Particulate matter in UK school classrooms – building an evidence base for improving classroom air quality

Alice Handy*[1], Henry Burridge[1], the SAMHE consortium[2]

1 Imperial College London, Department of Civil and Environmental Engineering, London, SW7 2AZ

2 The SAMHE consortium, see †

**Corresponding author: a.handy23@imperial.ac.uk*

SUMMARY

Identifying factors that affect classroom concentrations of particulate matter is important for enabling effective mitigation of the associated negative health and cognitive effects, of which children can be especially susceptible. This study examines particulate matter concentrations in school classrooms from across the UK which have participated in the Schools' Air quality Monitoring for Health and Education (SAMHE) project. Data from the 2023/2024 academic year is analysed and outdoor sources of particulate matter (PM) are shown to be a key source of PM in classrooms. Outdoor particulate matter events, taken to be short periods of elevated outdoor PM concentrations, are evidenced within classroom measurement and result in the likely classroom exposures during these events being significantly over-weighted within the longer-term exposure to PM over the academic year.

KEYWORDS

Indoor Air Quality, Particulate matter, Schools, Exposure

1 INTRODUCTION

The air quality of school classrooms can be a modifier to the health of students and teachers due to the durations spent indoors as school, predominately in classrooms. Negative health effects of poor air quality can be more pronounced in children than in adults and, due to its effects on cognitive performance, air quality has also been linked to attainment in schools (Sadrizadeh et al. 2022). Understanding and monitoring the air quality in schools is essential for evidencing strategies to reduce exposure to indoor air pollutants. The Schools' indoor Air quality Monitoring for Health and Education (SAMHE) project has set out to produce an unparalleled data set of UK classroom indoor air quality across a range of metrics.

This study investigates the particulate matter $PM_{2.5}$ in UK classrooms, which is of particular interest as childhood exposure to $PM_{2.5}$ is associated with the onset of asthma, and the UK has one of the highest rates of childhood asthma globally (Bloom et al 2019). Central to the goal of the SAMHE project is to better enable students and teachers to manage their indoor air quality.

2 METHODS

Schools that participate in the SAMHE project receive a low-cost air quality monitor and access to an interactive Web App. Once connected to the school WiFi, data is stored by cloud-services for analysis and, data feeds to the Web App enable, schools to view readings of CO_2, relative humidity, total volatile organic compounds, temperature and particulate matter. A citizen science approach was adopted to recruit and engage schools and tailor educational materials to the needs of pupils and teachers, this method highly scalable deployment

(Chatzidiakou et al 2023). As of July 2024, over 1,300 schools have been recruited to the project and each has received a monitor, over 880 of these monitors within schools have recorded IAQ data. Recruited schools are broadly representative of the UK school population in terms of the balance of constituent countries, fee-paying status, and Index of Multiple Deprivation. This study reports on the three terms of the academic year of 2023/2024. In this study a selection of schools was considered that met data completeness criteria. The SAMHE data set is compared to outdoor concentrations of $PM_{2.5}$ as reported from Defra AURN background stations that are the nearest to the selected schools.

3 RESULTS

By comparing the concentration of $PM_{2.5}$ averaged across the study SAMHE school monitors and outdoor concentration of $PM_{2.5}$ averaged across the AURN stations, we find that school PM concentrations are largely determined by outdoor concentrations. Whilst the outdoor concentrations are generally larger than school concentrations, the peaks in indoor occur simultaneously with peaks in outdoor levels. Given the many possible sources of $PM_{2.5}$ within schools it is perhaps surprising that such a close correlation between schools' and outdoor concentrations are seen at a national scale. These peaks in outdoor concentration occur over the period of a day to a week and can be caused by metrological events or arise due to anthropogenic sources. We investigate how outdoor 'events', periods of elevated outdoor $PM_{2.5}$, affect the classroom concentrations. Some of the short events occur during evenings when school buildings are typically closed. Despite this, the events are detected in the readings of $PM_{2.5}$ from classroom monitors. This indicates that UK school buildings are relatively permeable to PM pollution even when closed. When the classroom concentrations are considered only during occupied school hours, some of these short events do not significantly increase concentrations in classrooms.

However, larger events, those that last up to six days and have higher outdoor concentrations, are shown to affect classroom concentrations during occupied school hours. Estimates of potential exposure to classroom $PM_{2.5}$ during school hours over the academic year shows that days of low concentration contribute to more than half of students' exposures. However, the contribution to in-school exposure on days of outdoor PM pollution events is significant, with exposure on these PM event days being 2-3 times overweight within the total exposure.

4 CONCLUSIONS

Trends in classroom particulate matter concentrations are significantly influenced by outdoor concentration trends. Periods of elevated outdoor $PM_{2.5}$ concentration 'events' were routinely detected by SAMHE school monitors, exposures on these days might contribute significantly to the long-term exposure to $PM_{2.5}$ over the academic year.

The findings of this study demonstrate the need for data driven evidence to develop guidance to improve indoor air quality and inform future building, and retrofitting, of school buildings. Ventilation is the key means by which indoor pollutants can be flushed from classrooms. However, in the context of particulate matter, care must be taken as outdoor air can be a major source of PM pollution in classrooms.

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