# 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.

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

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| Volatile Organic Compounds (VOC's) | Carbon dioxide and Carbon monoxide | Airborne fungi, bacteria, and viruses |
| Mold and mildew | Dust and dust mites | Smoke and odors |

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:

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| Lethargy, lack of attention, drowsiness | Headaches | Dryness and pain in the eye |
| Nasal stuffiness and sinus infections | Dry and itchy skin | Sore throat |

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.

### Indoor Air Quality Affects Children's Health and Comfort

1. Indoor exposure to VOCs has been associated with SBS symptoms in school children.
2. Elevated $CO_2$ levels have been linked to symptoms of wheezing among children.
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 wheezing, exhaustion, headaches, and other breathing illnesses in 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 $CO_2$ 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.
8. Teachers and staff face all 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.

### Indoor Air Quality Affects Children's Performance at School.

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

### Causes of Poor Indoor Air Quality

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

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| Low ventilation rates | Outdoor pollutants or vehicle exhaust | Formaldehyde |
| Presence of mold and bacteria | VOCs used in paints and lacquers or glues | Nitrogen or carbon monoxide |
| Chemicals in cleaning products | Moisture or dirt in an HVAC system | Animal and other biological allergens |

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.

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

1. Poor ventilation results in high levels of pollutants, pathogens, and $CO_2$ in classrooms.
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 busy highways are inundated daily with noxious gases like carbon monoxide and industrial waste products. Opening windows or dampers to bring in outside air exacerbates the problem.
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 chemical products have led to an increase in indoor air pollution in buildings.
5. A recent report by the GAO 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.
6. Clutter and debris that partially 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.
9. Cleaning supplies, paint, and lacquers used in maintaining school property can be a source of air pollution.

**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 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 iAIRE <u>Active</u> Air Cleaner - iAIRE*** 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. They also neutralize volatile organic compounds, odors, and allergy-causing dander. 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 SARS-2 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**.
3. ***Install iAIRE $CO_2$ Sensors in the Building Management System*** - $CO_2$ 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 $CO_2$ sensor will then alert building operators about the problem.
4. ***Install iAIRE VOC Sensors in the Building Management System*** - 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.
5. ***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, an ***iAIRE*** 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 iAIRE Economizer Package*** - Install ionization devices in the rooftop unit (RTU). Install a VOC sensor in the building space to monitor the cleanliness of the air. Install a $CO_2$ sensor in the space 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 & $CO_2$ sensors determine the amount of outside air, if any, required). The air inside the building space is constantly monitored to maintain a consistent level of indoor air quality using an algorithm to maximize clean indoor air quality and minimize the influx of outside air. The need of outdoor air to maintain clean indoor air is minimized. The reduction leads to a 6% - 12% on-going utility savings by reducing energy consumption used to heat or cool outside air to indoor air temperature settings.
7. ***Replace Existing HVAC Equipment with iAIRE Dedicated Outside Air Systems*** – Since current HVAC equipment is so efficient, they do not bring in much, if any, outside air into a building. 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 additional outside air. When used in conjunction 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 Indoor Air Quality that is constantly monitored by the sensors.