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Dorm Rooms to Mountain Views: An Air Pollution Analysis

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Dorm Rooms to Mountain Views: Air Pollutants

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ENVE 130: Air Pollution and Climatology

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Abstract

This study presents a parallel analysis of indoor air quality in UC Merced dormitories with outdoor air pollution levels within Yosemite Valley, underscoring the importance of understanding how outdoor pollution impacts indoor air quality and offers insights for improving environmental health practices in residential and natural settings. Data was collected from October 2 to October 9, with indoor air samples taken twice daily, once in the morning and once at night, focusing on particulate matter in the size of 2.5 and 10 micrometers (PM2.5 and PM10). Outdoor pollution data for the same period was obtained from the Environmental Protection Agency (EPA) website. The analysis reveals unique patterns in PM2.5 and PM10 measurements across indoor and outdoor environments, reflecting the influence of human activity indoors and environmental conditions outdoors. Factors such as dormitory ventilation, occupancy, and regional atmospheric conditions contribute to these differences.

Keywords: particulate matter, air quality, atmospheric conditions

Dorm Rooms to Mountain Views: Air Pollutants

Air quality plays a crucial role in both environmental health and human well-being. According to the World Health Organization, exposure to fine particulate matter (PM2.5) significantly increases the risk of cardiovascular and respiratory diseases (World Health Organization, 2021). As urbanization and environmental concerns increase, it is important to understand the dynamics of air pollution in different settings, particularly in areas with varying environmental conditions. Particulate matter, specifically PM2.5 and PM10, poses a significant threat to health, as these tiny particles can be inhaled deep into the lungs. Once inside, they can bypass the body's natural defense systems and enter the bloodstream. For example, fine air particles can accumulate in the alveoli, the small air sacs in the lungs, and from there, they can trigger inflammation or travel into the circulatory system. This process has been linked to a higher risk of respiratory conditions like asthma and bronchitis, as well as cardiovascular issues such as heart attacks and strokes (World Health Organization, 2021). Understanding this pathway is crucial when evaluating air quality's impact on human health.

The location of this study examines air quality in two distinct environments: outdoor air quality in Yosemite Valley, located in Mariposa County, and indoor air quality in UC Merced dormitories. The outdoor air pollution data was collected from the Yosemite National Park monitoring station, located at the Yosemite Village Visitor Center. Indoor air samples were collected from the Valley Terraces dormitory, specifically room Kern 230, at UC Merced. By examining these two environments, this research seeks to highlight the potential impact of outdoor pollution on indoor air quality in a university setting, emphasizing how external environmental factors such as vehicle emissions, construction activity, or seasonal changes can influence the air that students, faculty, and staff breathe indoors, potentially affecting health, comfort, and academic performance.

Data and Methods

Figure 1

EXTECH VPC300 Particle Counter

Note: This handheld instrument measures six particle size thresholds (0.3, 0.5, 1, 2.5, and 10 micrometers) and includes sensors for reading environmental conditions like temperature and humidity. It was used in this study to collect indoor air quality data over a period of eight days.

The EXTECH Particle Counter (Figure 1) was used to measure the concentration of particle sizes at two thresholds: 2.5µm and 10 µm. Additionally, the device recorded four key environmental conditions during each test: air temperature, dew point, relative humidity, and wet bulb temperature. A tripod attachment was used to stabilize the particle counter, ensuring minimal movement throughout the measurement period.

Measurements were taken twice daily, once immediately upon waking and once before going to bed. For each measurement, the protective cap was removed, and the device was powered on. The “run” function was activated, initiating a 15-second sampling period during which air was drawn through the metal intake cylinder at the top of the instrument. Upon completion of a cycle, the device displayed the recorded data on-screen. After documenting the measurements, the instrument was turned off, and the protective cap was replaced.

Table 1

Indoor Particulate Matter Concentrations by Day and Time

Indoor Measurements			
Date	Time	PM 2.5 µm (particle per ft^3)	PM 10 µm (particle per ft^3)
10/2/2024	8:14pm	24	4
10/3/2024	8:44am	24	2
	8:35pm	77	19
10/4/2024	9:15am	43	11
	9:07pm	41	9
10/5/2024	11:04am	2	0
	10:46pm	56	4
10/6/2024	10:21am	40	4
	10:15pm	18	3
10/7/2024	10:09am	82	15
	9:44pm	34	4
10/8/2024	8:26am	90	15
	8:27pm	69	14
	10:57pm	57	7

10/9/2024	9:13am	86	9

Note: This table shows the concentrations of PM 2.5 and PM 10 measured indoors at UC Merced, recorded twice daily over an eight-day period. The corresponding times are listed for each measurement. On October 8th, an additional test was run after a sudden change in indoor air quality conditions; it is noted at 10:57pm.

Table 2

Outdoor Particulate Matter Concentrations by Day and Time

Outdoor Measurements		
Date	PM 2.5 ($\mu g/m^3$)	PM 10 ($\mu g/m^3$)
10/2/2024	5.7	17
10/3/2024	5.3	14
10/4/2024	6.2	24
10/5/2024	4.9	15
10/6/2024	4.5	14
10/7/2024	4.1	16
10/8/2024	6.4	22
10/9/2024	6.1	19

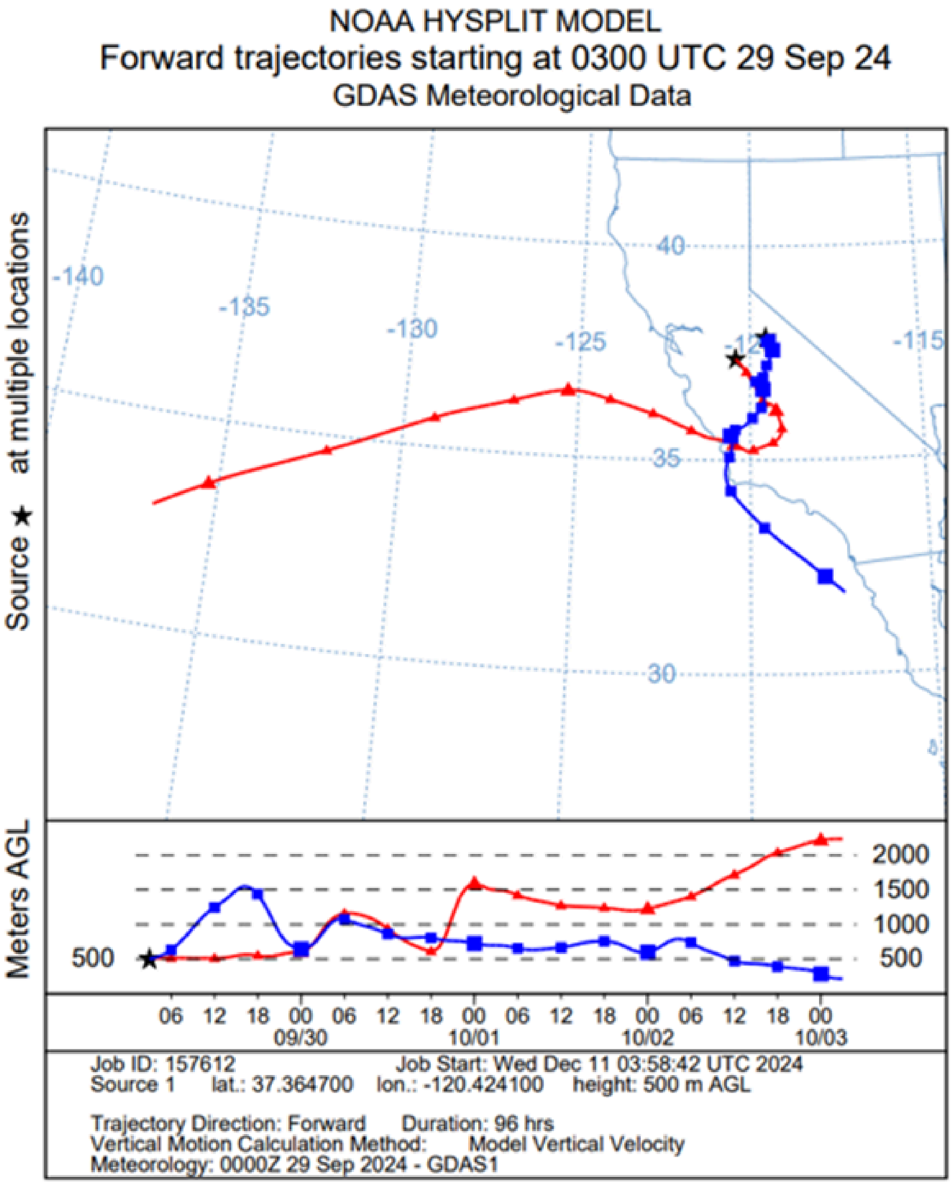
Note: This table presents the daily concentrations of PM 2.5 and PM 10 measured outdoors in Yosemite Valley from October 2 toOctober 9, 2024. The measurements were obtained from the U.S. Environmental Protection Agency monitoring station in Yosemite National Park (Site ID: 60413001).

Measurements for both indoor and outdoor pollutants were recorded for the same dates (Table 1 and Table 2). It is important to note that for the indoor air quality test, the first and last days only include one measurement for each particulate matter category. An additional measurement was recorded on 10/8/2024 at 10:57 PM when a hairdryer was in use. This measurement revealed a significant spike in the concentration of only finer particles, particularly those at 0.3 µm.

To better understand where outdoor particulates may have originated, the NOAA HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) model was used, shown in Figure 2 below. A forward trajectory model was run starting at 0300 UTC on September 29, 2024, using GDAS (Global Data Assimilation System) meteorological data (Stein et al.; NOAA ARL). The source location was set at UC Merced, at a height of 500 meters AGL, with a duration of 96 hours. The results showed two pathways: one moving west-northwest and rising to about 2000 meters AGL, and another staying near 500 meters AGL while moving south and east. These differing paths indicate variability in atmospheric transport conditions during the sampling period

Figure 2

NOAA HYSPLIT Forward Trajectories Starting at 0300 UTC on September 29, 2024

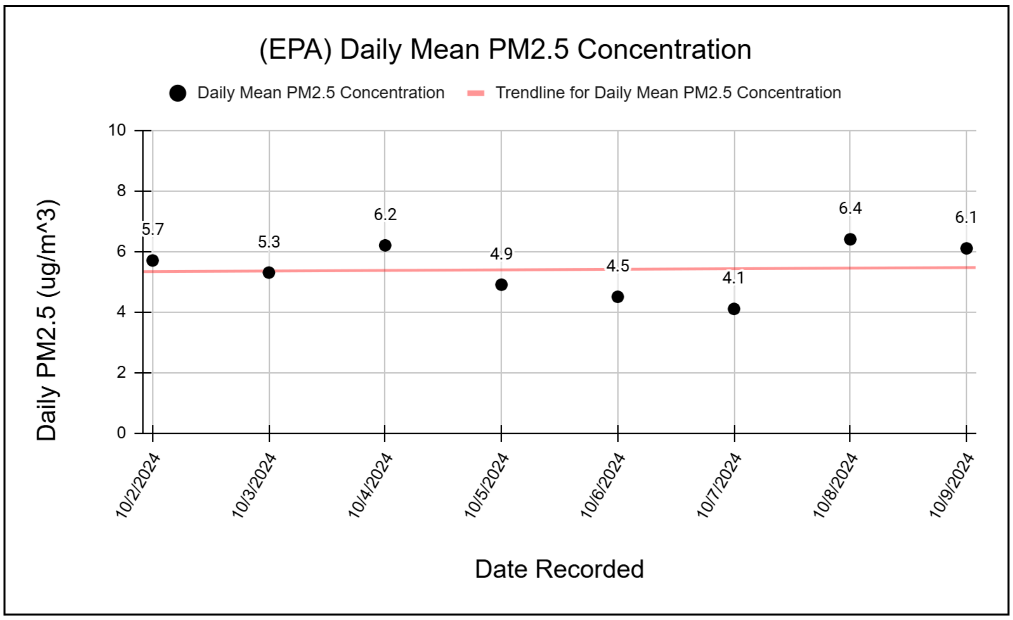


Note. This figure displays the NOAA HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) model results, showing two forward air parcel trajectories originating from UC Merced (lat: 37.3647°, lon: -120.4241°) at a height of 500 meters above ground level (AGL). The red trajectory indicates air movement rising to approximately 2000 meters AGL and heading northwest, while the blue trajectory remains closer to the surface and moves south and east. The bottom panel displays vertical motion profiles for both trajectories over the 96-hour model duration.

Results

Figure 3

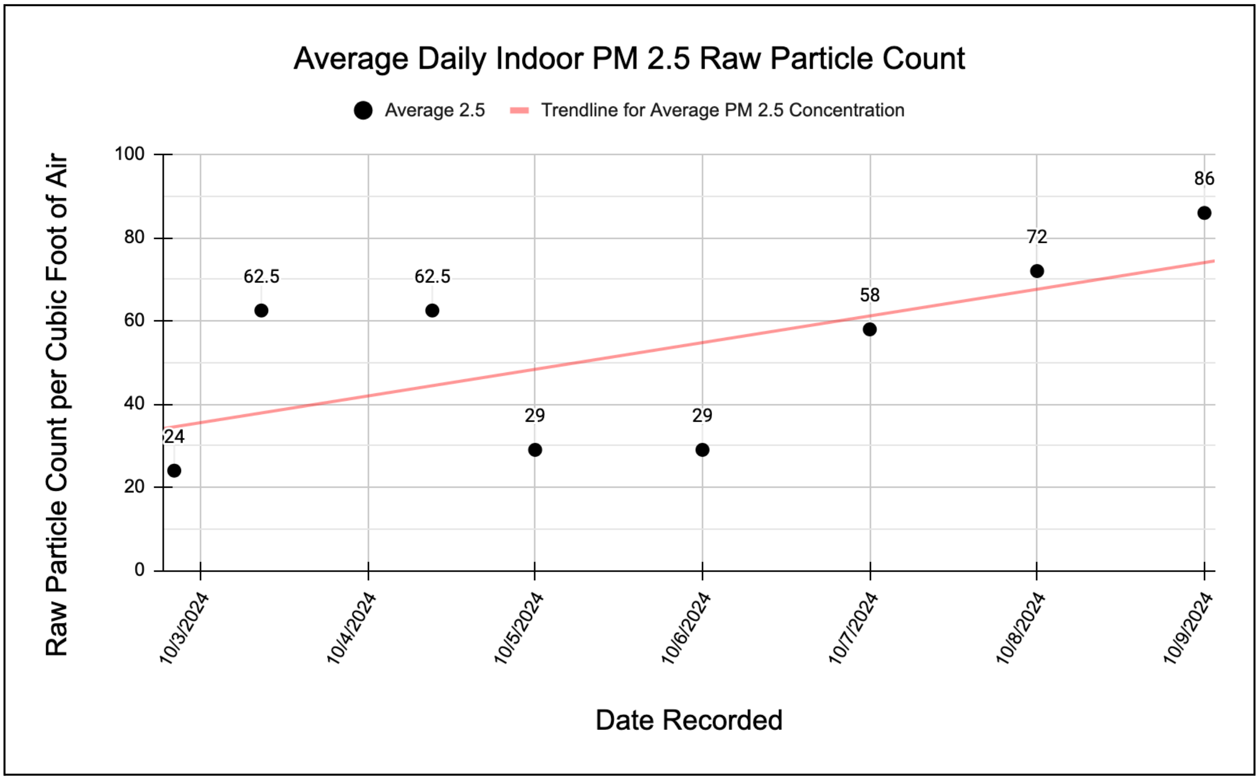
EPA Average Daily Outdoor PM 2.5 Concentrations from October 2–9, 2024



Note: This figure displays the daily mean outdoor PM2.5 concentrations (in µg/m³) recorded between October 2 and October 9, 2024. Black dots represent the observed daily concentrations, while the red line shows the trendline for the daily mean PM2.5 concentration. Data indicate fluctuations throughout the week, with the lowest concentration on October 7 and the highest on October 8.

Figure 4

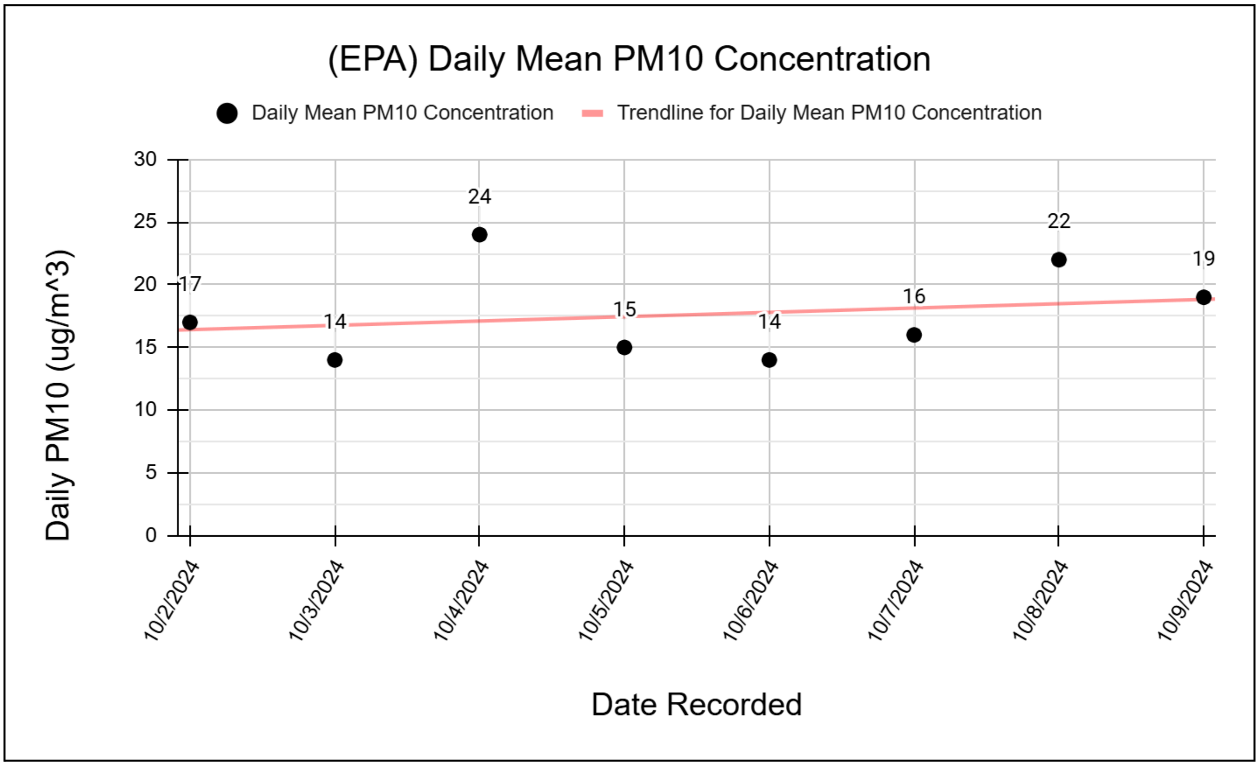
Average Daily Indoor PM2.5 Concentrations from October 2–9, 2024



Note: This graph presents the raw particle count of indoor PM2.5 per cubic foot of air over an eight-day period. Black dots represent the observed daily particle counts, while the red line illustrates the trendline indicating a general increase in particle count over time. Notably, the particle count peaked on October 9 and was lowest on October 3.

Figure 5

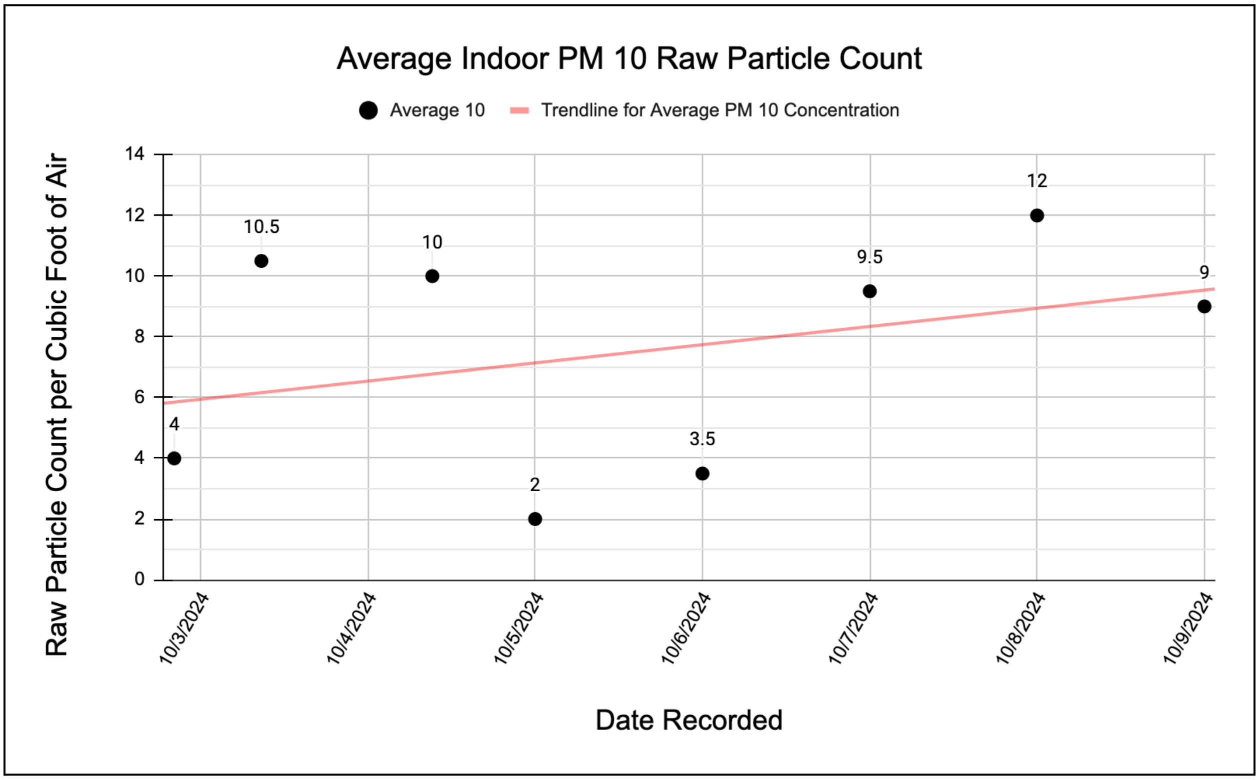
EPA Average Daily Outdoor PM 10 Concentrations from October 2–9, 2024



Note: This figure illustrates the daily mean outdoor PM10 concentrations (in µg/m³) recorded over an eight-day period. The black dots represent observed concentrations, while the red line shows a trendline for the data. PM10 levels ranged from 14 to 24 µg/m³, with the highest value observed on October 4 and a slow gradual upward trend seen as the week went on.

Figure 6

Average Daily Indoor PM10 Concentrations from October 2–9, 2024



Note: Daily average indoor PM 10 particle counts per square foot. Indoor PM 10 levels remained consistently low compared to finer particle counts, indicating limited generation of larger particulate matter indoors.

The comparison of morning and evening indoor PM10 concentrations, excluding the hairdryer data, reveals minimal fluctuations across the eight-day period, with levels consistently low overall. Table 1 shows that on certain days, nighttime indoor PM10 levels were slightly higher than in the morning. For example, on October 3rd, indoor PM10 increased from 2 particles/ft^3 in the morning to 19 particles/ft^3 at night, while on October 5th, levels rose from 0 particles/ft^3 in the morning to 4 particles/ft^3 at night. Although these increases are modest, they suggest that evening activities or limited nighttime air circulation may contribute to slightly elevated indoor PM10 concentrations. Conversely, several days showed higher morning indoor PM10 levels. For instance, on October 4th, morning PM10 was measured at 11 particles/ft^3, decreasing slightly to 9 particles/ft^3 at night, and on October 7th, morning levels were 15 particles/ft^3, compared to just 4 particles/ft^3 at night. Figure 6 illustrates that October 8th exhibited consistent indoor PM10 levels throughout the day, with 15 particles/ft^3 in the morning and 14 particles/ft^3 at night. Meanwhile, on October 6th, indoor PM10 remained stable, fluctuating only slightly from 4 particles/ft^3 in the morning to 3 particles/ft^3 at night.

Outdoor PM10 concentrations, shown in Table 2, consistently remained higher than indoor levels, with values ranging from 14 to 24 $\mu g/m^3$, compared to the lower indoor particle counts. These outdoor measurements were influenced by environmental factors such as dust, soil, and traffic emissions.

Discussion

The analysis highlights the significant impact indoor activities can have on PM2.5 concentrations. For instance, the spike observed during the hair dryer event clearly demonstrates this, likely caused by the release of fine dust, hair, or other debris. Similar increases in indoor PM2.5 levels could occur during activities like cooking, vacuuming, or even opening windows (U.S. Environmental Protection Agency, n.d.). Conversely, using HEPA filters in vacuums or air purifiers can help reduce indoor PM levels (American Lung Association, n.d.).

In contrast, PM10 levels indoors remained relatively low and consistent throughout the study. This likely reflects the nature of coarse particles, which don’t stay airborne as long and are less commonly produced by regular indoor activities. The data suggests that, in a stable indoor setting without significant ventilation changes or disruptions, PM10 remains relatively unchanged throughout the day.

When analyzing indoor PM2.5 data, spikes were observed, particularly on October 8th, where indoor levels peaked significantly due to the hairdryer event. These fluctuations support the idea that indoor sources of pollution, such as everyday activities, are more influential than outdoor pollution in shaping indoor PM2.5 levels.

For PM10, outdoor concentration readings were generally more stable than indoor levels, as can be seen in Figure 5, where outdoor PM10 ranged from 14 to 24 $\mu g/m^3$. In comparison, indoor PM10 was recorded between 24 and 86 particles/ft^3.

Limitations

There are some limitations to this study that should be considered. The study was conducted over the course of only one week and took place in a dorm room at UC Merced, not in a rural or high-exposure area like Mariposa. These conditions may limit the generalizability of the results.

Future research could extend the observation period, compare data from both urban and rural environments, and use controlled experiments to better understand how specific activities affect indoor PM concentrations. Incorporating seasonal data, using multiple sensors, and comparing the findings with real-time EPA data could further strengthen the robustness of the results.

Ultimately, the results underscore the significant role of everyday indoor activities in shaping indoor air quality, particularly with respect to fine particulate matter (PM2.5). However, outdoor sources must also be considered, especially for coarse particles like PM10, which are influenced by environmental factors. A significant limitation of this study is the vast difference in the measurement scales used for indoor and outdoor particulate matter data. Indoor data was measured in particles per cubic foot (particles/ft^3), while outdoor data was measured in micrograms per cubic meter (μg/m^3). These different units of measurement inherently limit the ability to make direct comparisons between the two datasets. However, despite the scale discrepancy, there may still be a potential correlation between indoor and outdoor particulate matter concentrations, as both were collected over the same time period.

Conclusion

The data demonstrates that indoor air quality, particularly for fine particulate matter (PM2.5), is significantly influenced by everyday activities, such as with the use of a blow dryer. The spike in PM2.5 on October 8th underscores how common indoor activities can substantially increase particulate levels within confined indoor spaces, particularly for smaller particles. This highlights the importance of recognizing and managing indoor air pollution sources.

Outdoor PM concentrations remained relatively stable over the study period, with higher levels observed for coarse particles (PM10), which were more affected by environmental factors like dust and soil. While the comparison of morning and evening indoor PM2.5 measurements suggests that reduced ventilation and particle accumulation may contribute to elevated indoor concentrations at night, it's important to note that these data are not directly comparable to outdoor levels due to differences in measurement units.

However, several limitations must be acknowledged. As stated, data collection was limited to a single week, and the study was conducted in a university dormitory setting, which may not fully represent other indoor environments. These factors limit the generalizability of the results. A future experiment could expand on this study by examining multiple types of indoor environments such as a kitchen, recreational area, or classroom over a longer time frame, incorporating seasonal changes, and exploring varying ventilation conditions. Incorporating real-time outdoor data comparisons at similar scales and using multiple sensors for data validation would provide a more comprehensive understanding of the dynamics influencing indoor particulate matter.

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