

# Schools' Air quality Monitoring for Health and Education

## SAMHE data on IAQ in UK schools



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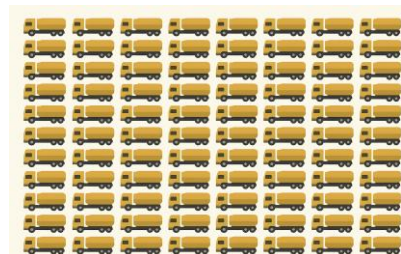
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### Why air quality matters, in schools and beyond...

We breathe a lot of air - that air often contains pollutants.  
We wouldn't drink, nor even bathe, in polluted water!

**Indoor air quality – IAQ** – describes how polluted the air we breathe is. **Manage by:**

- **Source control** is the first thing to consider is removing/mitigating the source; this works well for some VOCs, e.g., by more careful choice of furnishings, paints, cleaning products, arts/crafts activities, etc.
- **Ventilation**, the process of refreshing indoor air with air from outdoors, is the core means of managing IAQ by diluting pollutants indoors.
- **Air cleaning** is a secondary measure to consider to assist ventilation, as required.



We breathe **180** tanker trucks of air at school.

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## Potential co-benefits of improving indoor environments and indoor air quality

- Better learning from higher cognitive function – higher productivity at work
- More consistent attendance as better health follows lower infection spread
- Improved long-term health of pupils/employees exposed to healthier learning/working environments
- Massive potential to reduce energy costs through lower heating/cooling loads
  - Significant investment required but necessary for 'net-zero' future
- Schools are a great place to gather evidence...

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## What is SAMHE?

- **SAMHE stands for Schools' Air quality Monitoring for Health and Education.**
- **SAMHE started in 2022 and is a research project working with UK schools to improve understanding of indoor air quality.**
- **SAMHE started as a collaboration between Imperial College London, University of Cambridge, SEI/University of York, University of Surrey, University of Leeds, and the UK Health Security Agency**

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# How does SAMHE measure air quality?

To measure school air quality at scale, SAMHE uses citizen science. 1000+ schools have been sent air quality monitors which measure:



The SAMHE monitor

- Carbon Dioxide (CO<sub>2</sub>)
- Relative Humidity
- Temperature
- Total Volatile Organic Compounds
- Particulate Matter (PM<sub>2.5</sub>)



# The SAMHE method: working with schools

Schools received and set up a SAMHE monitor



SAMHE team set activities on the co-designed SAMHE Web App



Pupils complete fun activities (24), learning about air quality and inputting important contextual data



SAMHE scientists analyse data to report on air quality in UK classrooms, schools can download own data



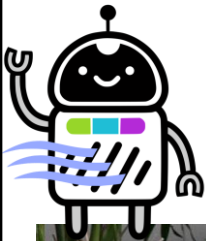
## SAMHE uses citizen science, why?

- Allows us to gather real-world data from hundreds of classrooms
- Pupils and teachers gain knowledge and understanding of air quality
- Pupils gain skills in interpreting graphs, analysing data, doing experiments, writing creatively, etc.
- Pupils and staff can see the air quality in classrooms and know what action to take to improve it
- Collaborative co-design ensured the SAMHE Web App meets pupil and teachers' needs and that they use it!



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## SAMHE: engagement to impact

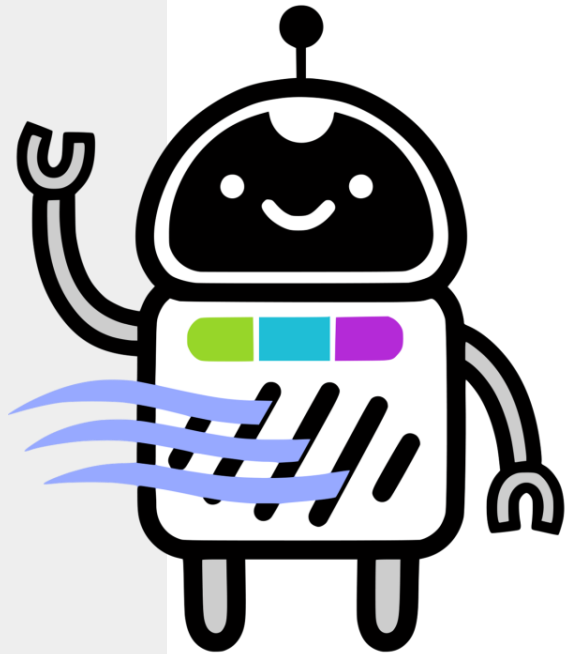


- These monitors are now gathering around 100,000 'school data days' every year from around 450 schools
- Each 'school data day' provides a day's worth of measurements every minute of:
  - Carbon dioxide
  - Temperature
  - Humidity
  - Particulate Matter
  - TVOCs



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# SAMHE findings & recommendations for ventilation and air quality in schools



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## Ventilation and carbon dioxide

Ventilation, the process of refreshing indoor air with air from outdoors, is the most important means of maintaining good indoor air quality

People give off CO<sub>2</sub> when they breathe, and it is removed by ventilation.

The number of people in a room, their age, and their activities affect the amount of CO<sub>2</sub> they produce.

We can estimate how well-ventilated a classroom is from the level of carbon dioxide measured on SAMHE monitors.



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# Ventilation and the weather

Many SAMHE classrooms use windows to provide ventilation - with the government guidance for classrooms coming from BB101.

People open windows more when it's warm, so ventilation rates are closely linked to outdoor temperatures.

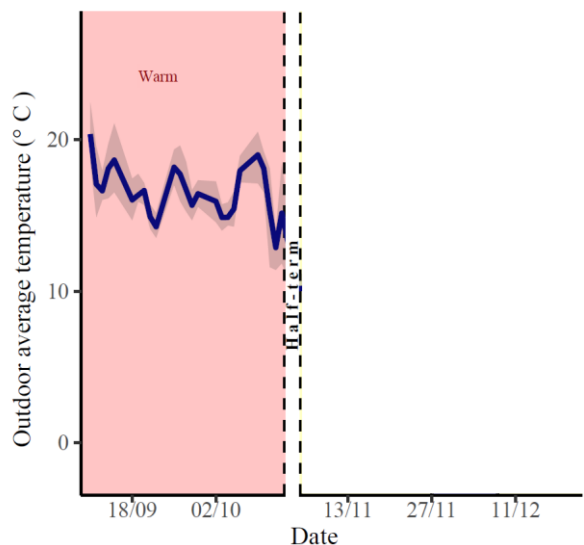
So we started by looking at the outdoor temperature across the UK over the Autumn 2023 school term.



# Ventilation and the weather

Over last Autumn's school term, there were four distinct weather periods:

- First a warm period (shaded pink on the graph), then



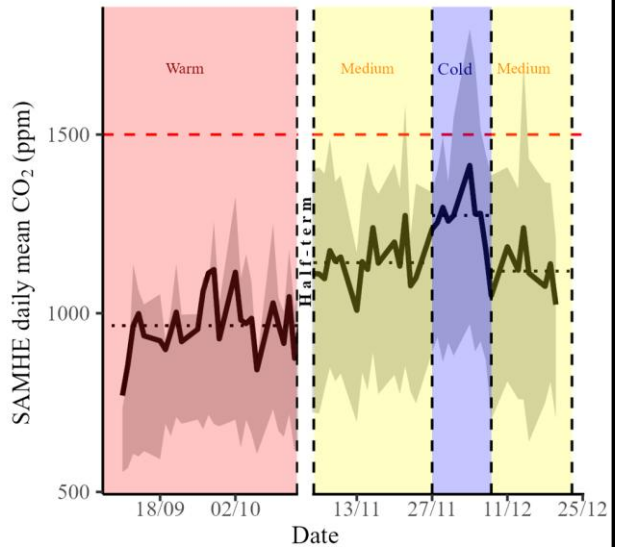
# Ventilation and the weather

Using these same weather bands, the SAMHE CO<sub>2</sub> concentrations are:

- Lower during the warm weather period, and
- Higher during the cold weather period,
- Levels during the medium weather periods fall in between.

In the cold period, SAMHE monitors sometimes measured CO<sub>2</sub> levels higher than the government guidelines.

**Recommendation: establish training classroom staff on air quality; provide monitors and encourage staff to use them**



# Adherence to BB101 guidance

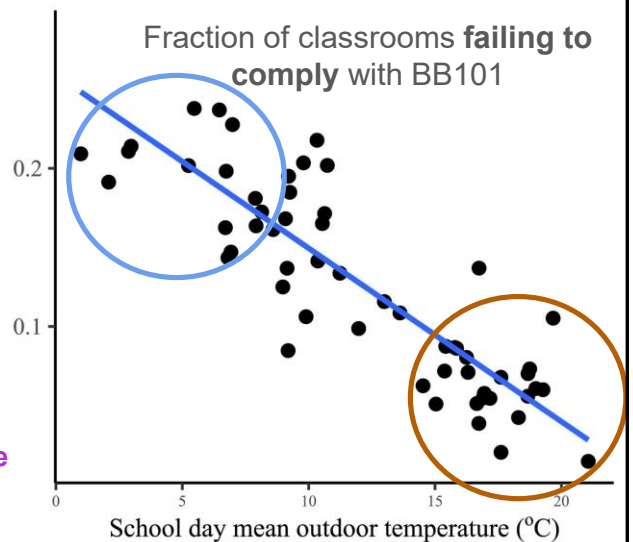


BB101 specifies that CO<sub>2</sub> levels averaged over the school day fall below 1,500 ppm within naturally ventilated (95% of UK) classrooms

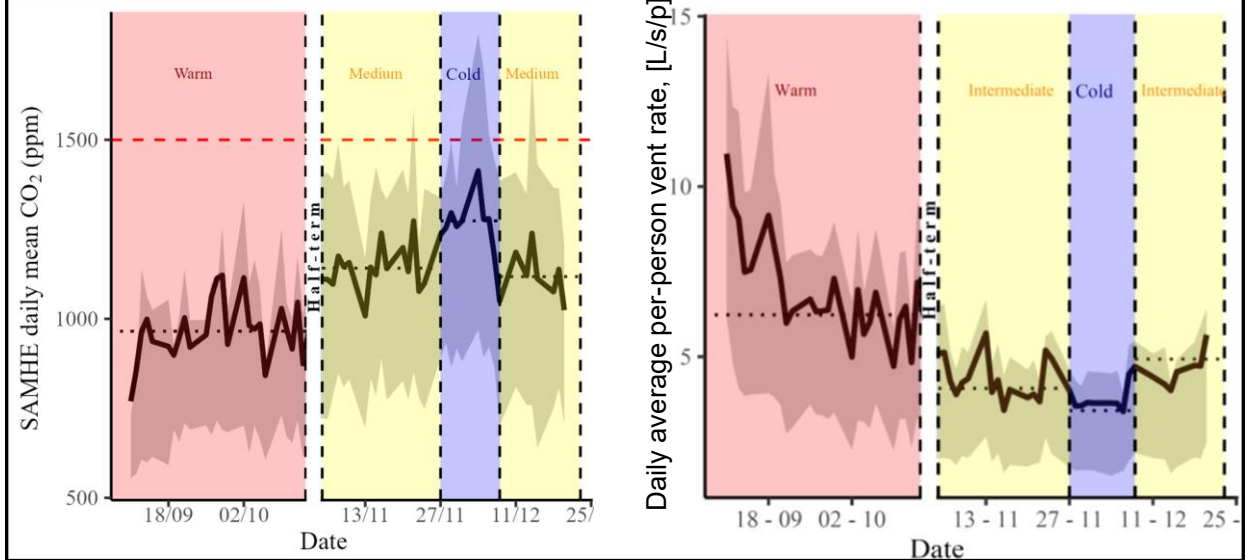
**When warm outside most classrooms can comply with BB101**

**When cold outside about 20% of classrooms fail to comply with BB101**

**Recommendation: provide training and improve support of school staff to manage good ventilation even on cold days**



# From CO<sub>2</sub> to per-person ventilation



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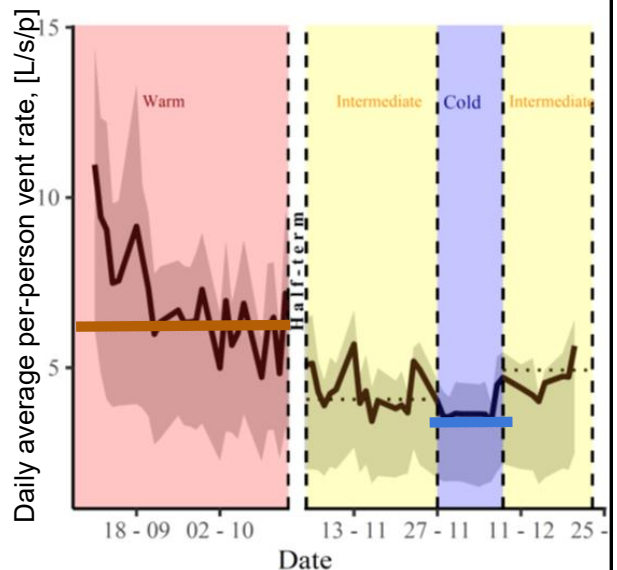
# From CO<sub>2</sub> to per-person ventilation

**When warm outside almost classrooms are able to comply with BB101 BUT ventilation rates are about 6 L/s/p**

**When cold outside ventilation rates fall to about 4 L/s/p**

**Generally, 8-10 L/s/p recommended for healthy environment (e.g. ASHRAE 62.1, EN 16798-1, Part F for offices)**

**Recommendation: update BB101 to focus on achieving 'good' levels of ventilation**



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# What we learnt about levels of classroom ventilation

As we have such a lot of data, we can 'control' for the weather and determine what factors significantly affect ventilation:

- Schools in area of greater deprivation showed lower ventilation and higher CO<sub>2</sub> levels.  
**Recommendation:** when investing in schools consider addressing this imbalance.
- Schools with more pupils than their 'school capacity' target, showed lower ventilation and higher CO<sub>2</sub> levels than those which did not.
- **Recommendation:** keep pupil numbers below the published 'school capacity'.

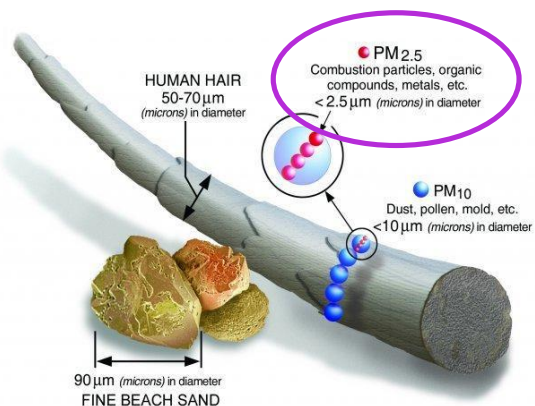
*Good ventilation does not guarantee 'good' air quality - what more should be done?*



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# Particulate matter in classrooms

- "Particulate matter" is the mixture of solid particles and liquid droplets found in the air
- Particulate matter PM<sub>2.5</sub> is a key pollutant present indoors
- We know that exposure to PM<sub>2.5</sub> is associated with negative health outcomes



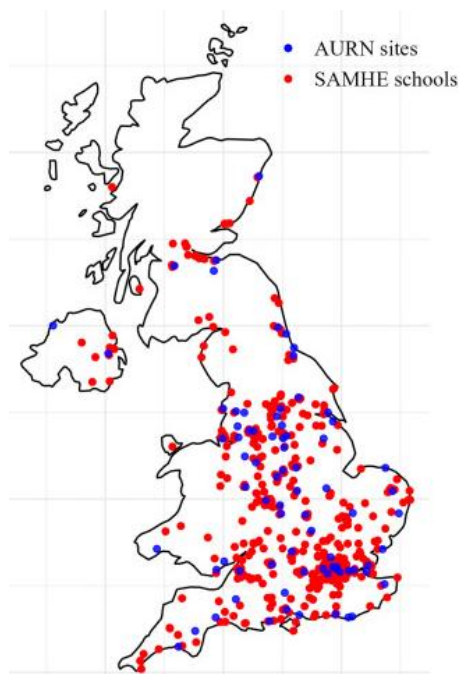
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## PM<sub>2.5</sub> can come into classrooms from outside

We know PM<sub>2.5</sub> can come into schools from outdoors...

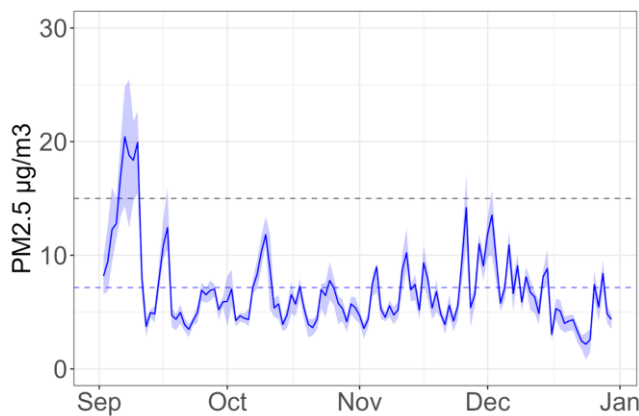
- We compared the SAMHE schools data set to outdoor PM concentrations at government AURN stations near schools.

Let's examine data from SAMHE schools from autumn term 2023...



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## Outdoor levels of PM<sub>2.5</sub>



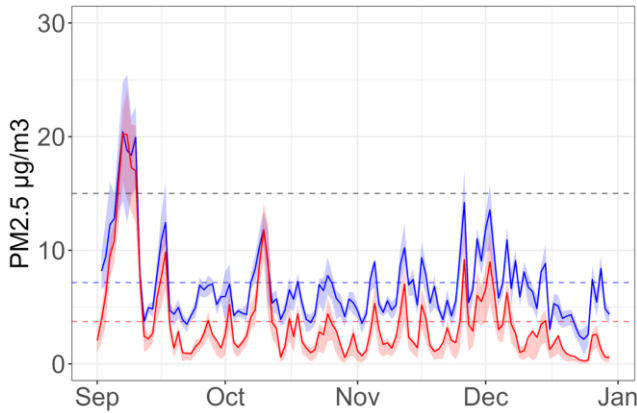
Outdoor average: 7.3 µg/m<sup>3</sup>



— Outdoor

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# SAMHE schools' levels of PM<sub>2.5</sub>



WHO daily average guideline: 15 µg/m<sup>3</sup>

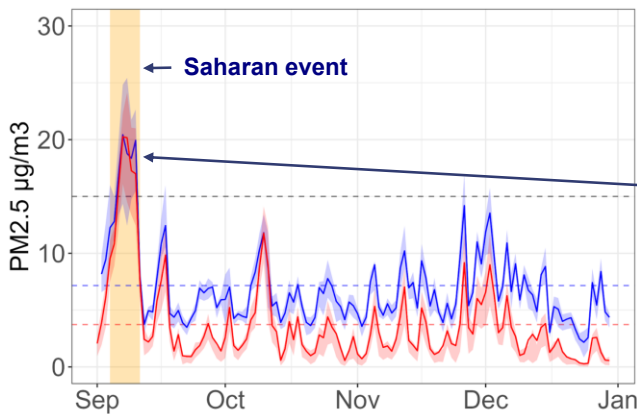
Outdoor average: 7.3 µg/m<sup>3</sup>

SAMHE school average: 3.6 µg/m<sup>3</sup>



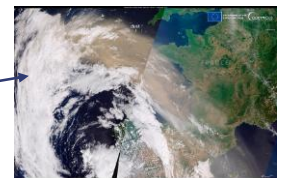
— SAMHE schools  
— Outdoor

# Large weather events raises PM<sub>2.5</sub> in schools



Saharan dust blown to the UK

Saharan dust came into SAMHE classrooms



— SAMHE schools  
— Outdoor

## What do we know about school PM<sub>2.5</sub> levels?

- **SAMHE classroom PM<sub>2.5</sub> levels can be affected by outdoor events that happen nearby and large events that affect the entire country**
  - **At least 75% of PM<sub>2.5</sub> in schools comes from outdoors**
  - **Recommendation: establish a legal right to clean air**
  - **Outdoor 'events' contribute significantly to long-term exposure**
  - **Recommendation: enforce 2021 WHO Air Quality Guidelines**



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## Evidence to inform improving ventilation and air quality in UK schools

- **Typically, classrooms architecture can deliver reasonable ventilation rates during clement weather, but often fail to do so during colder weather**
- **Engineering retro-fit technologies, which provide a greater control of ventilation rates, are available both at classroom and building level.**
- **Air filters can reduce the concentrations of PM<sub>2.5</sub> in classrooms by 40%-50% during wintertime. Air filters significantly reduced illness-related absence during the pandemic.**



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## Provides a framework for recommendations

- We need to work together to set suitable targets for 'good IAQ' - balancing energy consumption with health and attainment concerns will be challenging but... *doing nothing should not be an option*
- We need to monitor the air in our schools.
- Provide school staff with the training they need to understand the benefits of ventilation & air quality, and how they can help manage them.
- Take action when monitoring indicates either the air quality or ventilation rates are not good, mitigation measures should be provided to schools. These should first seek to improve ventilation, but where this is not possible or sufficient, other measures, such as air cleaners, should be provided.



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## Insights beyond schools: improving indoor air quality in UK buildings

- Schools show that modern technology can enable large-scale data collection to provide evidence and target changes
- Engineering technologies are available, both for retro-fit and new build, to help deliver better IAQ.
- These investments in technology should be used to reduce our energy consumption and will be required for 'net-zero' or any other climate mitigation strategy.



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Thanks for listening!

Find out more:



[www.samhe.org.uk](http://www.samhe.org.uk)



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