

Best Practices for Reducing Near-Road Pollution Exposure at Schools: Case Studies

Building Design and Operation Strategies for Reducing Near-Road Pollution Exposure

Ventilation, Filtration, and Indoor Air Quality in Schools

Pilot study of high-performance air filtration for classroom applications Southern California, United States

Summary: This study investigated the effectiveness of three air purification systems in reducing exposure to air pollutants inside nine classrooms in southern California schools. The authors measured concentrations of ultrafine particles (UFPs), particles that are 2.5 microns or less in diameter (PM_{2.5}) and particles 10 microns or less in diameter (PM₁₀), black carbon (BC), and volatile organic compounds (VOCs, gases). The three tested systems were an HVAC-based high performance panel filter, a register-based air purifier, and a stand-alone air cleaning system. They found that a combination of the HVAC-based high performance panel filter and the register-based air purifier were the most effective solution and lowered BC, UFPs, and PM_{2.5} by an average of 87-96%. All three methods resulted in improved air quality over preexisting conditions, and the HVAC-based high performance panel filter alone reduced levels by almost 90%. The performance of the register-based air purifier and standalone unit to remove VOC gas was inconclusive, and more work is needed to determine this system's effectiveness for gas removal.

Link: <https://onlinelibrary.wiley.com/doi/abs/10.1111/ina.12013>

The impact of particle filtration on indoor air quality in a classroom near a highway Amsterdam, Netherlands

Summary: PM₁₀, PM_{2.5}, and BC concentrations were measured inside a classroom and outside the school building at a school in Amsterdam to determine the effectiveness of an upgrade to the school's ventilation system to a fine F8 (MERV-14) filter, and how well it improved air quality for students. During school hours, the upgraded filter reduced BC exposure by an average of 36%, PM₁₀ by 34%, and PM_{2.5} by 30%. The researchers concluded that using a fine particle filter in a mechanical ventilation system can reduce classroom exposure to traffic pollution. However, the filters must be frequently replaced and properly maintained to ensure effective filtration.

Link: <https://onlinelibrary.wiley.com/doi/abs/10.1111/ina.12308>

**Filtration effectiveness of HVAC systems at near-roadway schools
Las Vegas, Nevada, United States**

Summary: BC and gas-phase pollutants (benzene and 1,3-butadiene) were measured in three classrooms at a school near a busy roadway in Las Vegas, Nevada. To assess the improvement in pollution reduction, the researchers monitored concentrations before and after the HVAC filtration was upgraded. The results show that before the HVAC upgrade, 31-66% of BC was removed by the filtration system. After the upgrade, indoor BC levels were reduced by 74-95% relative to outside concentrations. However, gaseous pollutant levels were higher indoors than outdoors by a magnitude of 1 to 2. The researchers state a possible reason for the elevated gas-phase pollutant levels is indoor sources of benzene and 1,3-butadiene.

Link: <https://doi.org/10.1111/ina.12015>

**Effectiveness of using enhanced filters in schools and homes to reduce indoor exposures to PM_{2.5} from outdoor sources and subsequent health benefits for children with asthma
Detroit, Michigan, United States**

Summary: This study investigated the exposure levels, health benefits, and costs associated with using high efficiency filters in homes and schools, especially with respect to asthma. MERV-5, 8, 12, and 14 filters were compared. The results showed that replacing the lower efficiency filters (MERV-5 and MERV-8) in schools with higher efficiency filters would reduce the PM_{2.5}-related asthma burden of children by 13% annually. Higher benefits are estimated for higher efficiency filters. They calculate that the average cost to implement the increased filtration is \$63 per classroom, or \$32 per child with asthma per year. They conclude that using more efficient filters is a potentially cost-effective way to reduce the asthma-related health burden for children.

Link: <https://doi.org/10.1021/acs.est.8b02053>

**High-efficiency air cleaning reduces indoor traffic-related air pollution and alters indoor air chemistry in a near-roadway school
Portland, Oregon, United States**

Summary: This study investigated the impact of upgrading an air-cleaning system at a school adjacent to a major highway. They installed MERV-8 and MERV-16 particle filters as well as gas-phase filters and assessed the improvements in air quality. The gas phase filters were chosen to remove NO₂ and benzene, toluene, ethylbenzene, and xylenes (collectively called BTEX). The results show that over eight months of monitoring, NO₂ was reduced by up to 96% and BTEX gases were reduced by over 80%.

Link: <https://doi.org/10.1021/acs.est.0c02792>

Influence of combined dust reducing carpet and compact air filtration unit on the indoor air quality of a classroom
Gelderland, Netherlands

Summary: Particulate matter (PM₁₀ and PM_{2.5}), gases (VOCs, nitrogen dioxide [NO₂], and formaldehyde), and other traffic-related pollutants were measured in two primary school classrooms equipped with compact air filtration systems. During school hours, PM_{2.5} and PM₁₀ were reduced by 27-43% compared to a classroom without the air filtration system. On weekends, the reductions observed were 51-87%. Because levels of VOC were low, the effectiveness of the interventions used to remove VOC concentrations was inconclusive.

Link: <https://doi.org/10.1039/C4EM00506F>

Site-Related Strategies for Reducing Near-Road Pollution Exposure

Transportation Policies: Anti-Idling Campaigns

The impact of an anti-idling campaign on outdoor air quality at four urban schools
Cincinnati, Ohio, United States

Summary: The goal of this work was to assess the impact of an anti-idling campaign on outdoor air quality at four schools that experience different degrees of automobile and bus traffic. The research team measured PM_{2.5}, elemental carbon, and particle count at each school for 5 days before and after the implementation of an anti-idling campaign. They also took simultaneous measurements at four community sites to determine background levels, which were subtracted from the measurements taken at the nearby school. After implementing an anti-idling campaign, the school with the most bus traffic (39 buses) saw a decrease in PM_{2.5} concentrations from 4.11 µg/m³ to 0.99 µg/m³, a decrease in elemental carbon from 0.40 µg/m³ to 0.15 µg/m³, and a decrease in particle number concentration from 11,560 particles per cm³ to 1,690 particles per cm³. Schools with fewer buses (5 to 11) did not realize a significant reduction in pollutants. The authors concluded that anti-idling campaigns are effective for schools that have significant bus and automobile traffic.

Link: <https://pubs.rsc.org/en/content/articlelanding/2013/em/c3em00377a>

Roadside Barriers: Vegetation

Impact of green screens on concentrations of particulate matter and oxides of nitrogen in near road environments Kensington and Chelsea, United Kingdom

Summary: To establish the efficacy of vegetative barriers in reducing road pollution at schools, an ivy screen was installed along the perimeter of a playground at a primary school in the UK. Oxides of nitrogen (NO_x) and PM₁₀ were measured on either side of the screen, and the difference in the concentration between the roadside and playground side was assessed as the ivy matured. The results show that the screen was an effective pollution barrier once the ivy had started growing, and significant reduction in pollution could be seen once the screen had matured. The ivy screen led to an overall decrease in the pollution concentrations on the playground side of the screen by 24% for NO₂ and 38% for PM₁₀. During school hours specifically, when both emissions and exposure are highest, the reductions were up to 36% for NO₂ and 41% for PM₁₀.

Link: https://www.londonair.org.uk/london/reports/GreenScreen_Report.pdf

The association between greenness and traffic-related air pollution at schools Barcelona, Spain

Summary: Traffic-related air pollutants, including NO₂, PM_{2.5}, BC, and PM₁₀, were monitored inside and outside of 39 schools across Barcelona. Satellite images were used to assess greenness (the degree of vegetation coverage and green space) within and around (50 m buffer) each school. Models were run to correlate the degree of greenness with traffic pollutant levels. The study found that higher greenness within and around schools was consistently associated with lower pollutant levels both outside and indoors. Further, the results suggest stronger associations between schools with increased greenness and lower outdoor pollution levels if a school was surrounded by more trees.

Link: <http://www.sciencedirect.com/science/article/pii/S0048969715003782>