building materials now on the market, some with little monitoring for health hazards.

The House of Representatives Committee on Energy and Commerce, Subcommittee on Health and the Environment (1993) determined that serious environmental threats exist in the air of the nation's schools. Comparative risk studies conducted by the EPA (1990) concluded that indoor air pollution is among the top four environmental risks to public health. Solutions depend upon the specific contaminant. However, most can be controlled by having appropriate HVAC systems installed and used.

Healthy Buildings?

When parents send their children to school, they hope that the students are in a safe nurturing environment. The fear of violence at school is not without justification. However, many students may be in more danger from the school building itself than from anyone at the school. Among the growing list of concerns of boards of education are problems caused by asbestos, radon, pesticides, chemical fumes, bacteria and mold in the air conditioning system, contaminated soil from fuel leaks, and lead in the drinking water which may seriously affect the development and health of school-age children (Goldberg, 1991; Rist, 1991).

Health problems associated with school buildings can be divided into five major areas: sick building syndrome, health-threatening building materials, environmental hazards such as radon gas and asbestos, lead poisoning, and poor indoor air quality due to such things as smoke or chemicals.

Sick Building Syndrome.

The term sick building syndrome has been given to a host of mysterious illnesses thought to result from tightly sealed, poorly ventilated buildings. Symptoms people experience from living, working, or going to school in sick buildings are often diffuse, nonspecific, and flu-like. They include headache, nausea, congestion, drowsiness, dizziness, and general respiratory distress. Symptoms of sick building syndrome often disappear when the people who are affected leave for a weekend or a longer vacation. More concerning even than the transient effects are questions about long-term effects.

Some symptoms become worse over time in some individuals because the person becomes sensitized to an allergen. However, many fear that long-term exposure will result in serious health hazards (Reecer, 1988).

Sick building syndrome appears to be a result of the energy crisis of the 1970s with efforts to make buildings as air-tight as possible to cut energy costs. The World Health Organization estimates that as many as 30 percent of new or newly renovated buildings have a high incidence of sick building complaints. Many buildings are designed with windows that do not open and air locks at the entrances, effectively stopping any exchange of air from inside and outside. If these buildings have HVAC (heating, ventilation, air conditioning) systems that have a design, operation, or maintenance problem, various air pollutants can increase to the point where they can cause illness. The Department of Epidemiology and Public Health at Yale University School of Medicine indicates that the problem may not be constant, making it even harder to identify. They state that any large modern building with air conditioning will exhibit episodic characteristics of sick building syndrome (Reecer, 1988).

Some of the most common causes of sick building syndrome in schools are:

- The building/HVAC system has a poor design or installation.
- The HVAC system has been altered, usually to save energy or from a janitor making alterations to the system.
- The school building houses many more students than it was designed to accommodate, and the students are doing activities with materials that were not

planned into the design.

- The HVAC system is poorly or incorrectly maintained, usually due to economy or ignorance (Reecer, 1988).

A sick school building creates three serious problems for a school district: health problems, financial problems, and public relations problems. The cure for a sick building depends on first diagnosing the problem. A consultant on indoor air quality must usually be hired to examine the facility, talk to the complainants, and conduct diagnostic tests. The costs of the evaluation alone can often be thousands of dollars. After a thorough evaluation, recommendations will usually be made for repairing, renovating, or maintaining the ventilation system (Reecer, 1988). After the physical problem with the building is solved, the hardest work remains to be done: convincing the parents that the school is a safe place for their children.

Health Threatening Building Materials.

Even if a school district ensures that the HVAC system is working properly, a school building itself might be poisoning the indoor air. New developments in the building industry have resulted in a multiplicity of building materials now on the market, some with little monitoring for health hazards. Wolf (1992) has outlined several harmful substances and their possible building applications such as: asbestos, often used in plaster, electrical storage heaters, and overhead projectors; formaldehyde, often used in chipboard, furniture, wallpaper, carpet, and adhesive; CFC used in refrigerators; hydrazin used as a corrosion-inhibitor for heating installation, plastics, dyestuff, adhesive, and foaming agents; isozyanat used in chipboard adhesive; Levoxin used as a corrosion inhibitor for humidifiers; Lindan used in wood preservatives and dyestuff; PCB used in the condenser of neon tubes, wood preservatives, lacquer, dyes, packing materials, and adhesive; Perchlorethylen used as a cleaning agent; PUR and PVC used for floor-underlay, wall-underlay, and cable covering; and coal tar/oil used as a wood preservative.

Environmental Hazards.

Radon.

The public became aware of radon as a potential health hazard when an employee of a nuclear power plant in Eastern Pennsylvania set off the radiation monitor as he went into the building. Investigators found that the man's house registered radon levels 40 times higher than the amount that would require the closing of a uranium mine for safety reasons (Reecer, 1988).

Radon is a colorless, tasteless, odorless radioactive gas which can be deadly. Radon occurs naturally in soil, rocks, underground water, and air as a byproduct of the natural breakdown of radium in soil and rocks. The radon decay products attach themselves to particles in the air. Breathing high concentrations of radon increases the likelihood of developing lung cancer. The danger depends both on the level of radon gas in the air and the length of exposure. The length of time between exposure and the development of lung cancer may be many years, but the EPA estimates that about 20,000 lung cancer deaths each year may be attributable to radon exposure. The EPA has stated that radon exposure is the second only to smoking as a leading cause of lung cancer (EPA, 1989).

The EPA (1989) interim report yields limited information about the exposure risks of radon on children but some data suggest that children may be more susceptible than adults to cancers caused by radiation. This may be due to children having smaller lung volumes and higher breathing rates, which could result in higher radiation doses. No evidence exists that children are suffering immediate, acute illness due to the radon levels in the schools. However, children's exposure to radon is a concern due to their many remaining years of life that allow the latency periods of diseases to pass and the disease to become manifest (Committee on Energy Commerce, 1993).

The EPA (1989) interim report on radon measurements in the schools indicates that school buildings, or individual rooms of school buildings, may contain unacceptable levels of radon. Schools may be a significant source of radon exposure, which could pose a health risk to the students and employees. A survey by the EPA concluded that there are over 70,000 classrooms have unacceptable concentrations of radon. Approximately 10 percent of schools have three or more rooms with dangerous levels of radon. In over 10,000 schoolrooms across the country, students and staff are exposed to higher radiation levels than the average worker in a nuclear power plant, making it more dangerous to go to school than to go to work in a nuclear power plant (Committee on Energy Commerce, 1993).

Schools are often built on several adjoining slabs. The cracks between the slabs can offer entry points for the radon gas, causing the basement and first floor to have a greater risk of elevated radon levels than upper floors. Depending on the type of HVAC system installed in the school, a positive or negative air pressure condition may exist. Positive pressure decreases the likelihood that radon gas will seep into a building. However, a negative air pressure increases the potential for radon entry. A school may have low radon concentrations when the HVAC system is turned off, but due to the creation of a negative air pressure, may have high concentrations when the system is on. The opposite may occur if the radon that is seeping into the building is dissipated when the HVAC system is turned on. Patterns of school occupancy can also have an effect on radon levels. Schools are often shut tight with HVAC systems turned off during weekends and holidays. This may allow high concentrations to build up and may distort measurements of radon levels. The EPA also found that radon concentrations can vary significantly due to changes in ventilation caused by weather conditions, occupancy patterns, and other variables. Also, schools in the same general area can have significantly different radon concentrations due to different construction techniques and underlying geological conditions (EPA interim report, 1989).

To determine the concentrations of radon in school buildings, the EPA recommends measurements in all rooms frequently used on or below ground level. If the school was designed as an open-plan without individual classrooms, the measurements should be taken every 2,000 square feet. If results of three-month screenings are between

4 pCi/L (picocuries per liter) and 20 pCi/L, confirmation tests should be conducted over a nine-month period. If results are less than 4 pCi/L, school officials should decide on a case-by-case basis whether further measurements need to be taken. Congress has set a national goal for indoor radon concentrations of .2 to .7 pCi/L. If measurements are greater than 20 pCi/L, immediate action (within weeks) should be taken to reduce the levels. If levels are over 100 pCi/L, school officials should consider temporary relocation until levels can be reduced.

Asbestos.

Asbestos, a metamorphosed rock, refers to a group of fibrous, incombustible, magnesium and calcium silicate materials. It is found in formations of limestone and has over 3,000 recorded uses (Malcolm, 1980). It is a valuable product for heat and noise insulation, as well as use as a binder (Olson, 1986).

Asbestos has a tendency to separate into tiny fibers can then enter the body in two ways: inhalation or ingestion. Significant health problems, whose full impact may not be felt for years, are caused by the presence of asbestos materials. Almost all asbestos-related diseases have a long latency period, most occurring 30 years after exposure. Deadly diseases that can occur from asbestos are: asbestosis, mesothelioma, and other cancers of the lung, esophagus, stomach, colon and other organs (Lang, 1984; Malcolm, 1980). Lang (1984) states that the danger to children is of particular concern because other factors, such as children's higher rate of metabolism, increased activity, and more rapid cell development during childhood result in a greater lifetime risk. As contrasted

Only one federal statute addresses asbestos in schools: the Asbestos School Hazard Abatement Act of 1984. This act authorizes the EPA to administer a program of technical and financial assistance to local school districts and private schools for detection and abatement of asbestos health hazards. The EPA, under the Toxic Substances Control Act, has banned the manufacture and distribution of all products containing asbestos (including art materials) by 1996. The Department of Education has estimated the average cost of asbestos abatement to be $100,000 per school (NEA, 1985).

The fear that all asbestos in schools represents an immediate danger, has resulted in hasty, unnecessary, and even dangerous asbestos removal. The Safe Buildings Alliance (1984) states that the real issue is identifying the few buildings where asbestos-containing materials pose a real risk. They propose adoption of uniform standards governing abatement, and the development of responsible inspection processes and training programs as alternatives to the dangerous process of indiscriminate asbestos removal. Testing for asbestos can be done through bulk sampling to determine if asbestos is actually present in the school. At least three small samples of each suspected material must be removed and taken to a qualified laboratory for analysis.

Lead Poisoning.

According to a 1991 statement by the Center for Disease Control, childhood lead poisoning is the most serious environmental threat to young children in the United States today; and it is entirely preventable. The EPA estimates that in 1990, 15 percent of the children under 6, more than 3 million children, had blood levels above 10 mg/dl.

with asbestos workers, school-age children have a significantly greater risk of developing mesothelioma in their lifetime because of the age of asbestos exposure. Lang (1984) explains the risk of developing mesothelioma remains constant for an initial period and them increases continuously with time from initial exposure. The EPA estimates that a child exposed from ages 5 to 10 has at least 10 times the risk of developing mesothelioma as an adult exposed to the same level between the ages of 35 and 40. In addition to the students, a substantial health risk to the faculty and staff exists. The EPA concluded that as many as 15 million students and 1.4 million staff in 31,000 schools may be exposed to asbestos (Lang, 1984; NEA, 1985).

The problem of asbestos in schools is not limited to health problems. The issues at stake are product liability, sovereign immunity, insurance, and bankruptcy. In schools, asbestos has been widely used in cement products, plaster, fireproof textiles, vinyl floor tiles, thermal and acoustical insulation, and sprayed material. From the 1940s to the mid-1970s, thousands of school buildings were constructed or renovated using asbestos (National Education Association, 1985). Not all asbestos-containing materials pose a risk. Hard materials, such as vinyl floors, do not usually present a problem (unless the fibers are altered or disturbed during building renovation or repair). It is the loose, or "friable," material that causes exposure problems. Friable materials are typically the ones that have been sprayed or troweled onto surfaces and that crumble easily. In schools, the most likely places to find friable asbestos is on ceilings, steel-supported beams and columns, cafeteria walls, and gymnasium ceilings (Lang, 1984, 1985).

Overwhelming evidence exists that adverse effects occur at this level. Even low levels of exposure can cause subtle brain damage and reduce a young child's IQ (Subcommittee on Health and Environment, 1993). Lead also poses health risks for adults. Exposure increases blood pressure and increases the risk of heart disease and stroke. Lead exposure may also damage the male reproductive system (House Committee on Energy and Commerce, 1992).

The House Committee on Energy and Commerce (1992) reported that lead-based paint and lead-contaminated soil are the most significant causes of childhood exposure. Most soil naturally contains a small amount of lead. However, in many places, human activities have dramatically increased concentrations. Soils contaminated from paint, gasoline, and industrial sources can pose a serious health risk, making urban areas the greatest risk. The most widespread cause of soil contamination is the fallout from leaded gasoline.

Federal efforts have controlled many new sources of lead pollution, but no federal program exists to reduce the level of lead already in soil. The federal Superfund program can be used to clean up lead-contaminated soil on industrial hazardous waste sites, but no federal efforts have been made to clean up lead-contaminated soil in residential or school areas, even though these sites generally pose the greatest health risks (House Committee on Energy and Commerce, 1992).

Drinking water also causes exposure to lead, resulting in 20 percent of the total public exposure to lead poisoning. Compared to lead paint, lead in drinking water affects more people, but at much lower levels. The EPA estimates that 30 million children are exposed to some lead in drinking water. Of these, 20 million are exposed to enough lead to reduce their IQ by at least small amounts (House Committee on Energy and Commerce, 1992).

Most lead in drinking water leaches into the water from lead-bearing materials in the plumbing and water distribution systems. Common sources include lead pipes, lead solder, and brass faucets (which contain up to 8% lead). Water fountains that cool drinking water can contain lead-lined tanks and other lead-bearing parts. Tests of water coolers at schools have shown lead levels as high as 100 parts for billion (ppb) or higher (House Committee on Energy and Commerce, 1992).

The House Committee on Energy and Commerce (1992) reports that the food supply is another important source of exposure to lead. Sources of lead in the diet include ceramic ware coated with lead-based glazes, crystal ware, and imported food cans using lead solder. Certain processed foods, including calcium supplements made from animal meal, may also have high lead levels.

The Subcommittee on Health and Environment (1993), reported that only 9 of 57 school districts surveyed inspect for lead paint hazards and only 3 inspect for lead-contaminated soils. They propose that schools investigate, disclose, and correct lead hazards. This can often be accomplished simply and inexpensively.

<u>General Indoor Air Quality.</u>

The House of Representatives Committee on Energy and Commerce, Subcommittee on Health and the Environment (1993) determined that serious environmental threats exist in the air of the nation's schools. Biological contaminants like bacteria and fungal spores, carcinogens like formaldehyde, and environmental tobacco smoke create long and short-term health problems for students and staff in schools. Comparative risk studies conducted by the EPA (1990) concluded that indoor air pollution is among the top four environmental risks to public health. Indoor levels of many pollutants may be 2 to 5 times, and occasionally 100 times, higher than outdoor levels. This is a concern because many people spend 90% of their time indoors. The EPA (1990) attributes the increase in indoor air pollutants to factors such as the construction of tightly sealed buildings, reduced ventilation rates to save energy, increased use of synthetic building materials and furnishings, and the increased use of chemically-formulated personal care products, pesticides, cleaners, etc.

Schools have unique characteristics that increase the likelihood of indoor air quality problems: special pollutant sources used in art rooms, science, and vocational laboratories; HVAC systems that are not adequate; and the large number of children in classrooms. The EPA has detected elevated levels of carbon dioxide, air pollutants such as radon, mold, fungi, mildew, and volatile organic chemicals in schools. The EPA (1990) states that exposure to indoor air pollutants can be significantly reduced by implementing better building operation and maintenance practices (Committee on Energy Commerce, 1993).

The House of Representatives Committee on Energy and Commerce, Subcommittee on Health and the Environment (1993) described the most common indoor air pollutants: bacteria, viruses, and fungal spores; formaldehyde (probable carcinogen in plywood, particle board, insulation and fabrics); radon gas; asbestos fibers; carbon monoxide (odorless gas produced through incomplete combustion such as gas stoves and improperly vented heating equipment); nitrogen dioxide (the product of high temperature combustion, such as gas stoves and unvented heaters); tobacco smoke (carcinogen); pesticides (used in approximately 84 percent of homes and almost all schools); lead dust (with an absorption rate through the lungs of 95 percent in children and infants); solvents (commonly contain butoxyethonal and xylenes which are possible carcinogens.

The EPA, Occupational Safety and Health Administration (OSHA), the Department of Energy, and the Consumer Product Safety Commission have partial authority to control indoor air pollution.

The Maryland State Department of Education (Turner,1991) found several sources of serious air contamination in schools: kilns, duplicating equipment, and welding materials. Kilns used in art departments cause emissions that include sulfur dioxide, metals, nitrogen dioxide, carbon monoxide, organic compounds, and ozone. There is also potential for hazardous dusts from the clay and glazes, particularly crystalline free silica. Choosing safe art materials for school systems is easier now by using Approved Products Program of the Art and Craft Materials Institute, a non-profit association of manufacturers of quality children's art materials. The AP seal appears on the materials.

Duplicating equipment has been identified as a major source of indoor air contamination. Mimeograph machines do not usually present an inhalation hazard. However, most other copiers do. Photocopiers employ an electrostatic copying process in which a photoconductive material is charged and discharged, producing ozone as the major contaminant. Ozone can cause irritation to mucous membranes, headaches, and impairment of vision. Spirit duplicating machines use methyl alcohol as a duplicating fluid. During the duplicating process, the methyl alcohol vapors are released into the ambient air. Overexposure to methyl alcohol may cause drowsiness, dizziness, nausea, vomiting, irritation and burning of the eyes, and blurred or temporary loss of vision. Diazo dyeline copiers use ammonia in an aqueous solution. Ammonia vapors are a strong irritant affecting eyes and mucous membranes and may be released from the solution to the ambient environment. Electronic stencil makers use high intensity sparks to burn characters in plastic stencils. In the process, hydrogen chloride, particulate matter, organic vapors, ozone, and carbon monoxide may be produced. However, at the concentration normally encountered, the contaminants are usually more of a nuisance than a health hazard (Turner,1991) .

Welding activities in school industrial arts classes can include welding, brazing, and thermal cutting. These processes generate many types of metal fumes and gases which present potential health hazards. The largest source of metal fumes is the filler metal. Fumes may also originate from the base metal, from coatings applied to the base metal, and from the flux or electrode coatings. Gases may come from the arc, the burning process, or from changes in the surrounding air, including acetylene, arsine, carbon monoxide, nitrogen dioxide, ozone, phosgene, and phosphine. Acute respiratory diseases, such as metal fume fever and pneumonitis are the most common problems. Some fumes may also be irritants (Turner,1991).

Before the banning of smoking in schools, environmental tobacco smoke (ETS) was a major problem. ETS is one of the most widespread and harmful of indoor air pollutants. About 467,000 tons of tobacco are burned indoors each year. Cigarette smoke contains more than 4,700 chemical compounds, at least 43 of which are known carcinogens. The main effects of the irritants present in ETS occur in the conjunctiva of the eyes and the mucous membranes of the nose, throat, and upper respiratory tract. Particularly acute symptoms may be found in infants, children, and persons with cardiovascular or respiratory disease, or wearers of contact lenses (Turner, 1991).

<u>Control of Indoor Pollutants.</u>

Source control or containment is the preferred method for achieving good indoor air quality. Exhausting air from the immediate vicinity where contaminants are generated limits their dispersion and is an effective strategy for kilns, photography developing, science labs, welding shops, and duplicating centers. Locating outdoor air intakes far from contaminated exhaust emissions is another good control measure. Other than source control, dilution with contaminant-free ventilation air is the preferred means of limiting the concentrations of contaminants. Ventilation air is usually a mixture of both outdoor air and recirculated air from which contaminants have been removed by air cleaning in the

HVAC system. Airborne particles are removed by filters. Gaseous contaminants are removed by adsorption or chemical modification. Ionizers are used to purify the air. Airborne particles charged with an electrical charge are ionized. Ionized particles are attracted to surfaces with an opposite charge, often room surfaces, and are thus removed from the air. Asbestos and radon are not controlled by HVAC systems. Radon control may involve ventilation, but of a specialized nature (Wheeler, 1992).

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Organization/Address:
Morehead State University
503 Ginger Hall
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Telephone: 606-783-5207

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