Evaluating the Efficacy of the MedicAir Air Purifier in Reducing Ambient Air Pollution in Classrooms

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Research Article

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Evaluating the Efficacy of the MedicAir Air Purifier in Reducing Ambient Air Pollution in Classrooms

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Abstract

In light of the novel coronavirus and transmission in schools, increased scrutiny has been placed on airborne viral and particulate contamination, and efforts to mitigate this have been suggested, including the use of air purification. The importance of this is increased given the relationship between increased airborne particulates and increased coronavirus transmission, as well as the significance of removing particulates in the size range of bacteria and viruses from the air.

Ambient levels of PM2.5 and PM1 in the absence of purification were recorded in two classrooms of similar size using medical grade data loggers, which then measured the change in these levels with the use of MedicAir air purifiers. It was found that baseline levels at times doubled the WHO limits for safe indoor air quality (IAQ). MedicAir units were able to rapidly reduce levels of particulates to significantly below WHO limits.

We propose that the use of these units is an effective and rapid solution for the mitigation of coronavirus transmission as well as the improvement of IAQ in schools.

Introduction

The COVID-19 pandemic has undoubtedly changed our lives, and has left a lasting impact on multiple industries which will inevitably take years to fully recover. However, perhaps one of the worst hit and irreparably damaged groups are children, many of whom will be set back significantly according to studies, and will potentially earn less over their lifetime due to coronavirus related restrictions (1). The COVID-19 pandemic has also brought fresh scrutiny to the issue of air quality in schools; in 2017, researchers from the university of Manchester found that a quarter of school children in the UK attended schools with air quality which was unacceptable by WHO standards (2). WHO guidance dictates that on average, no more than 10 μg/m3 particulate matter of the size 2.5 micrometres (PM2.5) should be inhaled (3), however schools surveyed in this study were found to contain twice this amount of particulate matter.

Particulate matter below 10 micrometres is capable of bypassing some of the body's defence mechanisms and is able to reach the lungs. However, it is only particulate matter below 5 micrometres which is able to reach the alveoli and pass into the bloodstream, which renders increased levels of PM2.5 in environments such as schools particularly concerning. Several studies have found that increased levels of PM2.5 can lead to a direct reduction of lung function, as well as indicate early lung disease in school children (4,5). There has also been an increased focus on finer particles, such as PM1, which are similarly able to penetrate the lungs and alveoli, and enter the bloodstream. This is particularly relevant due to the contemporary focus on infectious disease transmission, given that this is the size range within which bacteria and viruses tend to fall (6,7,8).

Furthermore, in light of the airborne mode of transmission of the novel coronavirus, PM2.5 poses yet another concern, due to the ability of particulates of this size to remain suspended in the air and provide viral particles with a nucleation site. This enables the viral particles not only to persist in the air but to reach the alveoli, where the virus is able to bind with ACE2 receptors and enter human cells to replicate.(9) It is not surprising, therefore, that an increase in ambient PM2.5 is strongly associated with an increase in transmission of COVID-19(8).

One strategy proposed by governmental bodies to reduce the risk of transmission of COVID-19 has been to employ natural ventilation in indoor spaces, which materially translates to opening windows in public spaces such as schools. However, given that indoor air pollution in schools is often linked to pollution from nearby roads, this may only exacerbate the issue of indoor air pollution in urban schools. Furthermore, given new evidence which implicates increased ambient air pollution, specifically with PM2.5 and PM1 air pollution, and increased risk of respiratory disease, it seems pertinent to explore COVID-19 mitigation solutions which do not exacerbate levels of indoor air pollution(10,11,12).

Another strategy piloted in some councils such as Bradford City Council (13) is the use of air purification as a method of reducing classroom air pollution and the risk of coronavirus transmission. In order to evaluate the efficacy of such a strategy, we placed air purifiers alongside medical grade data loggers in classrooms in a rural school.

Materials and Methods

Two classrooms were used in our experiment, of similar size, with the same number of occupants. Windows were open throughout the experimental period, to reflect guidance on increased ventilation, and a rural school was chosen to mitigate the confounding effects of road pollution which would affect readings in urban schools.

We then placed two medical grade data loggers in the classrooms for 2 days in order to establish a baseline level of PM2.5 and PM1 in both rooms. After the five days had passed, we then moved identical MedicAir units (air purification units fitted with carbon and HEPA 13 filters, as well as a UVC bulb) into both classrooms. However, only one of the two units contained a HEPA filter and the other functioned as a control unit.

The units were then left on REAKT mode, which increased or reduced the throughput of the units depending on ambient particulate matter levels, for two weeks. After this period, the filter was removed from the first unit and placed in the second unit, and the experiment was repeated for a further 2 week period.

Readings from each data logger were recorded every minute for this time period. In order to reduce bias, only one of the researchers was aware of which unit contained the HEPA filter and was responsible for changing it after the two week period.

Table 1 shows the details of both rooms- henceforth termed rooms A and B:

	Room A	Room B
Room (L)	8.975	9.51
Room (W)	5.905	4.839
Room (H)	3.096	4.267
Cubic Metres	164.079873	196.36260363
Heigh of AQ Monitor (m)	1.5	1.5
Placed Monitors	11/15/21	11/15/21
Placed Unit with filter	12/1/21	11/17/21
Placed Unit witout filter	11/17/21	12/1/21
Units turned off	12/14/21	12/14/21
Monitors Removed	12/17/21	12/17/21

Results

Data analysis showed that baseline levels of particulates were at times double the WHO guidelines on airborne particulate volume prior to placement of filters in the rooms. When the HEPA filters were on, the PM2.5 in the presence of HEPA filters then dropped significantly below the WHO guidelines for safe air quality.

Fig 1 - Graph showing baseline levels of PM2.5 particulates in room A with no purification

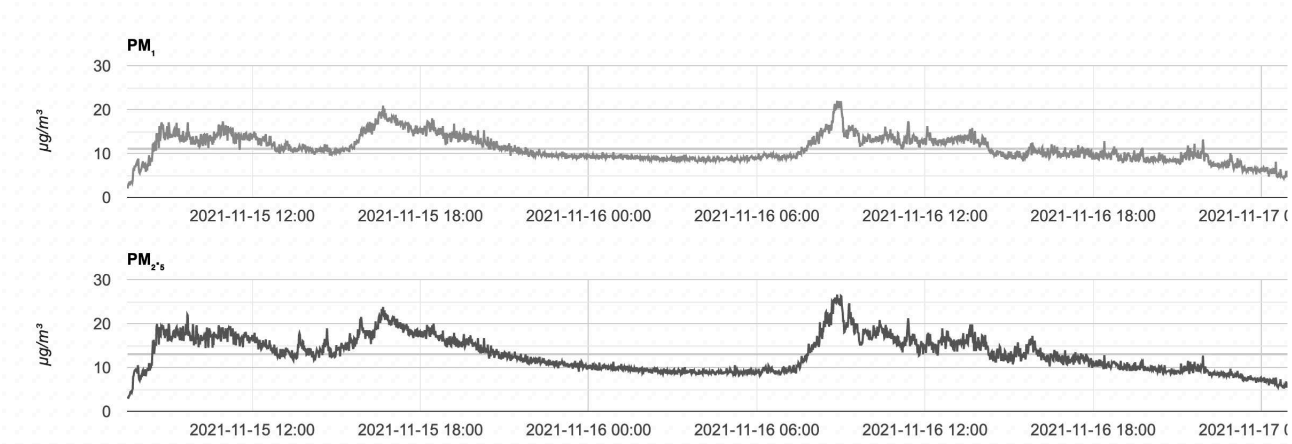


Fig 2 - Graph showing baseline levels of PM2.5 particulates in room B with no purification

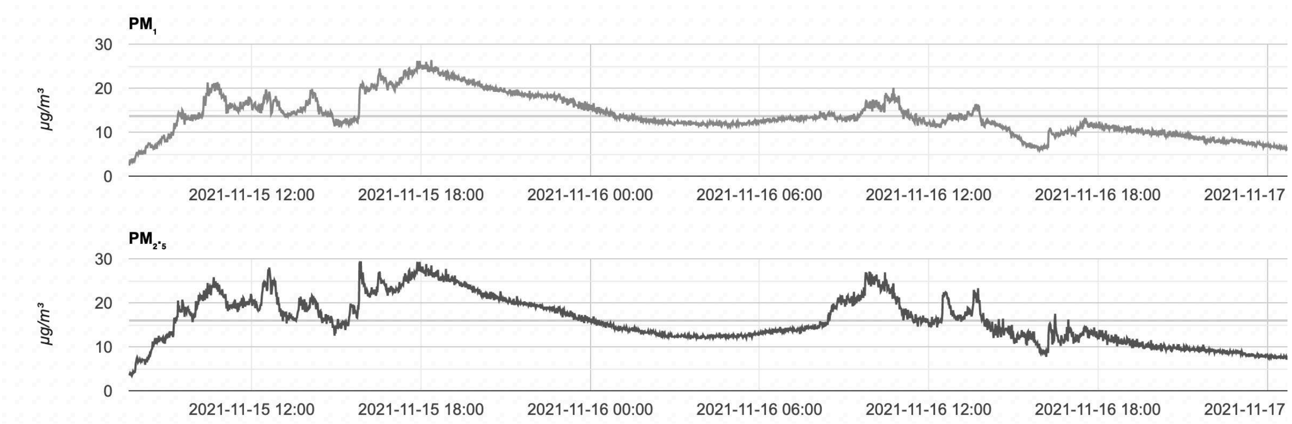


Fig 3- Graph showing particulates when MedicAir with a filter was placed in room A

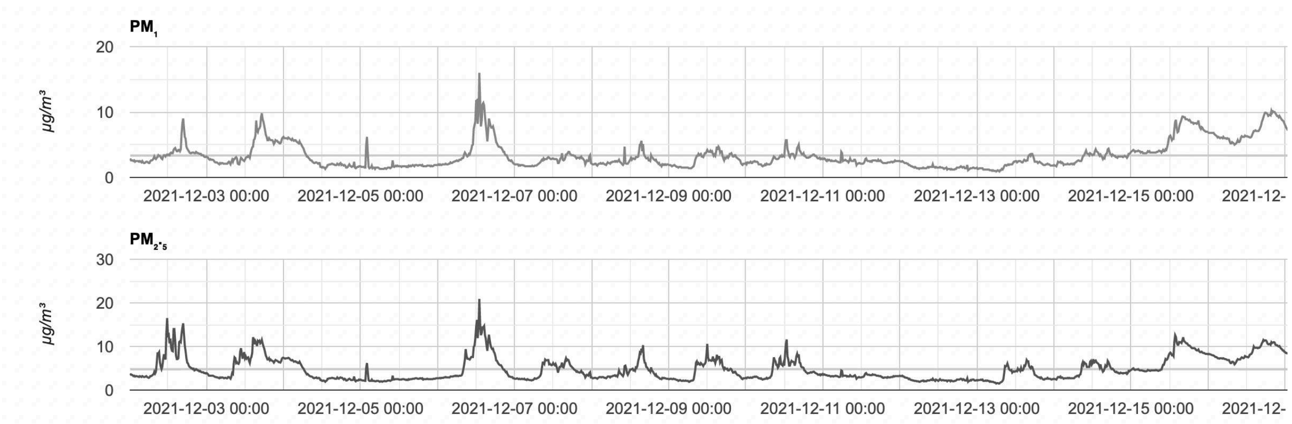


Fig 4- Graph showing particulates when MedicAir with a filter was placed in room B

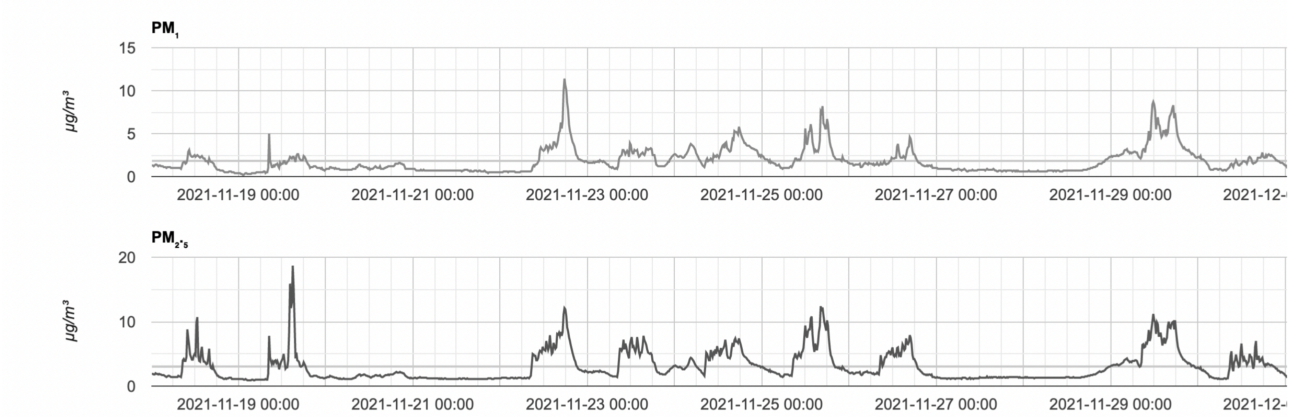


Fig 5- Graph showing particulates when MedicAir filter removed in room A

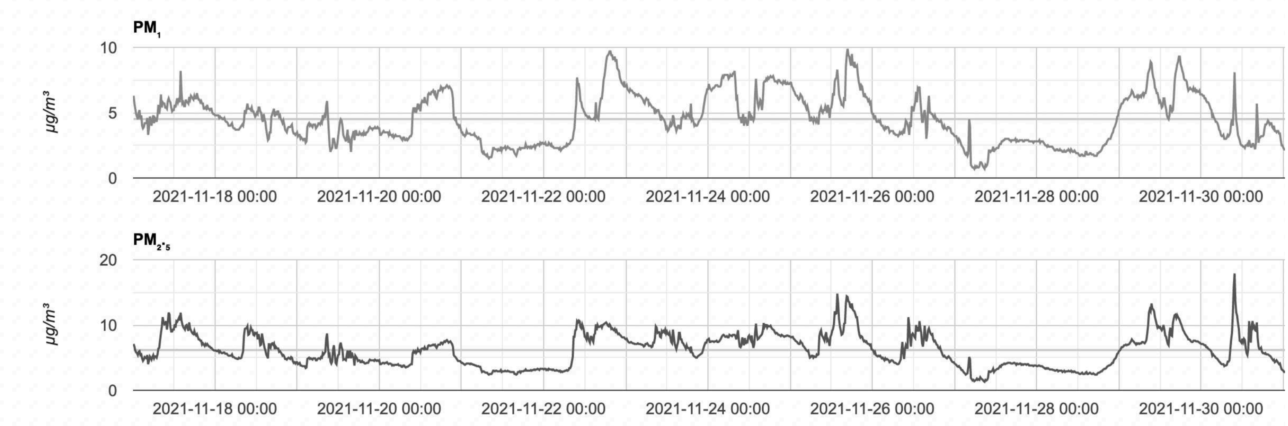
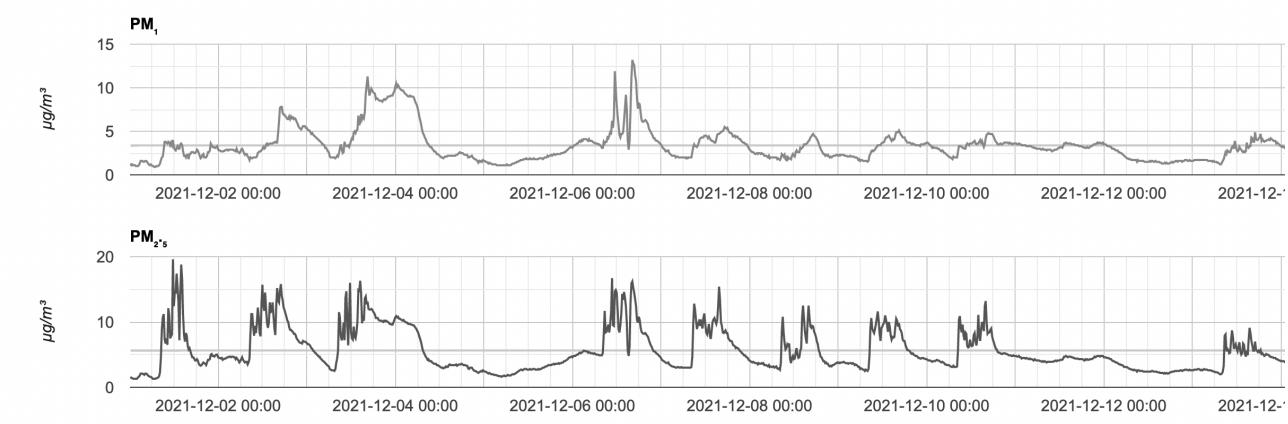


Fig 6- Graph showing particulates when MedicAir filter removed in room B



Regular spikes in PM2.5 data were noted throughout all phases of the experiment and we posit that this can be explained by the times children entered and left the room, and the evenings when cleaning was taking place in both classrooms.

Use of the MedicAir air purifier was able on average to reduce the airborne PM2.5 concentration by over 50% in both rooms, and reduced the average PM2.5 level to significantly under the WHO guidelines.

Although it was not the specific focus of this study, the data logger used also recorded ambient nitrous oxide levels. Concerningly, classroom A's levels of nitrous oxide were on average over twice the WHO recommended level. On further investigation, it became clear that the gas flue located outside the window of Room A was likely responsible for this increased reading, the detrimental effects of which have no doubt been exacerbated by open window guidance.

Discussion

Baseline data from data loggers showed that in the absence of air purification, with open windows, both rooms had an average PM2.5 and PM1 value higher than WHO limits: in room A at 11.1 for PM1 and 13.1 for PM2.5, and in Room B these values were higher still, at 15.9 for PM2.5 and 13.6 for PM1.

This is particularly concerning given the rural location of the school, as it can be extrapolated that values in a similar room in an urban school in proximity to more roads would be far higher, and the detrimental impacts of this on children studying there could be severe.

After the Medicair units with a filter were placed in the rooms, these values dropped significantly- in Room A values were 3.6 PM1 and 4.8 PM2.5, and Room B 1.8 PM1 and 3.4 PM2.5- which lie well below the WHO guideline level. This also reduces the number of nucleation sites for any airborne viral particles, which has far-reaching implications in coronavirus transmission prevention.

Spikes in the data which slightly increase the average in data collected while purifiers were in the rooms, as well as when absent, are proposed to be caused by cleaning activities in these time windows. Spikes were also observed at the times when children entered and exited classrooms, as was expected.

Limitations in this study are undoubtedly related to the small sample size and our focus on particulates alone. Given the incidental finding of concerning levels of NO_2 in the ambient air in Room A, we would invite further studies on NO_2 levels in classrooms, and would ideally replicate the experiment in an increased number of classrooms over a longer period of time.
We would also in future omit readings taken over weekends and during non-school hours, which contribute to skewing of the data set - we propose that, had these readings been omitted, the baseline levels of particulates in the absence of purification may have been significantly higher.

Conclusions

The effects of PM2.5 and PM1 on human, and particularly, children's health have been under increased scrutiny in light of the novel coronavirus pandemic. Several studies have suggested that air purification was able to effectively reduce the quantity of particulate contamination in air(14,15). This is rendered increasingly important given the the correlation between indoor air quality and increased viral perpetuation and transmission in the air.

The results of this experiment highlight the concerning levels of PM1 and PM2.5 in classrooms in the UK, even in rural surroundings when naturally ventilated per current guidelines using open windows. We have also shown that the use of the MedicAir air purification unit is an effective solution for the rapid clearing of particulates from the air, and is also effective at clearing particulates in the size range of bacteria and viruses rapidly in order to prevent transmission.

Financial Disclosure Statement

This work was commissioned by MedicAir DentAir Ltd. The funders had some role in study design, data collection or analysis. MedicAir DentAir Ltd was involved in the preparation of the manuscript and the decision to publish.

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Figures

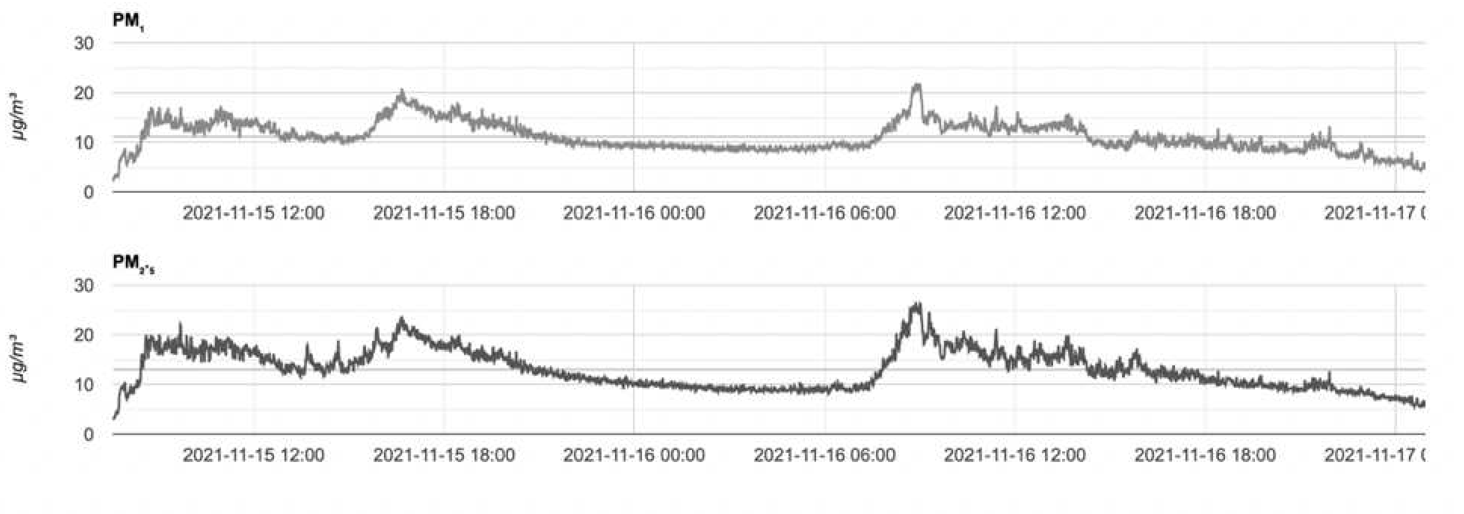

Figure 1

Graph showing baseline levels of PM2.5 and PM1 in room A

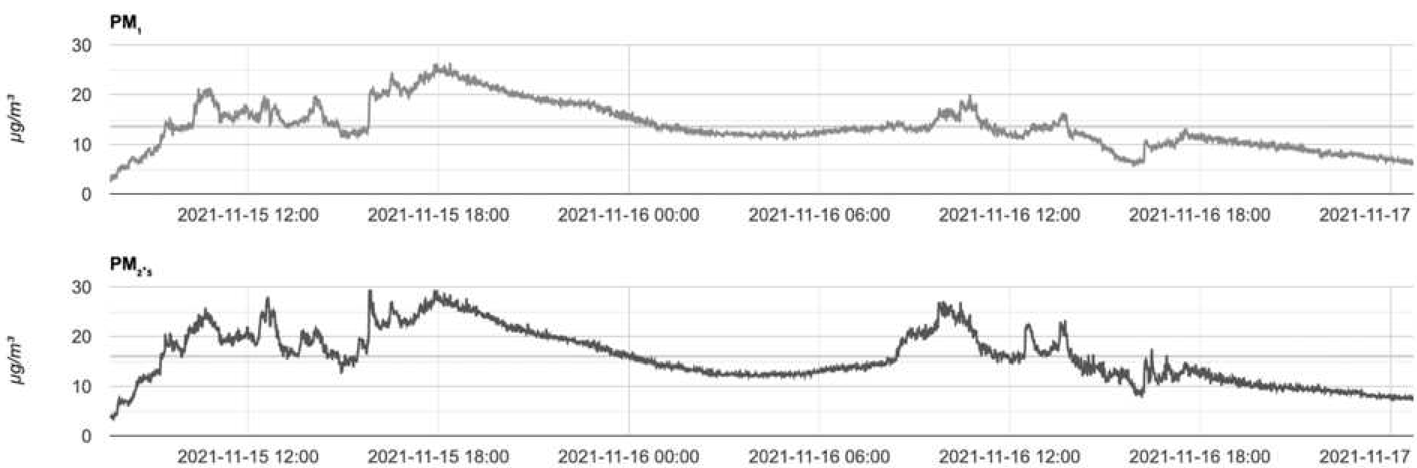

Figure 2

Graph showing baseline levels of PM2.5 and PM1 in room B

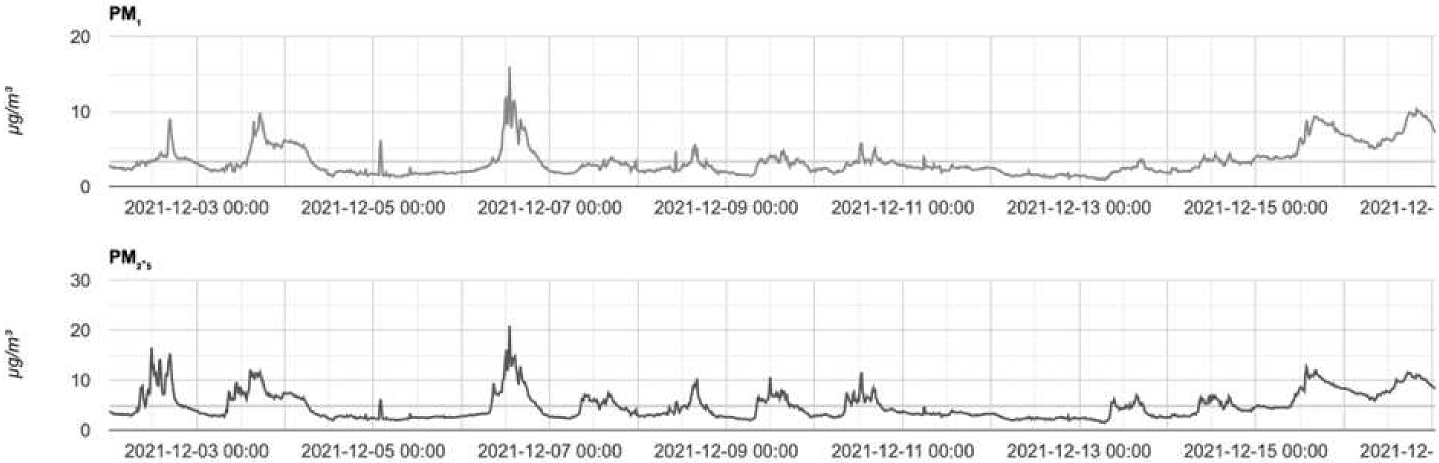

Figure 3

Graph showing levels of PM2.5 and PM1 in room A with a MedicAir with filter

Figure 4

Graph showing levels of PM2.5 and PM1 in room B with a MedicAir with filter

Figure 5

Graph showing levels of PM2.5 and PM1 in room A once the MedicAir filter is removed

Figure 6

Graph showing levels of PM2.5 and PM1 in room B once the MedicAir filter is removed