

The impact of fireworks events on classroom air quality

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1 Introduction

In the Autumn of every year, there are two events in the UK which are often celebrated by the lighting of fireworks: Bonfire night (or Guy Fawkes night) and Diwali. Bonfire night is on the 5th November every year, with big celebrations running over the weekend of Friday 3rd to Sunday 5th November in 2023. In 2023, Diwali occurred on the 13th November, with many celebrations focused over the period Friday 10th to Monday 13th November. When set off, fireworks burn chemicals and so affect air pollution levels. Most noticeably for the measurements made by the SAMHE monitors, fireworks release particulate matter into air outdoors.

Children, young people and teachers spend lots of their time in school classrooms and so it is important to monitor and better understand air quality, including the concentration of particulate matter, in school classrooms. In this technical report, we use the levels of PM_{2.5} recorded by air quality monitors, connected to the Schools' Air quality and Monitoring for Health and Education (SAMHE) project, to investigate whether the Autumn's fireworks events had a noticeable effect on the indoor air quality of SAMHE classrooms.

2 Indoor and outdoor PM concentrations

To find the outdoor concentration of PM_{2.5} around SAMHE schools, data from the nearest Defra station, monitoring background outdoor air quality, to each school was used (Defra is the Government's Department for Environment, Food & Rural Affairs). The hourly concentrations of PM_{2.5} was averaged across all of these stations and then compared to the hourly average concentration of PM_{2.5} from the SAMHE air quality monitors. Figure 1 shows the hourly mean concentration of PM_{2.5} averaged across SAMHE monitors (in red, 'Indoor') and averaged across the Defra stations (in blue 'Outdoors'). These trends are shown over a four week period which includes the two consecutive weeks in which Bonfire night and Diwali both fell, as well as more 'typical' weeks before and after the weeks of the firework events. The days of Bonfire night and Diwali are each highlighted by vertical coloured bands, as are the Saturdays nearest to each event (on where many celebrations are likely to have occurred).

Across the entire period shown, the outdoor levels of PM_{2.5} are higher than the levels in classrooms. On the evenings of the 4th, 5th and 11th November, the outdoor levels of PM_{2.5} are significantly higher than at other times. The levels of indoor PM_{2.5} from the SAMHE monitors seem closely correlated to the outdoor levels. Specifically, the peaks in indoor PM_{2.5} occur very soon after peaks in outdoor PM_{2.5} (on average around two hours later). Over this period, the highest concentration of PM_{2.5} is on Saturday 11th

November, the Saturday after Bonfire night and before Diwali. The PM_{2.5} concentration was also higher over Bonfire night weekend (Saturday 4th and Sunday 5th November) than in the week before or after. It is also worth noting that the indoor and outdoor levels on Thursday 16th and Friday 17th November are similar to those over Bonfire weekend. Whilst it is possible that belated fireworks celebrations occurred over these dates there may be other, unexplained, contributions to the higher levels of PM_{2.5}.

In order for sources of outdoor pollutants, such as the particular matter produced by fireworks, to be present within indoor air, they must be carried by the air flows into buildings; these are described as ventilation flows, and often occur through windows, doors and ventilation openings. It may seem surprising then that the levels of indoor PM_{2.5} were high over the weekends of Bonfire night and Diwali, as it could be expected that the ventilation of schools would be reduced at weekends as doors and windows should be shut for security reasons. These readings from the SAMHE monitors suggest that there might still be quite a lot of outdoor air ventilating these schools even at weekends.

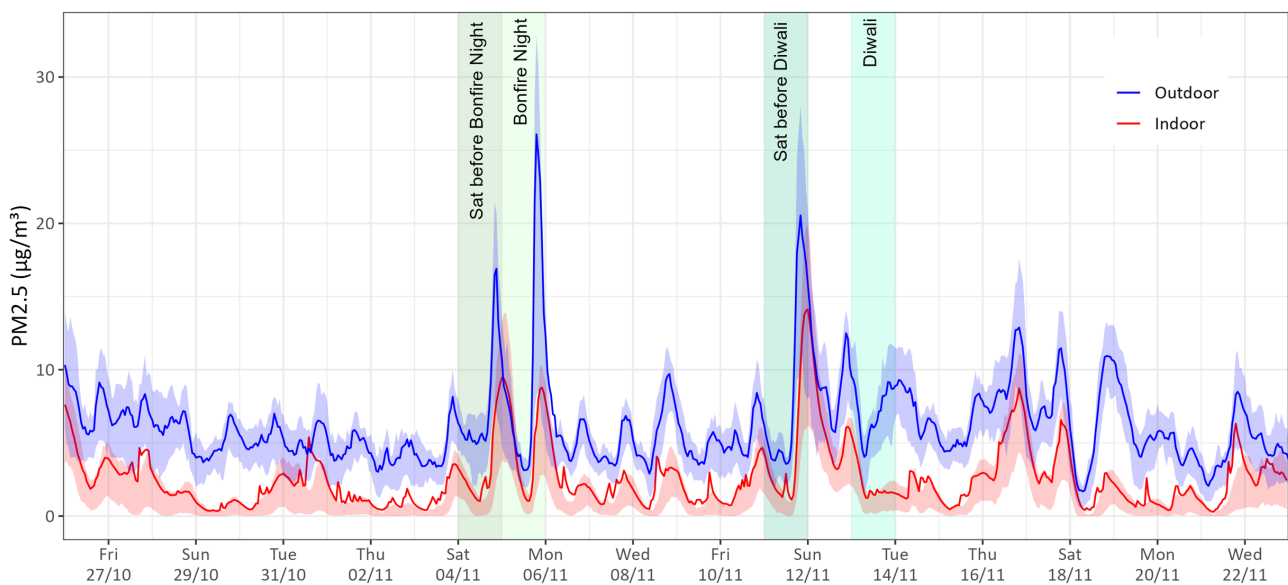


Figure 1: The hourly mean concentration of PM_{2.5} ($\mu\text{g}/\text{m}^3$) against time between 26/10/23 to 23/11/23. The indoor measurement (in red) is the average of the concentration measured by all connected SAMHE classroom monitors. The outdoor measurement (in blue) is the average concentration across the Defra measurement sites closest to schools. The interquartile range is shown by the shaded region. The dates of Bonfire Night and Diwali and the nearest Saturday to each event are also highlighted in various shades of green.

Both Bonfire night and Diwali were predominantly celebrated at weekends, when pupils were not at school. Therefore, we next wished to establish whether these events had an impact on the air quality in classrooms during the school week that followed each celebratory weekend. Figure 2 shows the PM_{2.5} concentrations measure but only those during school hours; so the data shown is the same as that shown in figure 1, but since school hours are just 7 hours per day, 5 days a week, figure 2 shows gaps within the data to help highlight levels during school time. The level of PM_{2.5} in the week after bonfire night is not significantly higher than in the week before, so despite PM_{2.5} permeating into school classrooms over the weekend, the levels had largely returned to be more 'typical' by the start of the school week. The level of PM_{2.5} after

