ANALYZING $PM_{2.5}$ TRENDS WITH AIR MONITORS

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Motivation

- The long term $PM_{2.5}$ exposure contributes to respiratory and cardiovascular disease, as well as variants of cancer.
- $PM_{2.5}$ indoors is as much of a problem outdoors since they are small enough to seep into most building structures. [1]

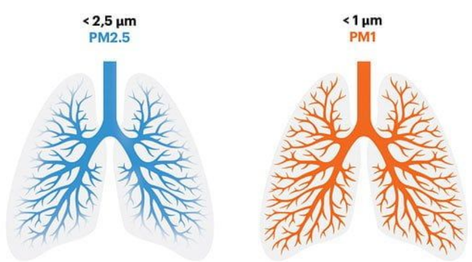

Figure 1: $PM_{2.5}$ vs. PM_1 in lungs

Objectives

To be aware of particulate matter in the air

1. Analyze long term variations with commercial EPA system
2. Compare EPA system with a lab built indoor sensor to evaluate systems' aerosol sensitivity.

Background on Air Quality

- Plantower PMS5003 sensor measures $PM_{2.5}$ from scattering of light.
- $PM_{2.5}$ = particulate matter (pollutant particle) measures 2.5 or less in micron diameter size (2500 nm)
- EPA Regional Lab located N. Chelmsford, MA loaned us with five PurpleAir monitoring systems
- AQI: numerical scale used nationwide to report levels of air pollutants over a period of time
- Values 151+ unhealthy in the U.S. [1] Five pollutants' intensity range 0-500/good to hazardous

$$PM_{2.5} = 2.5\mu m = 2.5 \times 10^{-6}\ microns\ diameter$$

Mie Scattering

The projected light of the laser causes the light to scatter in the forward direction.

Non-dimensional particle size parameter x describes the radius of spherical particle (r) and the wavelength of incoming light (λ)

Projected Light Direction

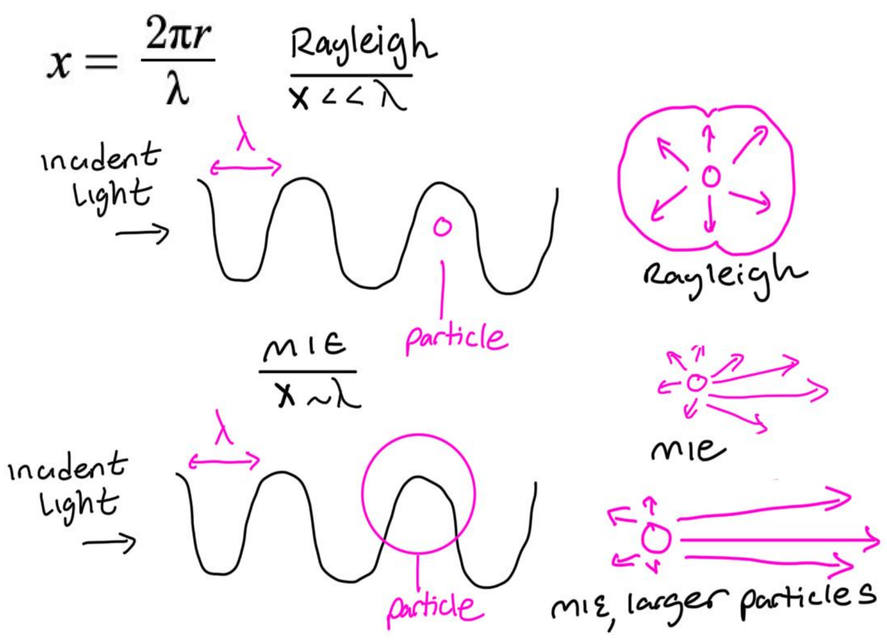

Figure 2:

- Particle scattering occurs upon the projected light.[2]
- Mie scattering particles can be greater than the wavelength of light.
- Larger particles scatter more light forward resulting greater light intensity. This research uses Mie scattering .

Research

Adafruit: Retrieved $PM_{2.5}$ data every 2 sec. transmit to Adafruit dashboard for a CSV file to be imported into Python

Purple Air: AQI recorded on PurpleAir Map. Python is used to retrieve an average of $PM_{2.5}$ every 10 min. from two channels at a desired timestamp from server.

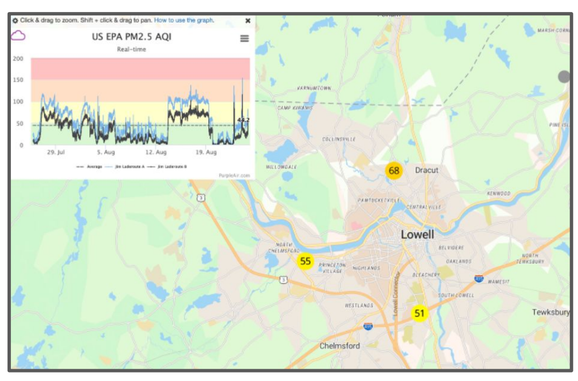

Figure 3: PurpleAir Map retrieve data[3]

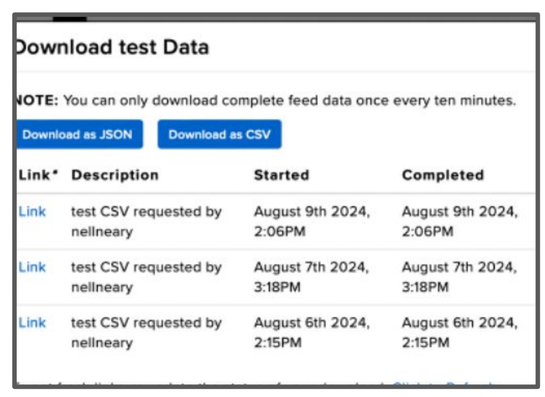

Figure 4: Adafruit dashboard retrieve data:

Experiment I- Objective 1: PurpleAir

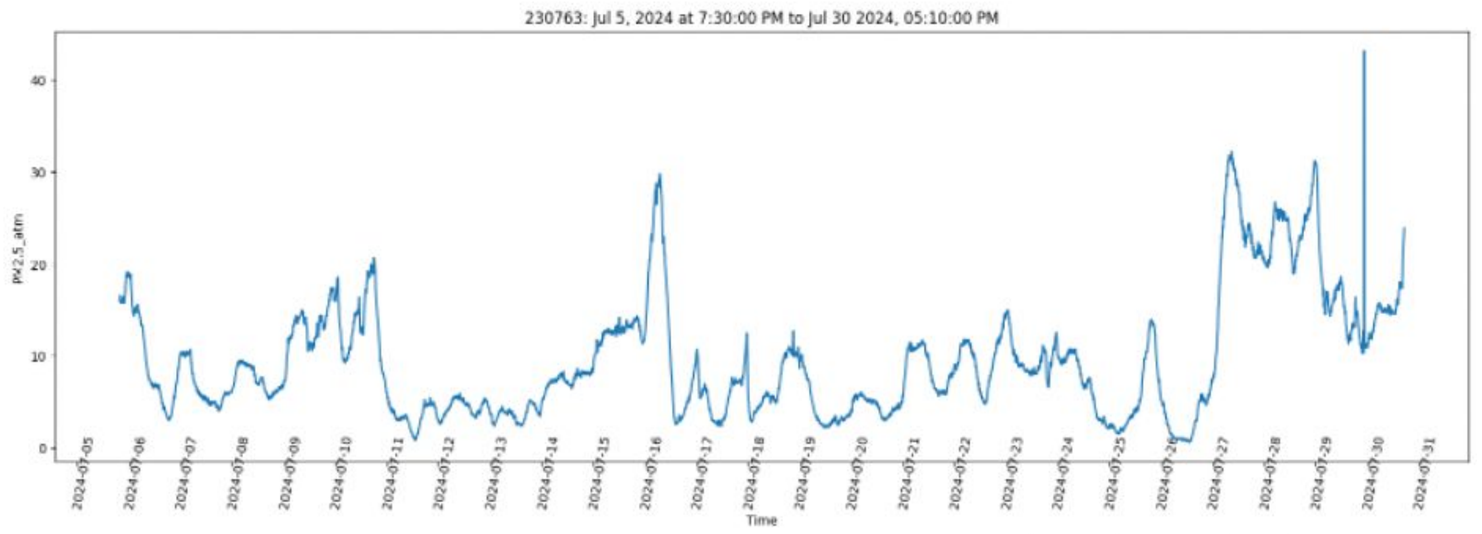

Figure 5: July 5 - 30 PurpleAir Data

Results: (Fig.5) AQI is good because the $PM_{2.5}$ is less than 151. All five sensors (Fig.6) compared are consistent.

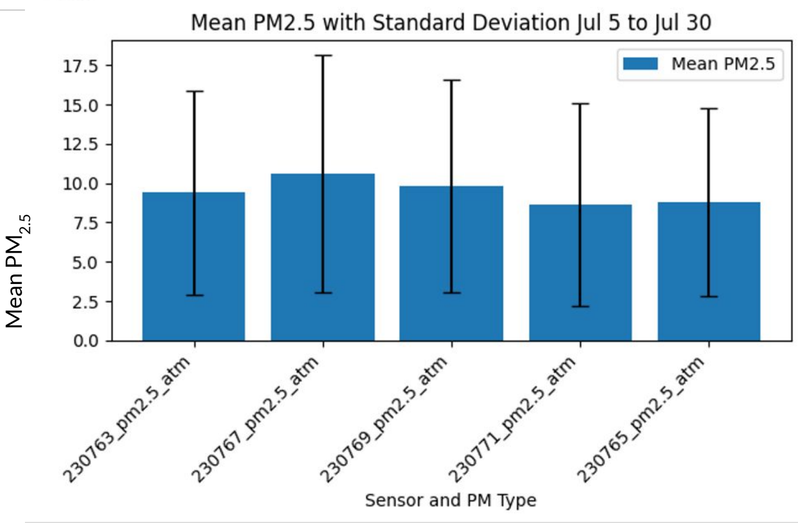

Figure 6: PurpleAir mean & STD

Experiment II-objective 2: Aerosol

- Installed on 20''Lx10''Wx11''H' tank roof covered in foil + cardboard.
- Three candles lit on tank bottom 10" away from both sensors
- Smoke resulting from the candles after they were blown out created aerosol particles in the tank

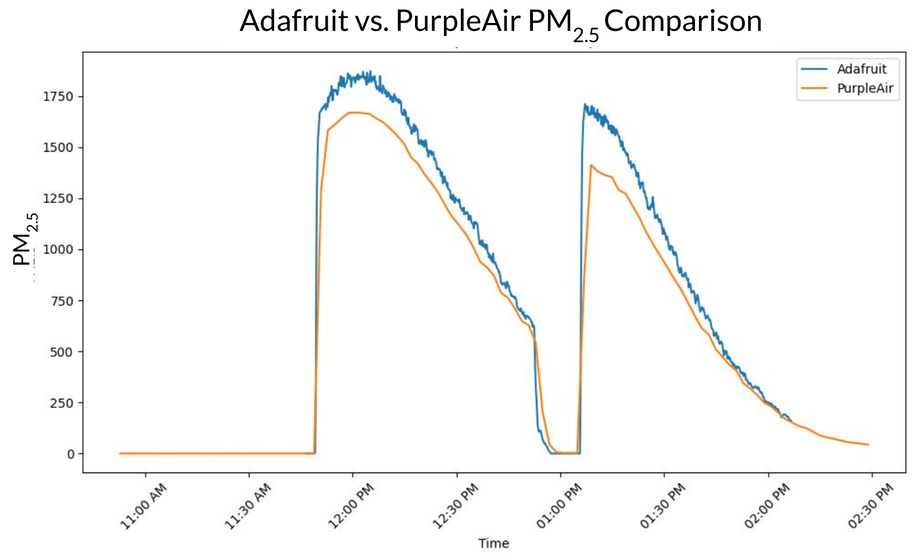

Figure 7: PurpleAir vs. Adafruit

Results : Figure $PM_{2.5}$ is scaled and nondimensional. Data and reaction time are consistent when compared to each other, with ~2,000 $PM_{2.5}$ value difference between their max peaks

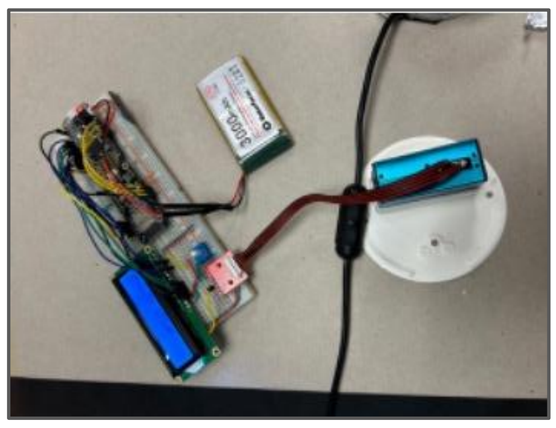

Figure 8: Adafruit System

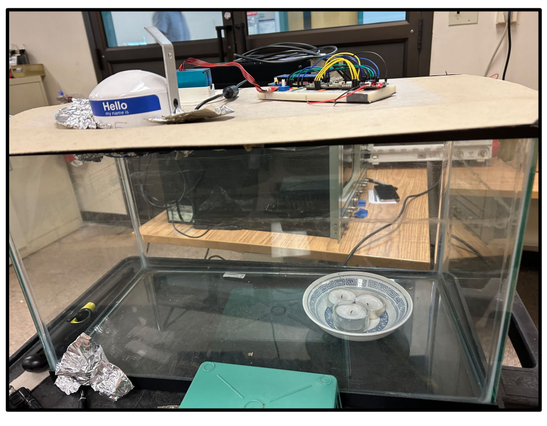

Figure 9: Exp. II Set up

References

[1] Andell, Henri. "Fine Particles PM2.5 Have Significant Impact on Health." Safera, 6 Apr. 2024,
[2] Morse & Ingard, *Theoretical Acoustics*. Princeton University Press, 1987, p.402.
[3] Real-Time Air Quality Map." *PurpleAir*, Accessed 3 Sept. 2024.

Acknowledgements

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