

# Practical recommendations to mitigate air pollution exposure to school children



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TAPAS

Tackling air pollution at school

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@AirPollSurrey @pk\_shishodia @GuildfordLL

**Clean Air Conference 2023**



**University of Birmingham**



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Science of the Total Environment 858 (2023) 159813

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journal homepage: [www.elsevier.com/locate/scitotenv](http://www.elsevier.com/locate/scitotenv)



ELSEVIER



Review

Interventions for improving indoor and outdoor air quality in and around schools



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Global Centre for Clean Air Research (GCARE), School of Sustainability, Civil and Environmental Engineering, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford GU2 7XH, United Kingdom

## Types of Interventions

## Air Purifiers & Instrumented classroom

Atmospheric Environment 289 (2022) 119303

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: [www.elsevier.com/locate/atmosenv](http://www.elsevier.com/locate/atmosenv)



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Investigation of air pollution mitigation measures, ventilation, and indoor air quality at three schools in London



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Environmental Research 217 (2023) 114849

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Environmental Research

journal homepage: [www.elsevier.com/locate/envres](http://www.elsevier.com/locate/envres)



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Micro-characteristics of a naturally ventilated classroom air quality under varying air purifier placements



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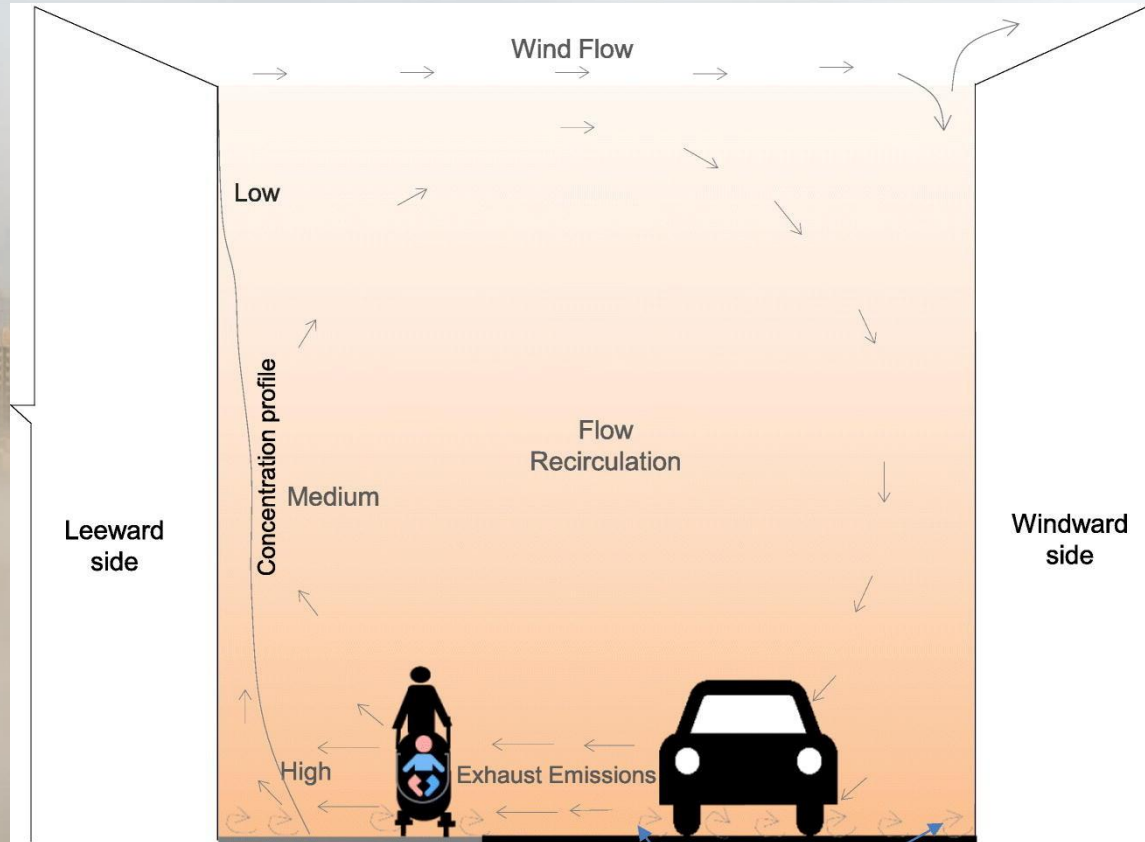
<sup>b</sup> Institute for Sustainability, University of Surrey, Guildford GU2 7XH, Surrey, United Kingdom

# Children Exposure



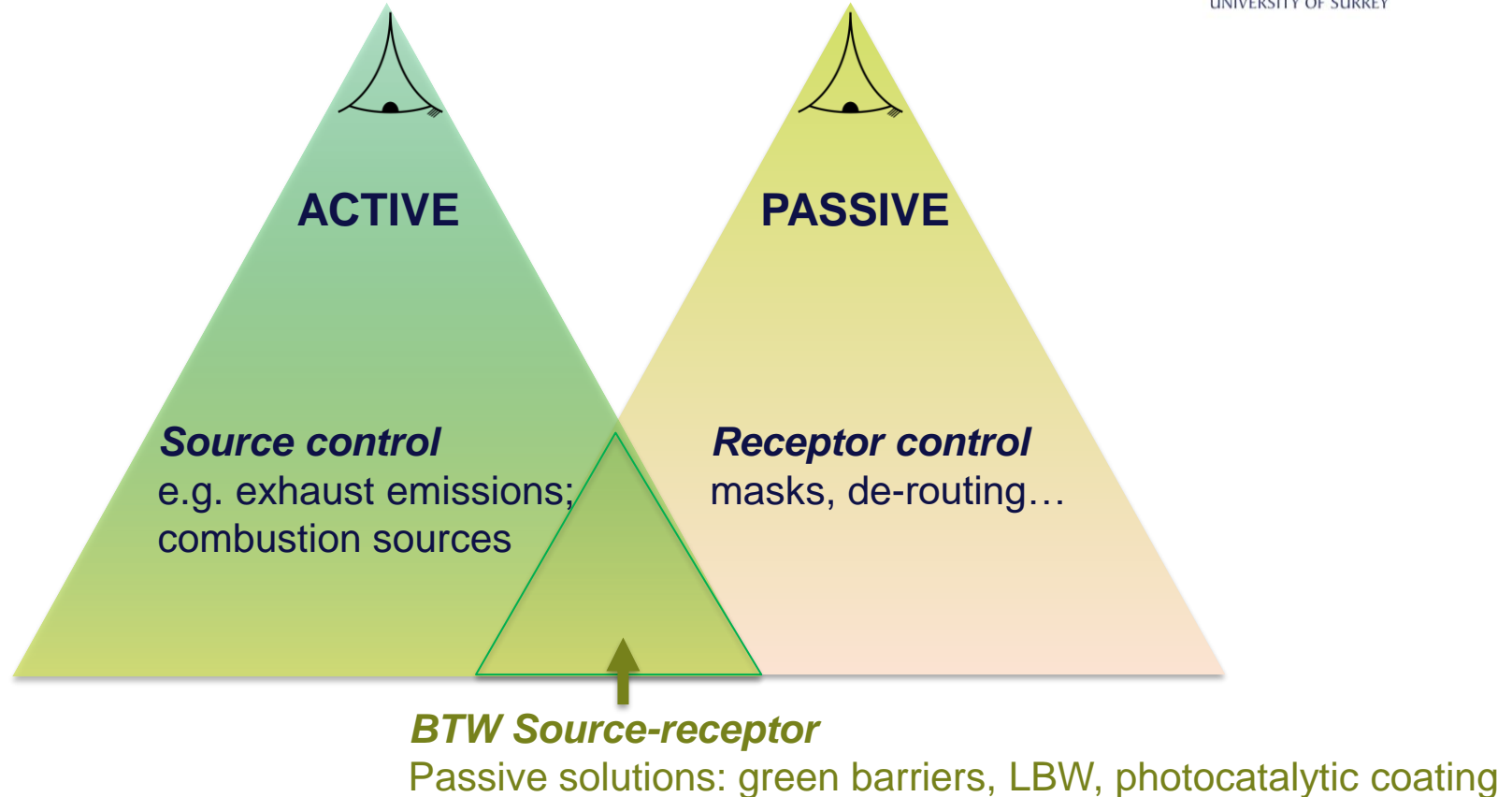
**“Air pollution accounts for almost 1 in 10 deaths in (~630 million) children <5 yrs.”**

**“Globally, 93% of the world’s 1.8 billion children <15 yrs are exposed to ambient PM<sub>2.5</sub> levels above WHO air quality guidelines.”**

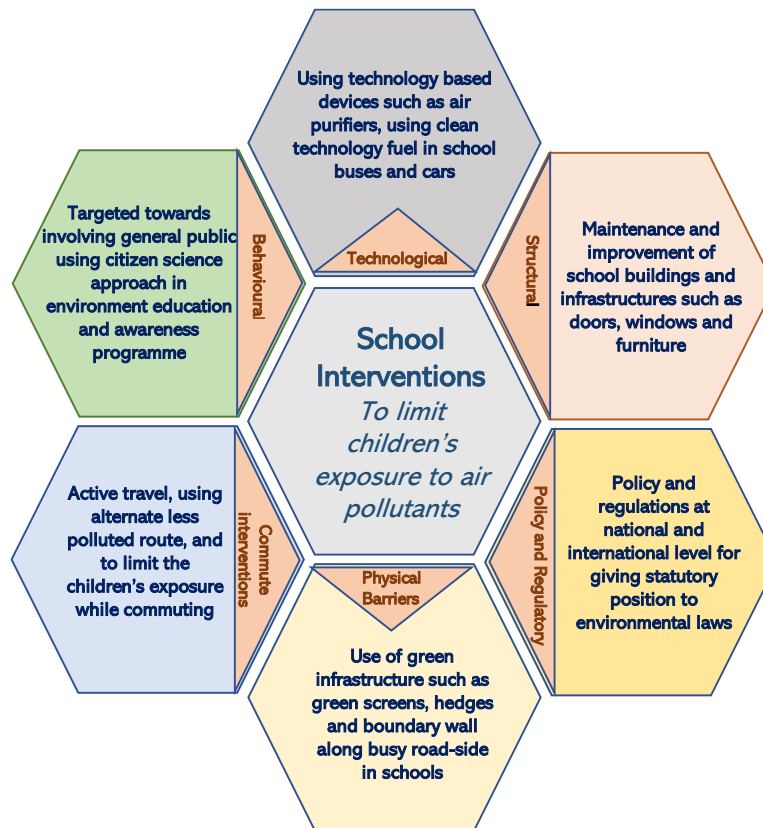


Sharma & Kumar (2018). *Environment International* 220, 262-278.

• Resuspension •

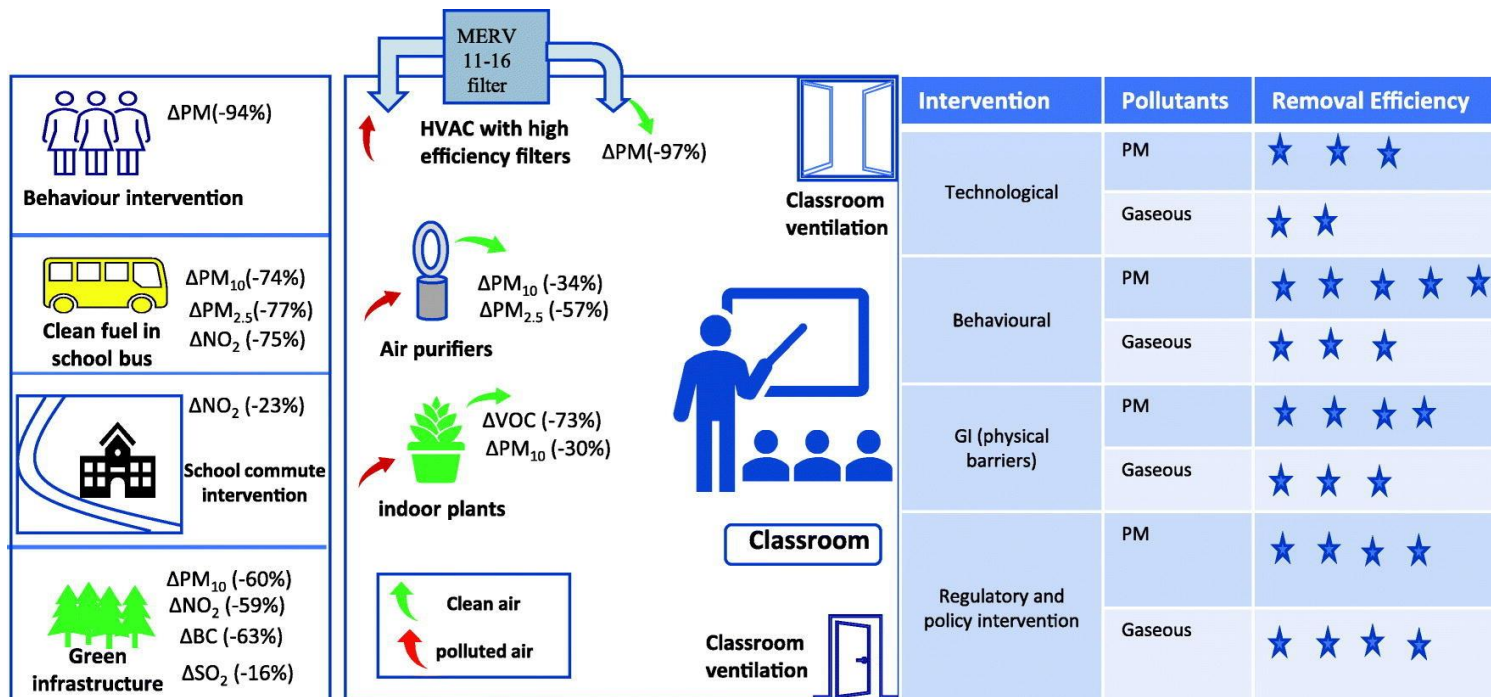


# Interventions summary



Rawat, Kumar, 2023. Interventions for improving indoor and outdoor air quality in and around schools. *Science of the Total Environment* 858, 159813.

# Interventions summary

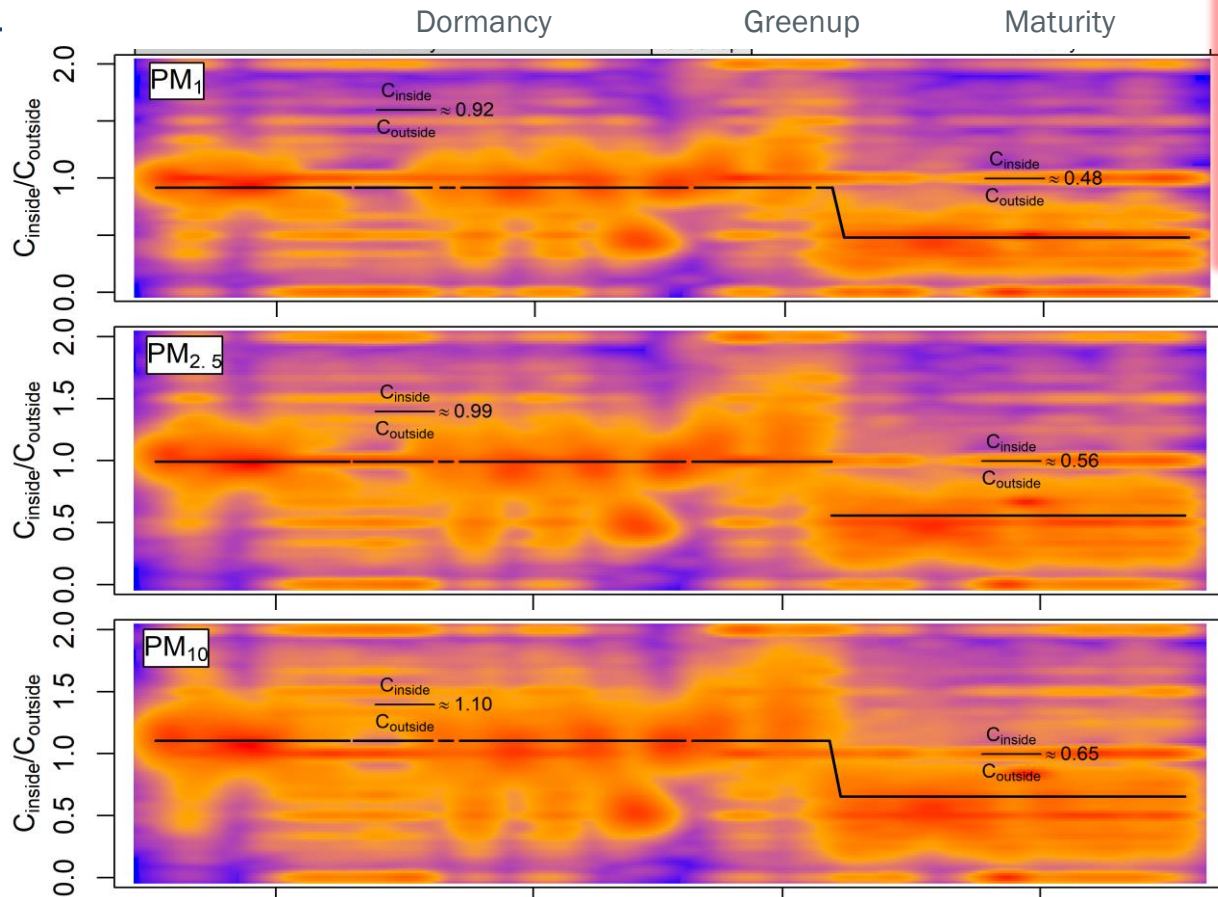


PM, particulate matter; BC, black carbon; SO<sub>2</sub>, sulphur dioxide; NO<sub>2</sub>, nitrogen dioxide; VOC, volatile organic compound; All the percentage values have been extracted from the respective articles discussed in the article. ★ sign shows the comparative reduction in PM and gaseous pollutants.

Rawat, Kumar, 2023. Interventions for improving indoor and outdoor air quality in and around schools. *Science of the Total Environment* 858, 159813.



# Passive intervention: Hedge



LAI < 2.9  
Dormancy



LAI > 2.93  
Greenup



LAI ~ 7-8  
Greenup

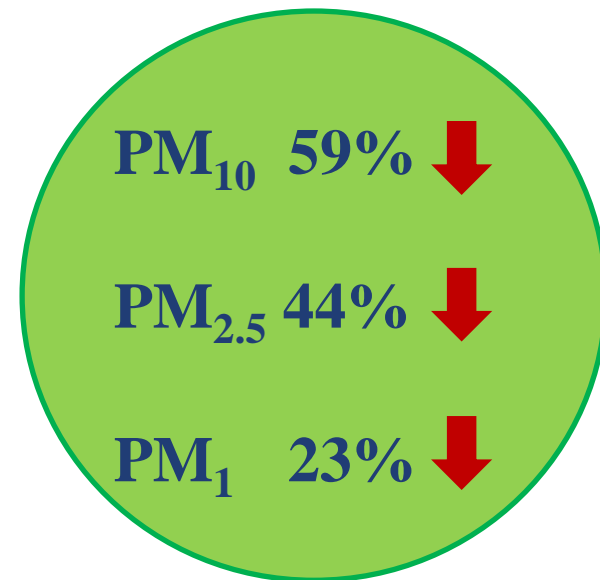
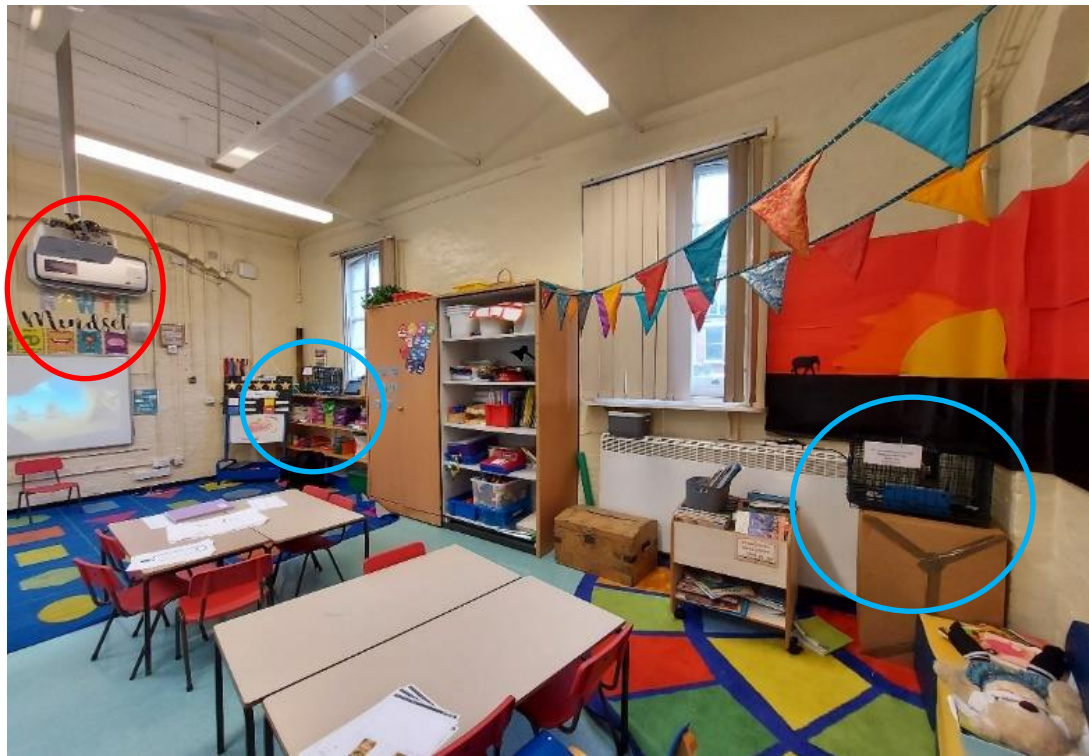
# Interventions: Classrooms



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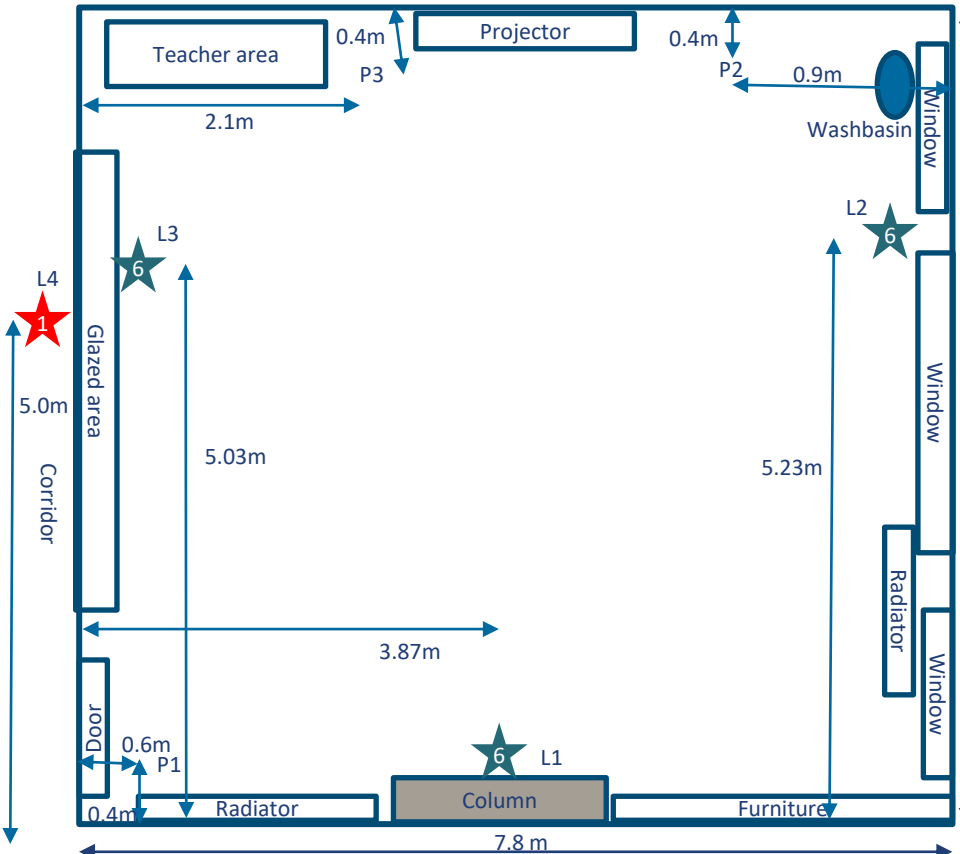
## Air Purifiers



Abhijith, Kukadia, Kumar, 2023. Investigation of air pollution mitigation measures, ventilation, and indoor air quality at three schools in London. *Atmospheric Environment* 289, 119303.

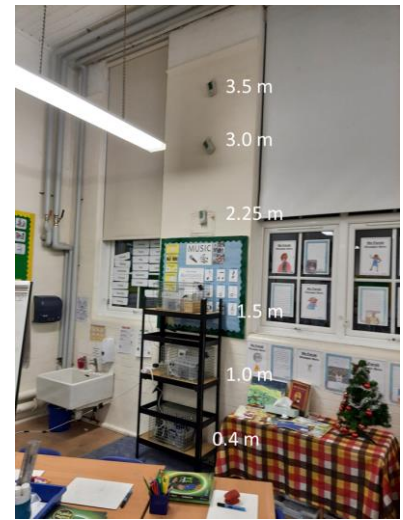
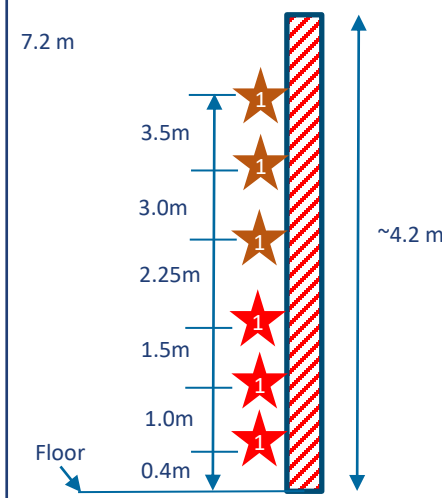


# Classroom micro-characteristics



- ★ 6 Six CO<sub>2</sub> monitors at 0.4m, 1.0m, 1.5m, 2.25m, 3.0m, 3.5 high and PM monitors at 0.5m, 1.0m, 1.5m.
- ★ 1 One set of measuring instruments; PM, CO<sub>2</sub> at 1.2 m high
- ★ 1 Only CO<sub>2</sub> monitor

- P1, P2, P3 are the location of air purifiers.
- **Dyson Pure Cool – 4.65 kg and 1044 m<sup>3</sup>/hr at maximum setting based on HEPA and activated carbon filter**
- L1, L2, L3, L4 are the location of monitoring



Picture of six point CO<sub>2</sub> monitoring and three point PM monitoring.

# Quality control

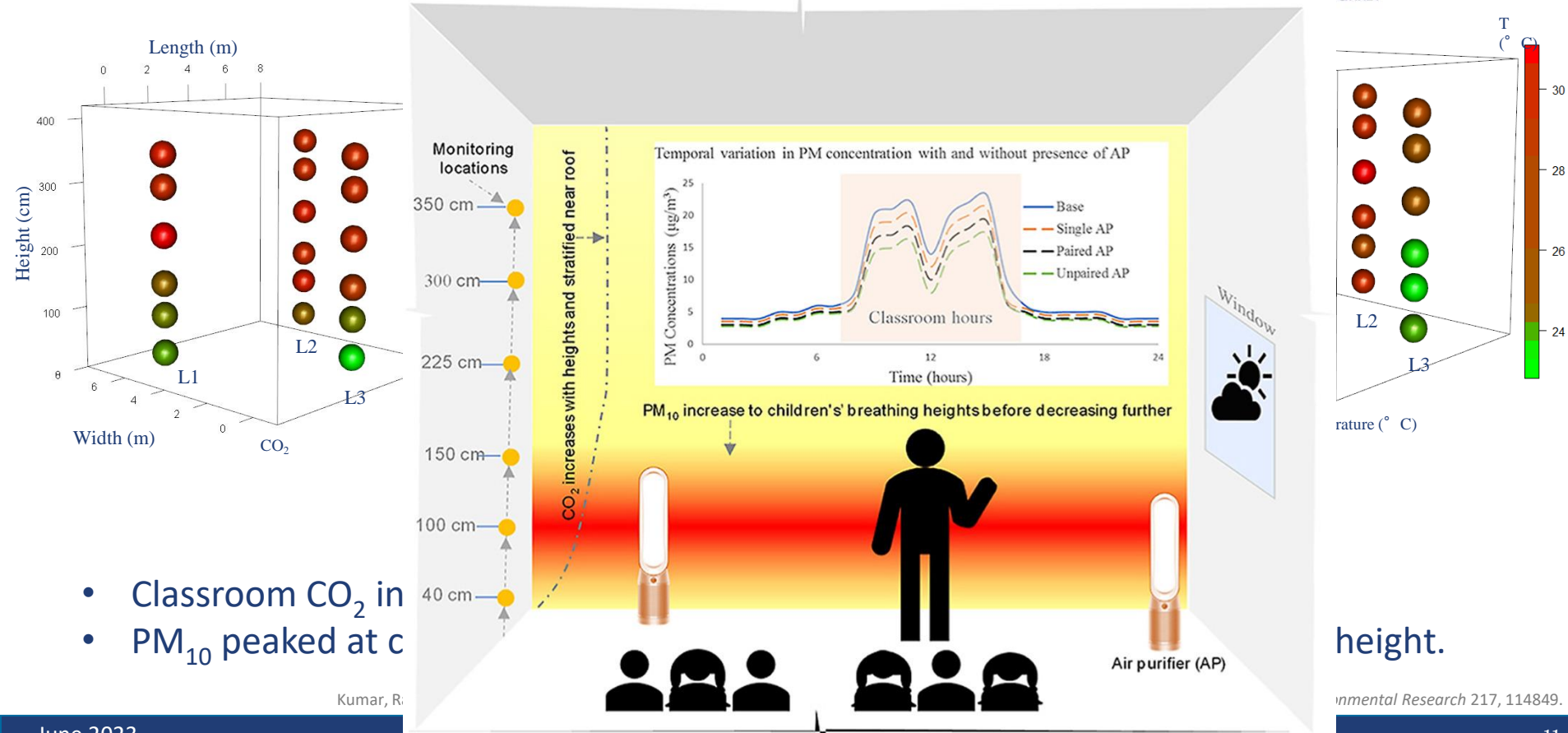


Collocation study in representative conditions: indoor environment (GCARE Air quality lab for PM) and living room of GCARE researcher (for CO<sub>2</sub>).

# Micro-scale variation



MURRAY



- Classroom CO<sub>2</sub> in
- PM<sub>10</sub> peaked at c

Kumar, R.

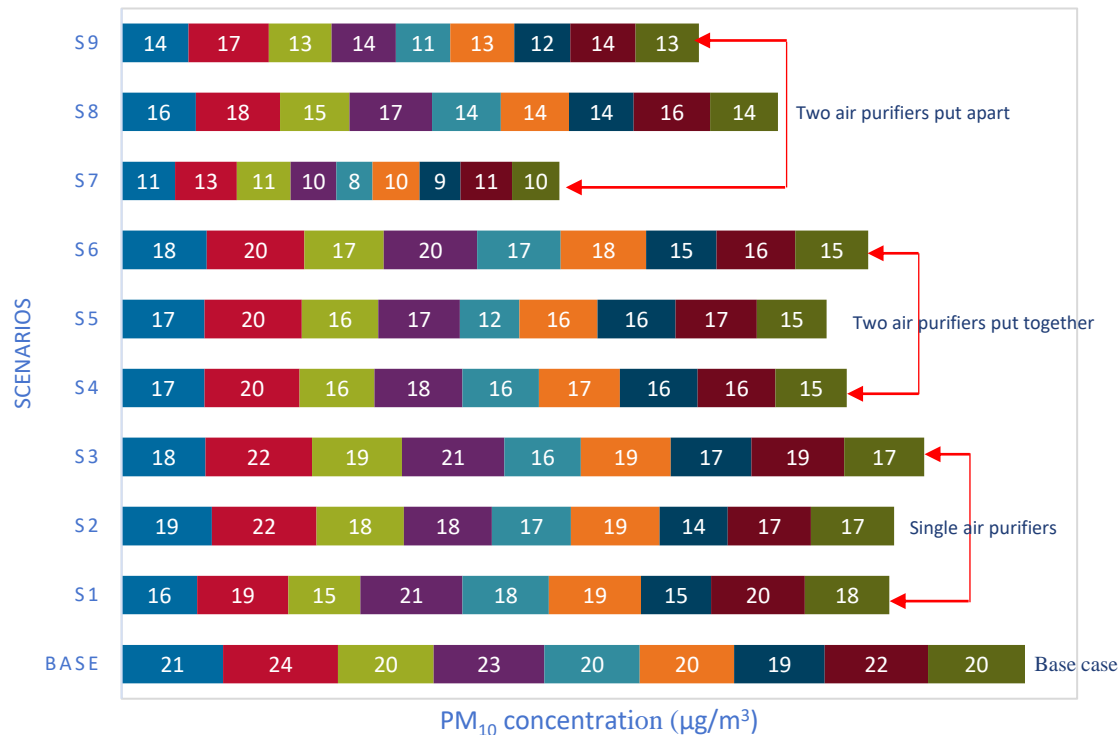
Environmental Research 217, 114849.

# Interventions: Classrooms



## Air Purifier placements

■ L1,40 ■ L1,100 ■ L1,150 ■ L2,40 ■ L2,100 ■ L2,150 ■ L3,40 ■ L3,100 ■ L3,150



Kumar, Rawat, Tiwari, 2023. Micro-characteristics of a naturally ventilated classroom air quality under varying air purifier placements. *Environmental Research* 217, 114849.

If multiple air purifiers are placed in a classroom, it is preferred to use them in unpair mode.

- Doubling an air purifier's flow capacity did not double the PM<sub>10</sub> reduction.

Placing air purifiers unpaired, and in polluted zones, yielded maximum reductions.

- Using air purifiers in unpaired mode more effective to reduce PM<sub>10</sub> levels up to 62% within a naturally ventilated classroom compared with the same capacity of air purifiers in paired mode.

Inlet of the air purifier should be provided within the breathing zone of sitting children.

- Highest PM concentrations at breathing height.

Air purifiers should be placed in the highest concentration zones for maximum effectiveness.

# Interventions: Classrooms



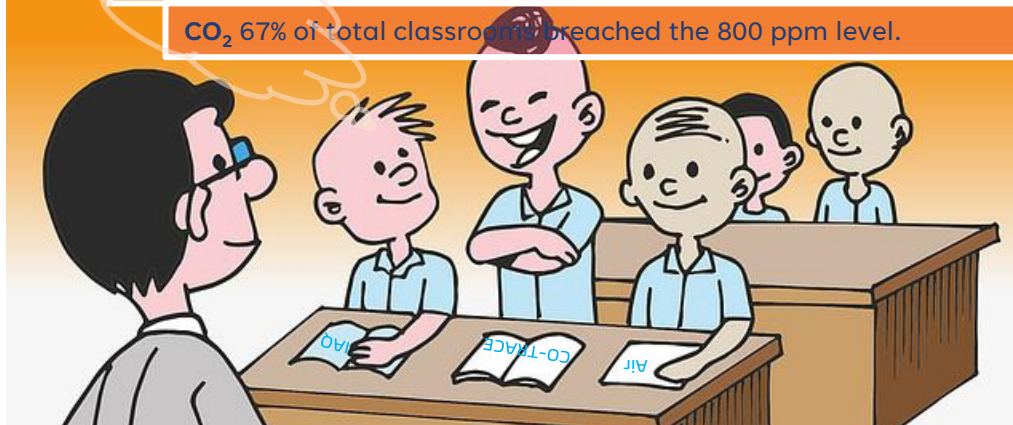
## Floor types

Thermal comfort RH <40% in all classrooms; temp >23°C in 60% classrooms.

Occupancy High occupancy levels increased CO<sub>2</sub> (150%) and PM<sub>10</sub> (230%).

Ventilation Dual ventilation reduced the PM<sub>10</sub> concentration by ~50%.

CO<sub>2</sub> 67% of total classrooms breached the 800 ppm level.



**PM<sub>10</sub> higher in classrooms with wooden ( $33 \pm 19 \mu\text{g m}^{-3}$ ) and vinyl ( $25 \pm 20 \mu\text{g m}^{-3}$ ) floors compared with carpet ( $17 \pm 12 \mu\text{g m}^{-3}$ ).**





## MITIGATING EXPOSURE TO TRAFFIC POLLUTION IN AND AROUND SCHOOLS

Guidance for Children, Schools and Local Communities

Prashant Kumar, Hamid Omidvarborna, Yendle Barwise, Arvind Tiwari | 2020  
University of Surrey, United Kingdom



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“... a holistic approach is required from those directly contributing to and/or affected by pollution to make a real difference at grass-roots level. A successful exposure mitigation strategy requires multifaceted actions that target school children, schools and the local community.”

10 General + 10 targeted recommendations  
Targeting children, school and community





## Pollution & ventilation

- **PM<sub>10</sub>** locally produced – high in hard floors than carpet floors
- **CO<sub>2</sub>** – good proxy of ventilation and risk of infection
- **Purging, opening windows/doors, effective**
- **Generally, a need across the board to increase the ventilation rate**

## Microscale

- **Not well-mixed – horizontal and vertical variations**
- **CO<sub>2</sub> stratification at upper heights (density increases as temperature gets colder)**
- **Displaced ventilation**

## Air purifiers

- **Effective in reducing PM concentrations**
- **Effects of flow on CO<sub>2</sub> dilution**

# Thank you

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**www.surrey.ac.uk/gcare**

**TAPAS**

Tackling air pollution at school

**CO-TRACE**

Healthy schools through air-quality science



**RECLAIM**

**ARUP**

Impact  
on **Urban**  
Health

Special thanks to GCARE, TAPAS, COTRACE & SAMHE Teams

June 2023



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Collaborative, cutting edge research  
leading to clean air for all

