

INDOOR AIR QUALITY IN SCHOOLS

When parents send children to school, they are concerned about their safety, well-being and learning environment. Unfortunately, most schools today do not provide acceptable levels of indoor air quality for the students, teachers, or staff. There have been many studies in the past few years which address the problems caused by inadequate ventilation, filtering, and air cleaning in school environments. Poor indoor air quality can have a negative effect on a child's health and academic performance. It has been estimated that more than 25 million children, over 50% of the students in the United States, attend schools without an adequate indoor air quality management plan.¹

Indoor air quality ("IAQ") is defined by the concentrations of various pollutants including:

- Volatile Organic Compounds (VOC's)
- Carbon dioxide (CO₂)
- Airborne fungi
- Mold and mildew
- Dust and dust mites

Specific concentration of these pollutants, as well as ventilation rates, have been linked to sick building syndrome ("SBS"). Sick building syndrome can be characterized by several symptoms, including:²

- Lethargy, lack of attention, drowsiness
- Headaches
- Sore throat
- Dry and itchy skin
- Nasal stuffiness and dryness (sinus infections)
- Dryness and pain in the eye.

Children have been shown, in recent studies, to be more prone to SBS than adults because they inhale more pollutants per body weight than adults, due to their higher breathing rates.³

Indoor Air Quality Affects Children's Health and Comfort

- 1. Indoor exposure to VOCs has been associated with SBS symptoms in school children.⁴
- 2. Elevated CO_2 levels have been linked to symptoms of wheezing among children.⁵
- 3. Increased rates of asthma and asthma-related illnesses cause over 14 million missed school days per year in the United States.

- 4. Mold and mildew in classrooms can lead to irritations, coughing, wheezing, exhaustion, headaches and other breathing illnesses that are especially detrimental to young people with compromised immune systems. High levels of humidity in a building can promote mold and mildew growth.
- 5. Students regularly miss class because of respiratory infections, allergies, or an adverse reaction to chemicals used in classrooms for cleaning.
- 6. Higher CO₂ levels cause many students to easily lose focus during school, hurting their performance on standardized tests. Other environmental factors such as abnormally high classroom temperature or particulate matter levels also contribute to inattention on the part of students during class time.
- 7. Low ventilation rates have been associated with increased nurse visits by school children.⁶
- 8. Teachers and administrative staff are also affected by poor indoor air quality. Teachers and staff face all of the negative impact of poor indoor air quality just like the students, plus teachers are also faced with the difficult task of trying to teach children in an environment where students find it hard to pay attention and learn. Administrators are responsible for not only the academic performance of children in their schools but also in maintaining a healthy environment for students, teachers, and staff which includes maintaining acceptable levels of indoor air quality.

Indoor Air Quality Affects Children's Performance at School.

- 1. In a study of over 100 US elementary classrooms, there was a 2.9% and 2.7% increase in math and reading scores, respectively, for each liter per second per person increase in ventilation rates.⁷
- Higher ventilation rates have been associated with faster and more accurate student responses for color, picture memory, and word recognition.⁸
- 3. A 1000 part per million (ppm) increase above ambient levels of CO_2 , has been linked to a 10 20% increase in absenteeism.⁹
- 4. Every 100 PPM increase in CO₂ was associated with roughly 1/2 day per year reduction in school attendance.¹⁰
- 5. Studies have shown that children perform better in classrooms as the speed of ventilation rate increases or pollutants are removed from the building.¹¹
- 6. Performance on standardized tests also increases in both math and reading as ventilation rates increase in classrooms.¹²

Causes of Poor Indoor Air Quality

The following building factors or pollution in buildings most frequently associated with respiratory health effects include:

- Low ventilation rates.¹³
- Outdoor pollutants or vehicle exhaust.¹⁴
- Presence of water damage or microbiological pollutants (such as mold and bacteria).¹⁵
- Animal and other biological allergens.¹⁶
- Combustible byproducts such as nitrogen or carbon monoxide from heat sources using fossil fuels.¹⁷
- Moisture or dirt in an HVAC system.¹⁸
- Formaldehyde.¹⁹
- Chemicals in cleaning products.²⁰
- VOCs used in paints and lacquers or glues and adhesives from craft materials.
- Asbestos found in buildings built before 2000.

Nearly 80% of the teachers responding to a survey in Chicago and District of Columbia schools reported that school building conditions were an important factor in teaching quality in their schools. Almost half of these teachers who graded their facilities at "C" or below would consider leaving the school district. The most frequently cited problem was bad indoor air quality.²¹

The following list includes many of the reasons for bad indoor air quality in schools:

- Poor ventilation results in high levels of pollutants, pathogens, and CO₂ in classrooms. This can lead to the growth of mold, mildew and bacteria which can be circulated throughout a building. If an HVAC system is not cleaned regularly and the filters changed on a regularly scheduled basis, these particulates can circulate through a building causing a harmful buildup in classrooms, offices, gyms, and cafeterias. A recent study by the National Energy Management Institute (NEMI) and the University of California - Davis concluded that over 56% of the classrooms they tested did not have active ventilation.²²
- 2. Modern HVAC equipment is made so efficiently that air handling units and split systems do not provide an adequate amount of outside air to enter buildings using the most energy efficient systems.

- 3. Schools located near sources of pollution or near busy highways are inundated daily with noxious gases like carbon monoxide and other industrial waste products. Opening windows or dampers to bring in outside air exacerbates the problem and causes worse indoor air quality than if these measures had not been taken by the building operators. A recent study by Paul Gabrielsen of the University of Utah shows that outdoor pollution such as wildfires, fireworks, and wintertime inversions can all affect indoor air quality to different degrees.²³
- 4. The construction of tightly sealed buildings, the reduction of ventilation rates to save energy, the use of synthetic building materials and furnishings, and the use of chemically formulated products such as pesticide and cleaning supplies have led to an increase in indoor air pollution in most buildings.²⁴
- 5. A recent report by the US Government Accountability Office indicates that over 50% of public-school districts need to update or replace multiple building systems in their schools. Improving HVAC systems is the number one priority with over 40% of school districts needing to update or replace HVAC systems in over half of the schools in their district.²⁵
- 6. Clutter and debris that partially or completely covers vents and makes proper cleaning difficult contribute to bad indoor air quality.
- 7. Ozone, radon, and other odors from outside sources are often overlooked.
- 8. Filtration systems are not properly maintained by periodic replacement or undersized filters cannot handle the capacity of the building HVAC system. School maintenance personnel may install MERV filters without physically verifying that the system can handle the increased resistance, which may result in inadequate ventilation and total reduced airflow.
- 9. Opening outside air dampers to 100% open will not only significantly increase energy usage and operating cost but could result in premature unit failure.
- 10. Cleaning supplies, paint, and lacquers used in maintaining school property can be a source of air pollution. In addition, classroom materials such as paints, craft supplies, and glues can also contribute to bad indoor air quality.

Suggestions to Improve Indoor Air Quality in Schools.

- 1. **Improve Ventilation** Keep the air in the building moving by checking the number of times per hour that the air is circulated throughout the school building. Air in classrooms, offices, gymnasiums, and cafeterias needs to be exchanged with fresh outdoor air four to six times per hour. If a particular room is occupied with more people than normal, additional ventilation for that room will be required.
- 2. *Install an <u>Active</u> Air Cleaner* BiPolar Ionization ("BPI") technology uses electric voltage to convert oxygen molecules to charged atoms that inactivate airborne contaminants. These negatively and positively charged atoms, called ions, are effective against viruses, bacteria, and mold. As a bonus, they also neutralize volatile organic compounds, odors, and allergy-causing dander. Depending on the contaminant, BPI replaces these charged particles with non-volatile gases such as oxygen, nitrogen, and carbon dioxide. BPIs inactivate airborne pathogens in two main ways. First, the charged particles surround the microbe and break it down. In the case of viruses, the ions induce a chemical reaction on the cell membrane surface. They **envelop the** COVID-19 virus and puncture the protein spikes on its membrane, neutralizing them. Second, the ions attach to contaminants and enlarge them enough to be trapped by the **HVAC system filters**. The ionic load also makes some particles heavy enough to fall to surfaces where they can be cleaned away or further inactivated.
- 3. Install CO₂ Sensors in the Building Management System CO₂ sensors should be installed in classrooms and other rooms in the school in order to continually monitor the space for adequate ventilation. If there is an unexpected ventilation malfunction, the CO₂ sensor will then alert building operators about the problem. Without CO₂ sensors, which are dynamic measurements of indoor air quality, ventilation failures can go unnoticed for years until the ventilation system is again verified by skilled, trained, and certified technicians.
- 4. **Install VOC Sensors in the Building Management System** Like CO₂ sensors, VOC sensors can inform the building operators about the level of volatile organic compounds in a school building system. Again, VOC sensors are dynamic measurements of indoor air quality allowing the building operator to recognize the level of potential pollutants in the indoor air of school buildings.

 Upgrade the Filters in the HVAC System to MERV 13 Filters – MERV 13 filters are 99% effective in trapping particles as low as 0.3 microns in size. Unfortunately, the SARS-2 virus is only 0.1 microns in

size. If putting in a MERV 13 filter is not feasible due to space constraints or existing fan size, a Bi-Polar Ionization unit installed in the HVAC system will increase a MERV filter rating by 4-5 points.

- a. MERV 8 + BPI => MERV 13 (Blue Heaven labs)
- b. MERV 12 + BPI => MERV 16 (NRC Canada)
- c. Saves cost of higher MERV filter + fan energy.
- 6. Install an Economizer Package Install ionization devices in the rooftop unit (RTU). Install a VOC sensor in the building space to monitor the quality of the air. Install a CO₂ sensor to monitor occupancy. The economizer controller does not bring in any outside air unless the sensors detect the building space needs additional air to be cleaned (VOC & CO₂ sensors determine the amount of outside air, if any, required). The air in the building space is constantly monitored to maintain a consistent level of IAQ using an algorithm to maximize clean indoor air quality and minimize the influx of outside air. The ionization devices clean all the air recirculating in the building leading to a cleaner indoor air condition. The need of outdoor air to maintain clean indoor air is minimized. The reduction leads to a 6% 12% ongoing utility savings by reducing energy consumption used to heat or cool outside air to indoor air temperature settings.
- 7. Replace Existing HVAC Equipment with Dedicated Outside Air Systems (DOAS) – Since current HVAC equipment is becoming more compact and efficient, conventional systems are no longer capable of handling the amount of outside air required to maintain a healthy indoor air environment. Therefore, DOAS are required, because outside air is needed to keep buildings safe but only when air quality sensors indicate that outside air is needed. Outside air is minimized and brought in only when the sensor(s) show a demand in the space that justifies the need for outside air. When used with an economizer, the building operator will normally see about a 2/3 reduction of the outside air being brought into the building while maintaining a healthy IAQ that is constantly monitored by the sensors. This reduction gives the building owner a large ongoing utility savings of approximately 6% - 12% that can pay off the initial investment of equipment in 3 years or less.
- Check Supplies for VOCs Cleaning supplies, paints and other items used in cleaning and maintaining the school should be checked for possible VOC's.

Federal and State Legislation

Federal - The US House voted to approve a \$1.9 trillion stimulus package proposed by President Joe Biden that would dedicate an additional \$170 billion for K-12 schools and higher education. Most of the money will be used to stabilize K-12 schools and will go directly to school districts based on the proportion of funding they received through Title I of the Federal Every Student Succeeds Act. The legislation discusses repairing school facilities, especially ventilation systems, to improve air quality to reduce the spread of COVID.

California - Since SARS-2 is primarily spread through air droplets, teachers' unions and state authorities are influencing schools to improve their indoor air quality by installing modern air filters or air purifiers, or replacing their outdated heating, cooling and air ventilation (HVAC) systems. However, costs can be very expensive, depending on the region, the condition of the existing buildings and the size of the school. Gov. Gavin Newsom announced a \$2 billion plan to reopen schools, beginning as soon as February for younger students and gradually phasing in older grades. The proposal provides for ventilation upgrades. Low-income students are more likely to attend schools with poor air quality and with facilities in poor condition. Many districts are hoping for money for HVAC upgrades from Assembly Bill 841, which Newsom signed in September. The law sets aside \$600 million for public school energy improvements, including HVAC systems.

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