Reviewing and Refocusing on IAQ in Schools:

When millions of students return to school after the long summer break, their first few days often are devoted to reviewing what they learned last year and getting refocused for the coming year's studies. The start of the new school year also is an opportune time to review the status of indoor air quality (IAQ) in our nation's schools and refocus on what can be done to ensure these facilities are as free of indoor pollutants as possible. This paper reviews which indoor pollutants in schools are of most concern, how poor IAQ impacts children's health and ability to learn, and some exciting new resources that can help turn the tide towards healthier indoor learning environments.

Do the Math: Poor IAQ = Widespread Health Risks, Negative Impacts on Learning and Productivity

According to the US Environmental Protection Agency (USEPA), 20 percent of the US population (55 million people) spends a significant amount of time each day in more than 120,000 public and private schools. Many of the school buildings are in poor condition, which accounts for the USEPA's estimate that 50 percent of US schools have IAQ problems. Other professional organizations and government agencies have reported similar findings in more than 20 years of monitoring conditions in schools. These findings are summarized in the National Research Council of the National Academies' interim report, *Review and Assessment of the Health and Productivity Benefits of Green Schools* (National Research Council 2006).

What this means is poor IAQ in schools continues to place 10 percent (27.5 million people) of the US population at risk for health problems, such as coughing, eye irritation, headaches, asthma, allergies, and in rare cases Legionnaire's disease, carbon monoxide poisoning and cancer. Among those most at risk are the more than 6 million students who have asthma.

Asthma can be life-threatening if not properly managed, and is the leading cause of school absenteeism and hospitalizations in children under the age of 15. Asthma accounts for an estimated 14 million lost school days and $16 billion in annual health care expenditures for both children and adults. Asthma also tends to be seasonal, especially among children, with a noticeable spike in asthma-related emergency room visits and hospitalizations in September (Johnston et al 2006, Neidell 2004, AAFA 2005, AAAAI 2005).

As a part of its review and assessment of the health and productivity benefits of green schools, the National Research Council found "a robust body of evidence indicating that the health of children and adults can be affected by air quality in a school," and "a growing body of evidence [suggesting] that teacher productivity and student learning, as measured by absenteeism, may be affected by indoor air quality as well" (National Research Council 2006). The California Air Resources Board (CARB) reached a similar conclusion in its report to the California Legislature on the quality of indoor air in that state (CARB 2005). Before reviewing the findings in these reports, an overview of which indoor air contaminants are of most concern may be helpful.

Indoor Air Pollution: A Complex Mixture of Particulates, Gases, Vapors and Odors

Airborne pollutants, including potential carcinogens, reproductive toxins, and human irritants, are 2 to 10 times higher indoors when compared with outdoor levels and can be as much as 1,000 times higher in newly constructed and renovated schools. These visible and invisible contaminants generally fall in one of two categories: (1) particulates or (2) gases, vapors and odors. The following provides a brief description of each category. For more detailed information about these indoor air contaminants, see the AQS research report, *Clearing the Air on Indoor Air Cleaners / Purifiers*, which is available at no cost under the White Paper tab of the premium content section in the AQS Aerias IAQ Resource Center website (**www.aerias.org**).

Particulates. Particulates are particles that are small enough to suspend in the air. Suspended inorganic particles, such as metals (lead, mercury); dust; pollen; asbestos and other fibers; car, bus and truck exhaust; or environmental tobacco smoke and other types of smoke, are often referred to as *aerosols*. Suspended organic compounds and small living organisms, such as bacteria and viruses; mold spores and pieces of mold colonies; dust mite feces and body fragments; cockroach body parts; and dander from cats, dogs and other mammals, are called *bioaerosols* (McDonald and Ouyang 2000). Allergens, associated with grasses, pollen, dogs, cats, dust mites, cockroaches and mice to name a few common examples, also fall into this category. Particles can range in size from very small (0.001 µm to 10 µm), which can remain in the air for a long time, up to relatively large (100 µm), which quickly settle out of calm air (ALA Special Report on Air Cleaners).

Inhaling particulates can cause eye, nose and throat irritation and increase the risk for respiratory infections. Health care professionals are especially concerned about the long-term effects of inhaling fine particles (less than 2.5 µm – also referred to as $PM_{2.5}$ or fine PM), because they can travel deep into the lungs where they can remain embedded for years or be absorbed into the bloodstream. Inhalation of fine PM have been linked to increases in respiratory health problems such as asthma, bronchitis, pneumonia and emphysema; hospitalization for heart or lung disease; and even premature death. The results of numerous studies have demonstrated a correlation between adverse health effects, including premature death, and the level of fine PM. In response, the USEPA has established an aggressive program and standards to reduce fine PM levels in outdoor air. These same concerns also apply to indoor air in schools. For more information and a comprehensive review of these studies, see Dockery DW et al 1993; Moolgavkar, Dockery and Pope 1994; Godleski JJ et al 2000; USEPA Provisional Assessment of Recent Studies on Health Effects of Particulate Matter 2006; and the USEPA website on particulate matter, **www.epa.gov/oar/particlepollution**.

Larger particles (greater than 10 µm) do not cause as much concern, because they get caught in the nose and throat and are cleared from the respiratory tract by coughing or swallowing (ALA Special Report on Air Cleaners).

Gases, Vapors and Odors. The types of gases or vapors most often found in schools include combustion byproducts, such as carbon monoxide, nitrogen oxides, sulfur dioxide, soot particles and polycyclic aromatic hydrocarbons (PAHs); human and cooking odors; carbon dioxide and volatile organic compounds (VOCs); and perhaps microbial VOCs and mycotoxins. Many of these substances also produce odors, some of which are pleasant while others can be distracting and irritating. Moisture also is a vapor that must be monitored as too much moisture can support indoor mold growth.

Materials and products used in school buildings frequently have organic compounds as a part of their composition. Under the right conditions, these compounds can evaporate or sublimate into the air – hence the term *volatile organic compounds*. As many as 100 to 1,000 different VOCs may be in the indoor air at any one time where both children and adults can easily inhale them. Examples of the materials and products that can emit VOCs include solvents, construction materials, textiles, furnishings, finishes, classroom supplies, consumer products, pesticides, fragrances, personal care products, and cleaning products and copy machines.

Air Quality Sciences, Inc. (AQS) has measured VOC levels in more than 200 US schools and found 345 different VOCs in the indoor air. Table 1 lists the 15 most common VOCs found in these schools. Other frequently found VOCs of concern in schools include perchloroethylene and methylene chloride, potential carcinogens related to spot cleaners, degreasers, and art supplies.

Table 1. Common VOCs Found in Schools

VOC	Source(s)
Toluene	Cleaners, construction materials
Xylenes	Cleaners, construction materials
Siloxanes	Waxes, polishes, deodorants
Formaldehyde	Furniture, ceiling tile, wood shelving, cabinetry
Hexane	Markers, cleaners
Acetone	Markers, art supplies
1,4 Dichlorobenzene	Cleaners, deodorizers
Naphthalene	Cleaners, adhesives, deodorizers
Hexanal	Wood cabinetry, shelving, paints
2-Butoxyethanol	Cleaners, paints
Ethanol	Disinfectants
TXIB	Plastics, paints
Acetaldehyde	Cleaners, wood products, flooring
Longifolene	Adhesives, art supplies
Limonene	Cleaners, fragrances

The AQS test results also show that the average total VOC (TVOC) level was 276 µg/m^3, with a minimum of 1.7 µg/m^3 and a maximum of 4600 µg/m^3. TVOC levels are usually compared with the following guide (Table 2) to determine potential health impacts (Mølhave 1992). Most standards and guidelines consider 200 µg/m^3 to 500 µg/m^3 TVOC as acceptable. Levels higher than this may result in irritation to some occupants. While TVOC is a good indicator of elevated VOCs and complicated VOC mixtures may lead to irritation, minimizing the presence of specific chemicals with known health hazards, provides the best protection for school occupants.

Table 2. General guide to TVOC emissions and health effects

Less than 0.20 mg/m^3	No irritation or discomfort expected
0.20 µg/m^3 – 3.0 mg/m^3	Irritation and discomfort may be possible
3.0 µg/m^3 – 25.0 mg/m^3	Discomfort expected and headache possible
Greater than 25 mg/m^3	Toxic range where other neurotoxic effects may occur

Complicating matters is the potential for interactions of VOCs with other chemical compounds to form a third compound that also may be a threat to health and comfort. As a result, even though the concentrations of individual VOCs may be well below odor thresholds or known toxic levels, their occurrence by themselves or in complex mixtures may lead to perceived poor indoor air quality or irritation among those exposed. For examples and more information, see the AQS research report, *Cleaning Products & Processes: Partnering for Healthier Indoor Environments*, which is also available at no cost under the White Paper tab of the premium content section in the AQS Aerias IAQ Resource Center website.

Some types of mold also emit VOCs, known as microbial VOCs or MVOCs, which are responsible for the characteristic musty, earthy odors associated with mold. People who are sensitive to MVOCs may experience eye, nose and throat irritation. In addition, a wide variety of molds can produce mycotoxins at various times during their lifecycles. Building occupants can experience potentially serious health problems if they are exposed to high levels of these compounds, but this is rare in most indoor environments.

Formaldehyde in Schools. Formaldehyde exposure is a major concern in schools, particularly in those that use portable classrooms. Formaldehyde is used widely by industry to manufacture building materials and numerous household products, and also is a by-product of combustion and certain other natural processes. Primary sources include pressed wood products such as particleboard, plywood, and medium density fiberboard (MDF); finished furniture, shelving, and cabinetry made with composite boards and certain coatings; decorative fabrics and textiles; and paper products. It also may be used as a biocide in certain paints and coatings, adhesives, and personal care items.

Based on more than 300 measurements collected in residences, office buildings and schools, AQS studies have found typical concentrations range from 0.01 ppm to 0.03 ppm in office buildings and 0.05 ppm to 0.08 ppm in homes. An average level of 0.04 ppm has been found in schools, with new or recently renovated or refurbished school environments reaching 0.14 ppm. The levels found in schools are as significantly higher than the 0.022 ppm (22 ppb) limit recommended in the new GREENGUARD Certification for Children & Schools.

Available clinical and epidemiological data indicate that individual responses to formaldehyde may vary substantially. Irritation may occur at levels of 0.08 ppm or less, and odor detection has been measured as low as 0.03 ppm. When formaldehyde is present in the air at levels exceeding 0.1 ppm, some people may experience watery eyes; burning sensations of the eyes, nose, and throat; coughing; wheezing; nausea; and skin irritation. Some people are very sensitive to formaldehyde, while others have no reaction to the same level of exposure. Other health effects include coughing, fatigue and severe allergic reactions. High concentrations also may trigger asthma attacks.

Although the short-term health effects of formaldehyde exposure are well known, less is known about its potential long-term effects. Because of the concern that formaldehyde may cause cancer, the USEPA has classified formaldehyde as a probable human carcinogen under conditions of unusually high or prolonged exposure. The International Agency for Research on Cancer (IARC), however, upgraded its initial classification of formaldehyde as a probable human carcinogen to a known human carcinogen in 2004. The California Air Resources Board supported the IARC findings by classifying formaldehyde as a “toxic air contaminant” after state experts concluded that based on current research, there is “no safe exposure threshold [for formaldehyde] … to preclude cancer.”

The World Health Organization (WHO) recommends keeping exposures below 120 $\mu g/m^3$ (0.10 ppm). The State of California recommends that levels be kept below 0.027 ppm. The Occupational Safety and Health Administration’s (OSHA) Hazard Communication Standard includes an important labeling provision addressing formaldehyde emissions from products. Specifically, hazard warning labels are required on any manufactured product that may emit 0.10 ppm or greater, regardless of its formaldehyde content. In order to receive certification as a low-emitting product from the GREENGUARD Environmental Institute, products must emit 0.05 ppm or lower. Products meeting GREENGUARD’s

Certification Children & Schools standard for sensitive populations must meet 0.014 ppm, based on intended use.

Poor IAQ and Health: Children At Greater Risk Than Adults

Children are more vulnerable to exposure and face greater environmental health risks to indoor pollutants than adults. Their organs and immune and neurological systems are still developing, and because of their lower body weight, they breathe in a relatively greater volume of air than adults. This results in a higher body burden of air pollutants for the same amount of exposure. A recent study, for example, found that children exposed to high levels of VOCs were four times more likely to develop asthma than adults (Rumchev et al 2004).

Other studies also have found an association between VOCs and asthma. The California Air Resources Board's report noted: "Delfino (2002) published a review of the epidemiological evidence for links between air toxics and asthma [in which he] cites Swedish studies that showed that self-reported asthma prevalence in school children increased with increasing VOC levels, and asthmatic adult symptoms occurred in association with toluene, C_8-aromatics, terpenes, formaldehyde and limonene." The report qualified Delfino by stating that he did not directly associate these findings with schools and that he cautioned that effects may be influenced or a result of other causal agents (CARB 2005).

A growing number of scientists also are concerned that exposure to very small traces of VOCs and some industrial chemicals in homes and schools may have profound impacts on fetuses, newborns and children, including disruptions to the endocrine system (hormones), gene activation and brain development. An especially striking finding is some chemicals may have health impacts at extremely low levels, which are not seen at higher levels. Minute levels of phthalates, for example, which are used to make toys, building materials, drug capsules, cosmetics and perfumes, have been linked to sperm damage in men and genital changes, asthma and allergies in children (Waldman 2005).

Researchers at the University of London suspected that small amounts of some environmental chemicals might have a dramatic effect on hormone levels. They tested the hormonal strength of 11 common chemicals, known to mimic estrogen. Alone, each chemical was very weak, but when low doses were mixed with natural estrogen, the strength of estrogen doubled (Waldman 2005, Rajapakse et al 2002). High levels of estrogen are associated with some forms of cancer and developmental problems during puberty.

At this time, research in this area is still very new, and as yet results do not present a clear picture. One upcoming study of particular note is the planned National Children's Study, sponsored by the USEPA and the Centers for Disease Control and Prevention. About 100,000 children at various ages from birth to puberty will participate in this study. Among the primary goals is to investigate the associations between exposures to environmental pollutants, such as VOCs among others, and adverse health outcomes, especially asthma, autism, attention deficit disorder and alterations at puberty caused by hormonal disruptions and other neurobehavioral and neurocognitive disorders (Özkaynak et al 2005).

Associating Poor IAQ With Health, Learning and Productivity

The National Research Council's interim report offers an excellent discussion on the challenges of establishing a direct causal link between the quality of indoor air and changes in building occupant health, learning achievements and teacher productivity. Among the reasons are individual responses to exposures to indoor pollutants are highly variable. Even so, the report concludes that after a comprehensive overview of the available literature, there is sufficient evidence that the quality of indoor air does impact health, student learning and teacher productivity.

The following lists the report's specific findings:

- “Numerous pollution sources and building system characteristics affect air quality in a school. The most important determinants of indoor air quality are (1) design and operation of the ventilation system to limit the buildup of pollutants and humidity and achieve thermal comfort, (2) control of indoor sources of pollutants, and (3) control of outdoor sources of pollutants.

- There is a robust body of evidence indicating that the health of children and adults can be affected by air quality in a school.

- A growing body of evidence suggests that teacher productivity and student learning, as measured by absenteeism, may be affected by indoor air quality as well.

- Indoor pollutants and allergens from house dust mites, pet dander, cockroaches, and rodents also contribute to increased respiratory and asthma symptoms among children and adults.

- The reduction of pollutant loads, both sensory and not, has been shown to reduce the occurrence of building-associated symptoms and to improve the health and comfort of people occupying the buildings.

- Although compliance with the American Society for Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) standards for ventilation rates may be the minimal acceptable standard for green schools, there is good evidence that increasing the ventilation rate beyond the ASHRAE standard will further improve comfort and productivity. However, an upper limit on the ventilation rates, indicating when the benefits of outside air begin to decline, has not been established.

- The body of available research is suggestive of an association between the condition of a school building and student achievement. All of the studies analyzed by the committee found that student test scores improved as the physical condition of school buildings improved. The degree of improvement of students’ test scores varied across the studies, but in all cases students in buildings in better condition scored higher than students in buildings in poor condition” (National Research Council 2006).

From a review of available research, the California Air Resources Board report to the California Legislature also concluded that: “Epidemiological studies have often found significantly lower prevalence of respiratory illness or surrogates for respiratory illness (sick leave, total absence from school) in buildings with higher ventilation rates, reduced office sharing, and less crowding” (Fisk 2000, Myatt et al 2004, Shendell et al 2004).

Making the Connection: Damp Buildings, Indoor Mold Growth and Asthma

In addition to the indoor air contaminants discussed above, moisture problems and indoor mold growth are a major concern, especially for sensitive individuals and those with allergies and asthma. Two studies released in 2005 provide the first solid evidence that damp buildings and exposure to mold bioaerosols is a risk factor for developing asthma and not just in making asthma symptoms worse. The results of these two studies indicate that there is clear connection between damp buildings, associated indoor mold growth and the development of asthma. The risk for developing asthma appears higher for, but is not limited to, people who are sensitive to mold allergens or who have parents with asthma (Jaakkola et al 2005, Cox-Ganser et al 2005).

These studies also update the often-quoted 2004 Institute of Medicine report, *Damp Indoor Spaces and Health*. This report offered a comprehensive review of the scientific literature on asthma, mold and other factors related to damp conditions in homes and buildings. The Committee on Damp Indoor Spaces and Health concluded that there is sufficient evidence that mold and damp conditions can cause asthma symptoms in people with asthma who are sensitive to mold, and to coughing, wheezing, and upper respiratory tract symptoms in otherwise healthy people. The committee at that time did *not* find sufficient evidence to establish a clear, causal relationship for the development of asthma, however these two studies were not then available (IOM 2004). With respect to mold, this report reaffirmed the findings of a 2002 Institute of Medicine report, *Clearing the Air: Asthma and Indoor Air Exposures* (IOM 2002).

In addition, the Jaakola and Cox-Gasner studies support the premise that cleaning up and preventing indoor mold growth by eliminating moisture and water intrusion is a critical factor for reducing the number of people who develop asthma and the frequency and severity of attacks among those who do have asthma. For more information and additional details about the impact of asthma on the US economy, see the AQS research paper, *Asthma and Damp Buildings: Making the Connection.*

Strategies and Resources for Improving IAQ in Schools

Efforts to improve IAQ in schools are gaining momentum, due in part to the explosive growth in the number of children developing asthma and the increased interest in using environmentally friendly products and green (sustainable) building methods. Powering this trend are mandates from colleges and universities, cities and municipalities as well as state and federal governments that buildings will be designed and built to meet US Green Building Council's (USGBC) LEED Green Building Rating System™ requirements (Zoning Practice 2005). The USGBC presently is developing a LEED – NC (New Construction) Application Guide for Schools (K – 12). In addition, states, such as Connecticut, Massachusetts, Minnesota, New York, Pennsylvania, Vermont and Washington, and cities, such as Seattle, Washington, and Santa Monica and San Francisco in California, also are mandating the use "green" or environmentally friendly cleaning products in state buildings and public schools (Doling 2005).

At the federal level, the USEPA's Indoor Air Quality Tools for Schools program continues to lead the way in providing resources and programs for school districts, administrators, facility managers and teachers to improve the air quality in schools. Since 2000, the Indoor Air Quality Tools for Schools (IAQ TfS) Program has recognized more than 100 schools and school districts for their accomplishments in creating a safe and healthy learning environment and maintaining good IAQ in their facilities. The USEPA also has developed an online resource, IAQ Design Tools for Schools that complements the IAQ Tools for Schools Program. The IAQ Design Tools for Schools helps existing schools prevent and solve IAQ problems. IAQ Design Tools for Schools also provides voluntary guidance for school personnel, architects and engineers, builders and contractors, parents and the community on key school construction and renovation issues.

At the state level, California has taken a lead role in raising awareness about the negative impacts of poor IAQ in schools and protecting students from indoor air pollution through its Collaborative for High Performance Schools (CHPS) program. To assist schools districts, the CHPS program has developed five Best Practices Manuals in design, construction, operation and maintenance. These manuals offer a non-regulatory approach that could yield large gains in indoor health in all types of buildings

Other states and local jurisdictions are following suit, as are private education organizations. See the Additional Resources and Articles listing below for more examples of these programs. Among the guidance offered by these programs is to use environmentally friendly construction materials, furnishings, finishes, office equipment, and cleaning products and processes. To date, however, none of the available product standards and protocols that ensure low emission levels of VOCs has taken children's special needs into account – until now.

The GREENGUARD Environmental Institute (GEI) has created a new standard and product certification for low-emitting products and materials for use in daycare and school facilities. The tough new GREENGUARD Certification for Children & Schools is an extension of the established GREENGUARD Indoor Air Quality Certification Program.

This standard takes the sensitive nature of school populations and the unique building characteristics and maintenance conditions found in schools into consideration and presents the most rigorous product emissions criteria to date. The following summarizes key provisions in the standard, requiring that all construction and furnishing products meet these emission levels within five days of manufacturing and installation in the school. This standard limits acute (irritation and odor) and long-term chronic exposure effects (Table 3).

Table 3. GREENGUARD Emission Standard for Educational Environments (see bullets following the table for important notes)

Chemical	Allowed Emission Contributions
TVOC	$\leq$ 215 µg/m³
Formaldehyde	$\leq$ 0.022 ppm
Total Aldehydes	$\leq$ 0.043 ppm
Individual VOCs	$\leq$ 1/100 TLV or ½ CA Chronic REL (whichever is less)
Total Phthalates	$\leq$ 10 µg/m³
Total Particles ($\leq$ 10µm)	$\leq$ 22 µg/m³

Notes:

- Formaldehyde requirement at 5 days ensures that products will meet the 13.5 ppb requirement according to California's 1350 environmental specification at 14 days of installation.

- Air concentrations based on usage of furnishings/materials within an educational/classroom environment with stringent outdoor air ventilation rates of ½ the value recommended by the ASHRAE 2004 Ventilation Standard for Acceptable IAQ.

- Total phthalates include dibutyl (DBP), diethylhexyl (DEHD), diethyl phthalate (DEP), dibenzyl phthalate, (DBzP), diisobutyl phthalate (DIBP), and diethyl (DEP), common material related phthalates.

- Identified VOCs measured in mass spectrometric scan of C_6 - C_{16} hydrocarbon range, evaluated for presence on ACGIH/TLV list and CA CREL list. TVOC includes all measured VOCs in scan range calibrated to toluene.

- Total aldehydes include 2-Butenal, Acetaldehyde, Benzaldehyde, Benzaldehyde 2,5-dimethyl, Benzaldehyde 2-methyl, Benzaldehyde 3- and/or 4-methyl, Butanal, Butanal 3-methyl, Formaldehyde, Hexanal, Pentanal, and Propanal.

- Particles applicable to fibrous, particle-releasing products with exposed surface area.

AQS provides product evaluation testing for this program, using environmental chamber technology (ECT), the most reliable and scientifically proven way to test for VOC emissions. This method allows a product to produce emissions similar to the way the product would emit in a school environment. Measured emissions data are then used to determine exposure concentrations expected by use of the product in many different indoor environments, including schools. Exposure concentrations are used in various risk models to predict cancer and non-cancer health effects, including expected odor and irritation responses.

AQS pioneered ECT technology more than 16 years ago and actively participated in establishing the methodology used to test products. This testing methodology was further developed by consensus during an official dialogue among various stakeholders and the USEPA and has been adopted by ASTM International as D 5116-97, *Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products*, and D 6670-01, *Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products*.

AQS has assisted numerous manufacturers in achieving GREENGUARD certification for products used in today's schools, including classroom furniture, adhesives, flooring, thermal insulation and flooring. Certified products can be found in GREENGUARD's free online product guide at **www.greenguard.org**.

AQS stands ready to partner with the school districts to create and maintain healthy indoor environments. In addition to supporting the GREENGUARD product certification programs, the firm also employs building consulting experts who can advise you on how to improve IAQ in schools as well as diagnose and resolve IAQ problems.

Visit us at at **www.aqs.com** to learn more about how the AQS Building Consulting Group and Product Evaluations team can help you, or call us at (770) 933-0638. Also visit the GREEENGUARD Environmental Institute at **www.greenguard.org** and the AQS Aerias IAQ Resource Center to learn more about particulates, VOCs and other indoor contaminants. Aerias may be accessed from the AQS website or at **www.aerias.org**.

For More Information: AQS Research Reports

The following research reports, published by Air Quality Sciences, offers more information on a related topics covered in this report, all of which are available at no cost from the Premium Content section of the AQS Aerias IAQ Resource Center website **at www.aerias.org:**

- Asthma and Damp Buildings: Making the Connection
- Cleaning Products & Processes: Partnering for Healthier Indoor Environments
- Clearing the Air on Indoor Air Cleaners / Purifiers
- If You Build It Green, They Will Come

Additional Resources and Articles

The following articles and resources provide more information on this important topic as well as strategies for improving indoor environments in schools. The list was compiled by the GREENGUARD Environmental Institute (**www.greenguard.org**). Many of these resources are available online.

American School Board Journal

- Schorr P. Breathe easy. American School Board Journal. (192)6: 35 – 37. June 2005. Available online at **www.asbj.com/specialreports/0605SpecialReports/S3.html**;

American School and University Magazine

- Hughes M and Epstein BL. More than mold. American School and University. (77)1: 41 – 43. September 2004. Available online at **http://asumag.com/mag/university_mold/**.

AQS Aerias IAQ Resource Center

- Indoor Air Quality in Schools. Available online at **www.aerias.org**.

The Association of School Business Officials International

- McPhee N. Addressing asthma and indoor air quality in schools. School Business Affairs.(71) 5:28, 29. May 2005. Available online at **http://asbointl.org/asbo/files/ccPageContent/DOCFILENAME/000000012577/SBA_**.

California Air Resources Board

- Report on Indoor Air Pollution in California. Available online at **www.arb.ca.gov/research/indoor/ab1173/finalreport.htm**
- Portable Classroom Study. Available online at **www.arb.ca.gov/research/indoor/ab1173/finalreport.htm**.
- The Know Zone. Available online at **www.arb.ca.gov/knowzone/knowzone.htm**.

California Department of General Services

- Sustainable Schools Resources. Available online at **www.sustainableschools.dgs.ca.gov/SustainableSchools/sustainabledesign/ieq/iaq/materialsandvocs.html**.

Collaborative for High Performance Schools (CHPS) and Massachusetts High Performance Green Schools

- California's Collaborative for High Performance Schools home page: **www.chps.net**
- Massachusetts High Performance Green Schools Guidelines: Planning. Available online at **www.masstech.org/RenewableEnergy/green_schools/CHPSMA_vI-PLANNING-FINAL.pdf**.
- Woods JE, Penney BA, Freitag PK, et al. Health, energy and productivity in schools: Overview of the research program. Indoor Air 2002: The Ninth International Conference on Indoor Air Quality and Climate. Monterey, California. 2002. Available online at **www.chps.net/info/iaq_papers/PaperIV.1.pdf.**
- Sowa J. Air quality and ventilation rates in schools in Poland: Requirements, reality and possible improvements. Indoor Air 2002; The Ninth International Conference on Indoor Air Quality and Climate. Monterey, California. 2002. Available online at **www.chps.net/info/iaq_papers/PaperIV.3.pdf**.
- Reiser R, Meile A, Hofer C, et al. Indoor air pollution by volatile organic compounds (VOC) emitted from flooring material in a technical university in Switzerland. Indoor Air 2002: The Ninth International Conference on Indoor Air Quality and Climate. Monterey, California. 2002. Available online at **www.chps.net/info/iaq_papers/PaperIII.4.pdf**.
- Heath GA and Mendell MJ. Do indoor environments influence student Performance? A review of the literature. Indoor Air 2002: The Ninth International Conference on Indoor Air Quality and Climate. Monterey, California. 2002. Available online at **www.chps.net/info/iaq_papers/PaperII.1.pdf**.

Environmental Law Institute

- Database of State Indoor Air Quality Laws: Excerpt IAQ in Schools. Available online at **www.eli.org/pdf/schools_excerpt.pdf**.
- Berstein and Tobie. Healthier schools: A review of state policies for improving indoor air quality. Environmental Law Institute, Washington, DC. January 2002. Available online at **www.elistore.org/reports_detail.asp?ID=56**.

GREENGUARD Environmental Institute

- GREENGUARD Product Emission Standard For Children & Schools™: Available online at **www.greenguard.org.**
- GREENGUARD Certified Product Guide: Available online at **www.greenguard.org**.

Lawrence Berkeley National Laboratory

- Daisey JM, Angell WJ, Apte MG. Indoor air quality, ventilation and health symptoms in schools. Indoor Air. (13)1: 53 – 73. March 2003. Available online at **http://eetd.lbl.gov/ied/pdf/LBNL-48287.pdf.**
- Hodgson A. Fisk WJ, Shendell D, Apte MG. Predicted concentrations in new re-locatable classrooms of volatile organic compounds emitted from standard and alternate interior finish materials. July 18, 2001. Available online at **http://eande.lbl.gov/ied/viaq/pubs/LBNL-48490.pdf**.

School Planning and Management Magazine

- Kirch K. The ABC's of IAQ. School Planning and Management. (43)12:18, 20 – 22. December 2004. Available online at **www.peterli.com/archive/spm/801.shtm**.

Thorax Journal, British Thoracic Society

- Rumchev K; Spickett, J.; Bulsara, M.; et al. Association of domestic exposure to volatile organic compounds with asthma in young children. Thorax. (59) 746-751. 2004. Available online at **http://thorax.bmjjournals.com/cgi/content/full/59/9/746**.

US Department of Education

- A Summary of Scientific Findings on Adverse Effects of Indoor Environments on Students' Health, Academic Performance and Attendance

US Environmental Protection Agency

- Tools for Schools. Available online at **www.epa.gov/iaq/schools**.
- Design Tools for Schools. Available online at **http://www.epa.gov/iaq/schooldesign/**
- Healthy School Environments and Healthy SEAT. Available online at **www.epa.gov/schools/**.
- Asthma. Available online at **www.epa.gov/asthma/**.
- Particulate Matter: Available online at **www.epa.gov/oar/particlepollution/**

University Business Magazine

- Sausner R. Sick buildings, sick kids. University Business. (8)7:48 – 52. July 2005. Available online at **www.universitybusiness.com/page.cfm?p=862**.

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