



**How Participatory Air Quality Sensing Shapes Participants' Exposure Experiences:  
Connecting Indoor Sensor Data and Participant Observations**  
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**Introduction/Methods**

This study seeks to understand how participants engaged in participatory air quality sensing to inform their understanding of indoor air pollution exposure and make decisions related to their exposure. For our study, we assembled a total of 11 indoor Plantower particulate matter sensors (PMS) in partnership with University of Utah chemical engineering students. To ensure PMS data accuracy, we calibrated each sensor utilizing the chemical engineering department's calibration chamber (Sayahi, 2019). We recruited seven participants for the study and conducted pre-and post-interviews with each participant. Each interview lasted one hour on average and was recorded and transcribed, and we translated four interviews conducted in Spanish to English. We distributed one PMS to each participating household and asked them to engage in participatory air quality sensing for four weeks. In other words, we included our participants in the scientific process of monitoring and reporting their indoor air quality data. We collected each participants' sensor data every week throughout the duration of the four-week study. After our final week of PMS data collection, we created data visualizations representing estimates of each participants' weekly averages, daily averages, and daily maximum values for particulate matter less than 2.5 microns in diameter (PM<sub>2.5</sub>). These PMS data visualizations were shown to each participant during the post-interviews and discussed to understand better our participants' perceptions of their exposure and their experiences with their PMS estimates. Lastly, we conducted preliminary analysis on the PMS data visualizations wherein we noted patterns among our participants' sensor data.

**Preliminary Findings**

The findings from our preliminary analysis of the PMS data visualizations revealed three patterns:

- 1) Weekly average PM<sub>2.5</sub> estimates varied, but the increases and decreases among our participants' PM<sub>2.5</sub> estimates followed similar weekly patterns (see Figure 1). The mean for our participants' weekly PM<sub>2.5</sub> estimates was 22.7 µg/m<sup>3</sup>.
- 2) Daily averages varied (with a mean daily PM<sub>2.5</sub> estimate of 19.1 µg/m<sup>3</sup>). However, distinct similarities in participants' daily averages occurred during poor air quality events, such as during the episode of wildfire smoke pollution from July 9<sup>th</sup>-12<sup>th</sup> (see Figure 3).
- 3) Participants' daily maximum PM<sub>2.5</sub> estimates varied considerably compared to one another (e.g., on July 6<sup>th</sup> the highest PM<sub>2.5</sub> estimate was 855 µg/m<sup>3</sup> while the lowest was 22 µg/m<sup>3</sup>).

Despite this variation across our participants' PMS data, we did find each participating household recorded maximum PM<sub>2.5</sub> estimates around a similar time each day. The greatest number of daily PM<sub>2.5</sub> maximum estimates occurred at 22:00 (i.e., 10:00 p.m. MST) for all of our participants, with a total of 17 (or 9.94%) occurrences.

We also present preliminary findings from our post-interviews in relation to the PMS data visualizations. These visualizations were created utilizing Microsoft excel:

- 1) During our post-interviews, when we showed participants' the PMS data visualizations, they commented on the environmental and household factors they believed contributed to their PMS estimates. The most common environmental factors that our participants noted were related to episodes of wildfire smoke and a dust storm. The most common household factors that participants described as contributing to their indoor air quality were evaporative/swamp cooling systems, cooking, neighbors smoking outdoors, and nearby landscaping activities.
- 2) Our participants also made distinct connections between the PMS data visualizations and their recollection of their experiences with maximum PM<sub>2.5</sub> estimates. Many participants were not surprised by what they saw for their daily maximum PM<sub>2.5</sub> estimates. For instance, most participants recalled the PMS showing higher PM<sub>2.5</sub> estimates while cooking in the evening hours. Specifically, most of our participants noted the changing LED color of the PMS sensor while they were cooking as it went from green (good) to red or blinking colors (indicating PM<sub>2.5</sub> levels at 151-200 for red, 201-300 for purple, and 300+ blinking colors, which can indicate unhealthy exposure levels for increased amounts of time). The second common cause for increased PM<sub>2.5</sub> estimates presented by our participants involved using an evaporative/swamp cooler in the home. One participant explained that during the evening hours when their swamp cooler was turned on, their neighbors smoked outside, causing the house to smell cigarettes and, subsequently, their PMS to indicate a change in the indoor air quality (i.e., from green to red LED). Another participant believed that their daily maximum PM<sub>2.5</sub> estimates occurred during the same time of day that their swamp cooler was turned.

## **Conclusion**

The preliminary findings of our study analysis support the argument that outdoor PM<sub>2.5</sub> pollution impacts indoor air quality negatively, as supported by local research conducted by Hegde et al. (2020) and Mendoza et al. (2021). The following steps of our research will be to perform statistical analyses on the PMS data to reveal if any of our preliminary findings related to patterns in the data are statistically significant. Our study is not exempt from limitations. The light-scattering methods of PMS are subject to error due to humidity, temperature, drift, and calibration (Sayahi, Kaufman, et al. 2019). Yet, they remain a valuable alternative for individual-level air pollution monitoring available to the general public. Two out of seven sensors failed during our study, but we promptly replaced them without further issue.

Further, our preliminary findings lend insight into the policy implications that can be enacted locally. Legislatures should consider and implement steps to reduce health-harming outdoor air pollution from infiltrating homes. Legislators should also create policies that enhance equitable access to indoor air quality sensors to all households. The cost of a commercial PMS creates access barriers for some socially marginalized groups.

Figure 1- Weekly PM<sub>2.5</sub> Averages

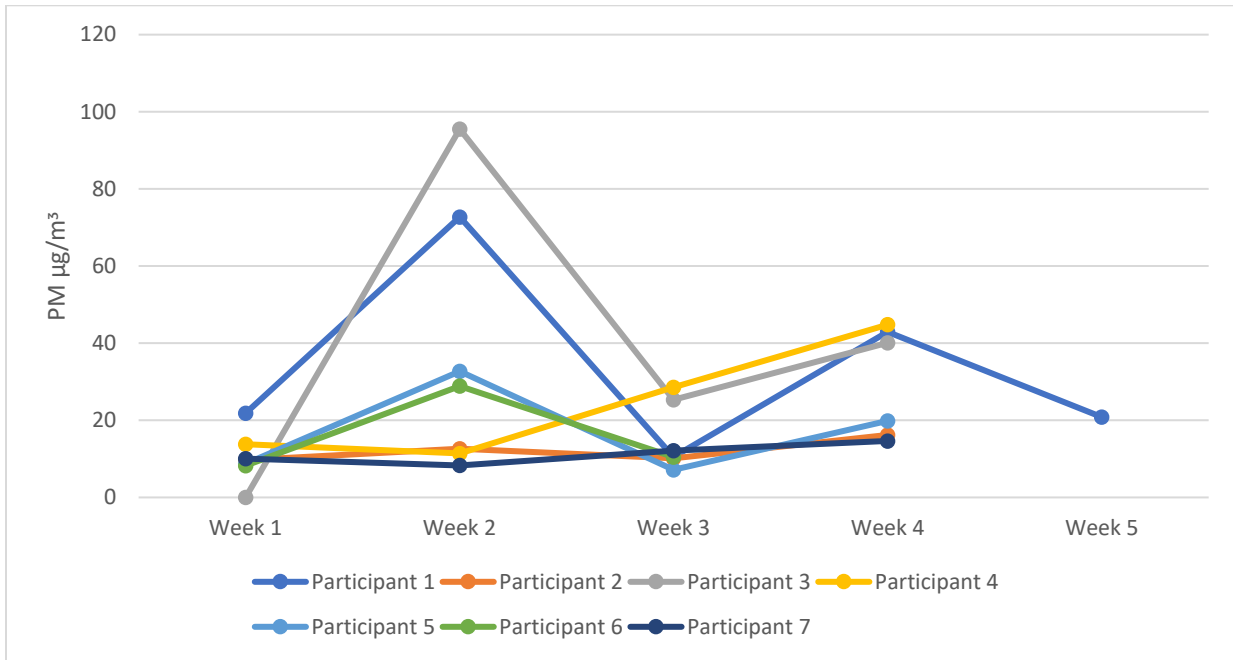


Figure 2- Daily PM<sub>2.5</sub> Averages

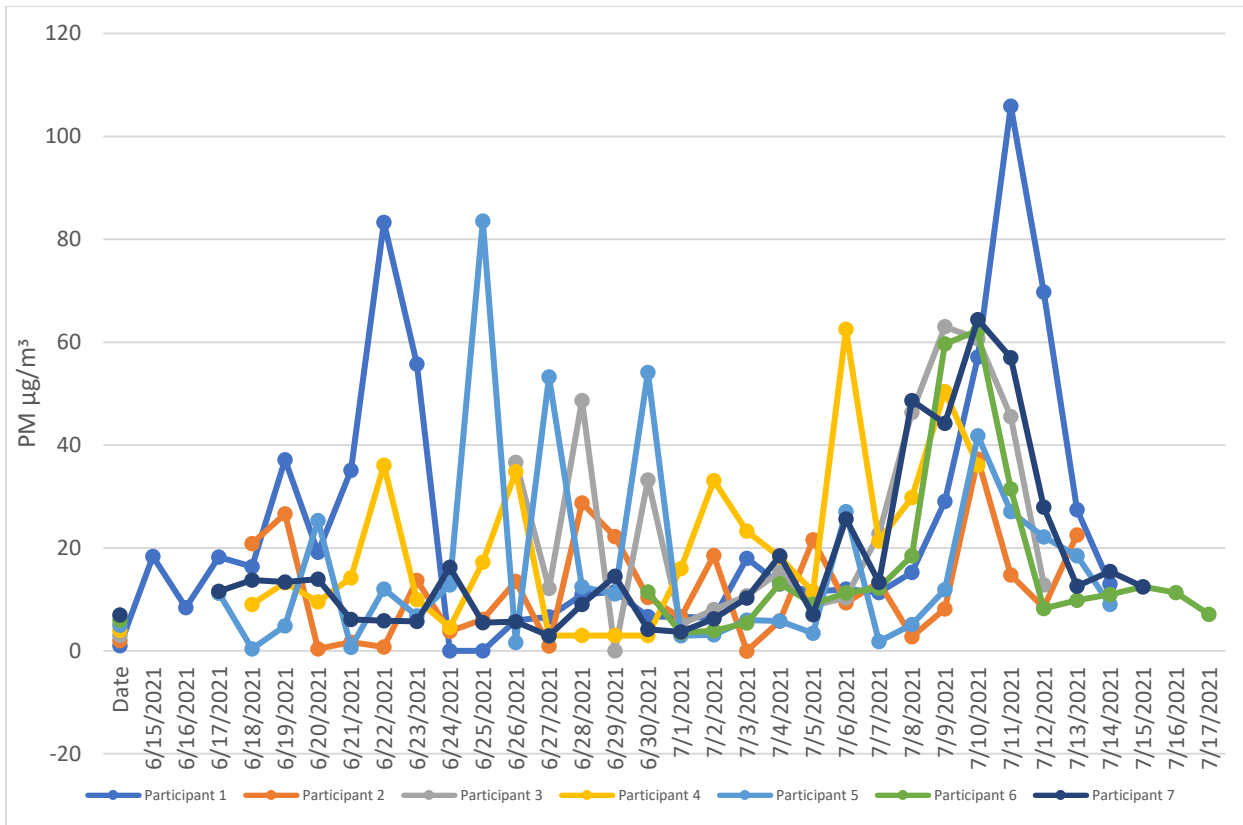


Figure 3- Weekly Maximum PM<sub>2.5</sub> Estimates Within 24-Hours

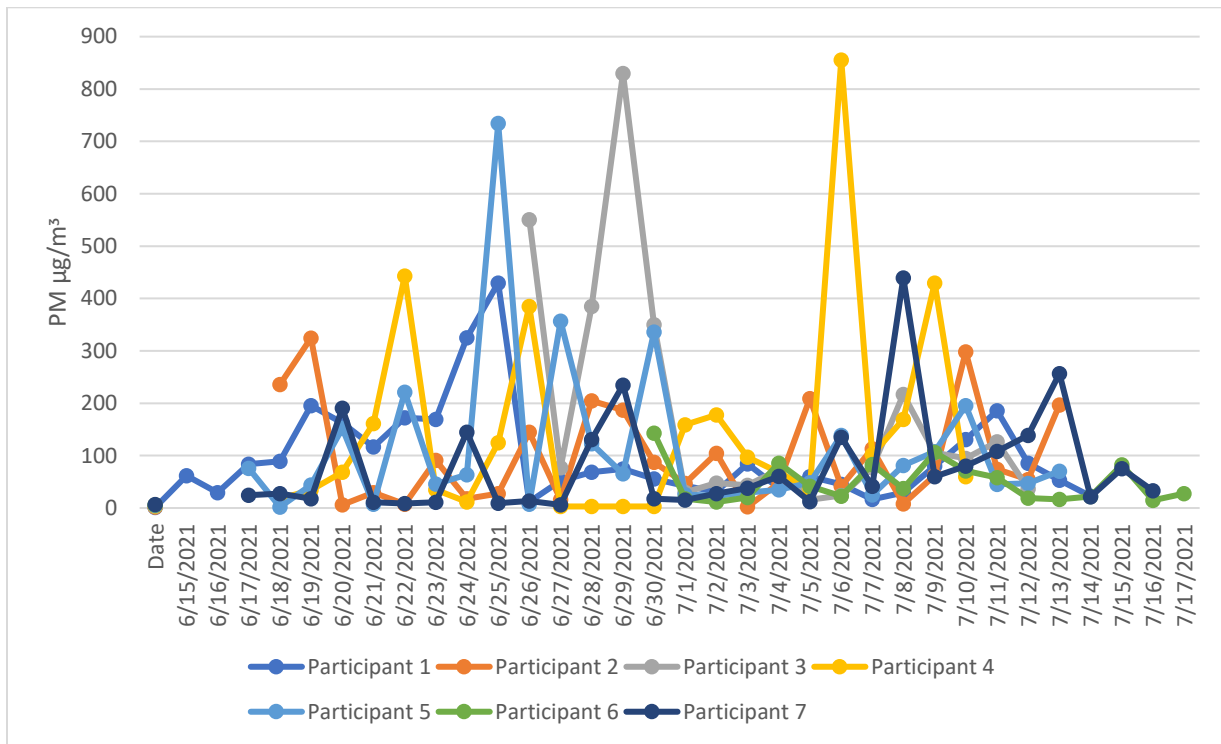
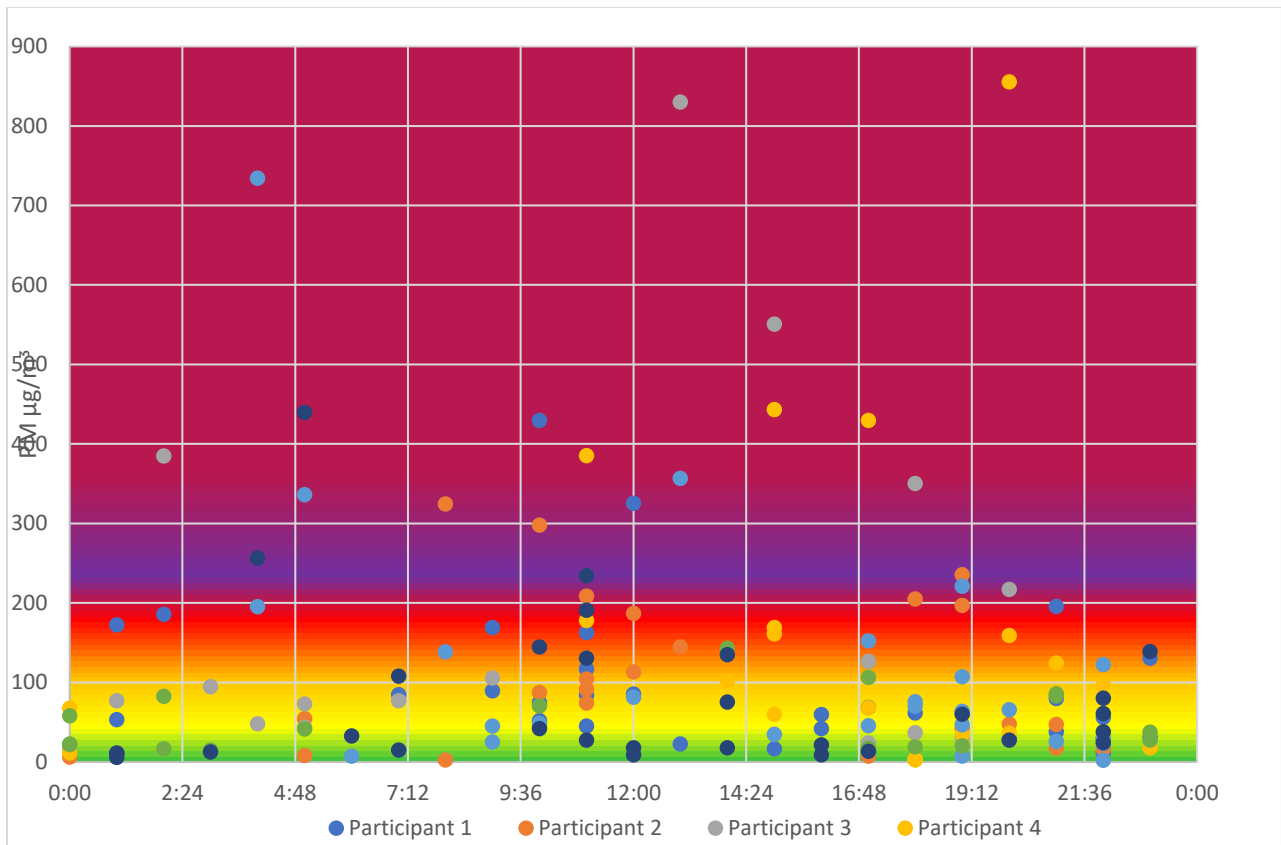


Figure 4- Scatterplot of Daily Maximum PM<sub>2.5</sub> Estimates



## References

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