Clean Air Carolina

Brian Kornegay

Abstract

The following research was conducted with the intent to further understand fine particulate matter, the impact of human activity on fine particulate matter, its effects on the air we breathe, and thus its negative impacts on the environment and our bodies. The collection of data that was used to conduct this research was conducted with an AirBeam air quality monitor. This project includes three tested locations. A collection of data of the air quality from the three locations, and the analysis of said data. Two of the three locations are considered low-income, and one location is considered high-income. The significance of this is due to a possible lack of consideration for the less fortunate and their health.

Fine particulate matter, also known as $PM_{2.5}$, is a pollutant that poses a substantial health risk in cities throughout the world. Sources of $PM_{2.5}$ include diesel vehicles, coal burning power plants, forest fires, and construction. The AirBeam is a portable air monitor, designed to help individuals monitor the air they breathe and help pinpoint areas of high concentrations of $PM_{2.5}$. The AirBeam contains a sensing chamber into which air is drawn in, and an LED bulb dissects the particles within the air sample. The device then counts the number of particles in the air, and from that you have your concentration number. This information is transmitted to the AirCasting app. The App uses a color-coded map to convey what areas what level of concentration. Red is the highest concentration, yellow areas fall in the middle, and green areas have a more normalized level.

Michael Heimbinder is the founder of HabitatMap, the company that created the AirBeam. In addition to inventing a product to monitor personal air quality, Heimbinder also started AirCasting. AirCasting is a website in which AirBeam owners can upload the data from their monitor to keep logs of their data. As AirCasting is a crowdsourcing website, it also helps keep an accurate track of air quality in all monitored areas, as others can view the data uploaded by others. This helps to hold polluters accountable with evidential support, and provides an online resource for updated data on air pollution. AirCasting provides an app so that users have easy access to AirBeams' data. Products like the AirBeam should be marketed in all areas, but especially areas of serious health concerns that are likely due to poor air quality and environmental neglect.

A higher quality air monitor, the pDR-1500 is used by government agencies and those doing in-depth research into air pollution. The pDR-1500 is a Thermo Fisher product and can picked up at Thermo Fisher's website after requesting a quote. The pDR-1500 prices in the $5.000.00 range, whereas the AirBeam, can be purchased for $250.00. Michael Heimbinder compared results from a pDR-1500 with results from AirBeam monitors and found that the correspondence between the two was not perfect, but it was relatively close, and deviation sometimes occurs even between identical instruments. R2 or R-squared values were used to compare the performance data of the two monitors. R2 is a "statistical measure" that is used to gauge how precisely data correspond with a statistical model. The R2 value ranges from

0.0 to 1.0 with higher values indicating that the regression came close to the points. An R2 value of 1.0 would indicate the predictive power of the model is perfect and that all the points fit along the line with no scatter. The research found that the relationship between the AirBeam and the pDR-1500 measurements becomes increasingly non-liner above 100 µg/m³. During separate sampling runs, R2 values were found to range from 0.60 to 0.80. The decrease in the R2 value is likely due to the higher variability near the AirBeam's maximum limit of detection. Although, the results from the two different monitors don't match exactly, they appear to be very similar up to a certain level of concentration. Considering the quality and accuracy of the AirBeam in combination with the fractional price compared to the pDR-1500, the AirBeam is an excellent alternative.

Methodology

A study of the spatial distribution of $PM_{2.5}$ began with selecting two disparate communities. The Walnut Creek area of Raleigh, NC, and residential areas surrounding CP&L Power plant in Lumberton, NC. These two sites were chosen because they are in low-income areas, and are also suspected to have high concentrations of $PM_{2.5}$. Given that the Walnut Creek area is very close to I-440, emissions from the thick traffic of the interstate is assumed to be the most significant contributor of the air pollution. The residential areas surrounding the CP&L Power plant are affected by the proximity of the plant and its consequential effect on the air quality in this triangle of Lumberton. Individuals located within these study areas may very well be facing significant health risks unknowingly. The data collected from these two study areas will be compared to data collected from Concord, NC. More specifically, data collected from Cannon School, a private school surrounded by higher-income neighborhoods. The Cannon School data set was collected by Jeremy Mattsson, a teacher at the school, and his students. The data was collected using a fixed

Figure 1. Walnut Creek Study Area

monitor from January 24th, 2017-March 1st, 2017 and is available on the AirCasting website. The hypothesis of this study is that in the two regions Lumberton and Raleigh, the $PM_{2.5}$ concentration is dangerously higher than that of the high-income areas surrounding Cannon School, and it can be concluded that there is a strong correlation between low-income neighborhoods and areas of high concentrations of $PM_{2.5}$.

For this study, an AirBeam will be deployed to capture data. The AirBeam is a portable air monitor, designed to help individuals monitor the air they breathe and

help pinpoint areas of high concentrations of $PM_{2.5}$. The AirBeam contains a sensing chamber into which air is drawn in, and an LED bulb dissects the particles within the air sample. The device then counts the number of particles in the concentration number. The monitor can be connected to the device via Bluetooth, allowing the AirCasting app to provide real-time maps and graphs for each data set. Instrumental errors with the AirBeam pose as a possible source of error. The AirBeam has been tested and compared to the pDR-1500, a high-quality air monitor that is mainly used by government agencies, and was found to collect relatively similar measurements.

In Raleigh, Bethel rd., Cricket Ridge rd., S New Hope rd., Old Poole rd., and Maybrook Crossing dr. form a 2.15-mile in perimeter pentagon in the Walnut Creek area. This region is located a half mile from I-440 and ranks in the 95-100 national percentile on the EJ index for $PM_{2.5}$. In Raleigh, the data will be collected starting at the corner of Maybrook and Cricket Ridge. After following Maybrook Crossing towards S New Hope rd., the selected route then turns left continuing down S New Hope for approximately 0.75 miles until intersecting with Old Poole rd. The route then makes another left onto Old Poole rd. until reaching Bethel rd. After reaching Bethel, the route takes another left and runs into Cricket Ridge rd.

In Lumberton, there is a triangle with a 2.8-mile perimeter formed from Beulah Church rd., Old Whiteville rd., and T&P rd. Within this triangle, are residences, and 1.25 miles Northwest of the triangle's west side is the CP&L Power plant. $PM_{2.5}$ concentrations will be measured from the perimeter of this triangle. Data will be collected on foot by walking around the perimeter of the study area. The data collection will start at the corner of T&P rd. and Beulah Church rd., continuing down Beulah, turning onto Old Whiteville rd., and then turning back onto T&P rd. to return to the starting point.

To improve accuracy, measurements will be taken three days a week for six weeks at each location, during both busy and less busy hours. The data will be collected using

Figure 2. Lumberton Study Area

an AirBeam and then uploaded to the AirCasting app on an HTC Desire 510, model OPCV1. The data collected will be analyzed and compared to data collected from Cannon School in Concord, NC using the monthly averages of the $PM_{2.5}$ concentrations.

Results

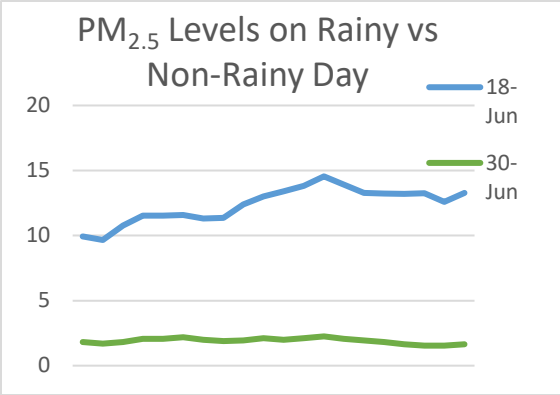

Figure 3. PM2.5 levels collected during a day with persistent rain compared to levels collected on an average day.

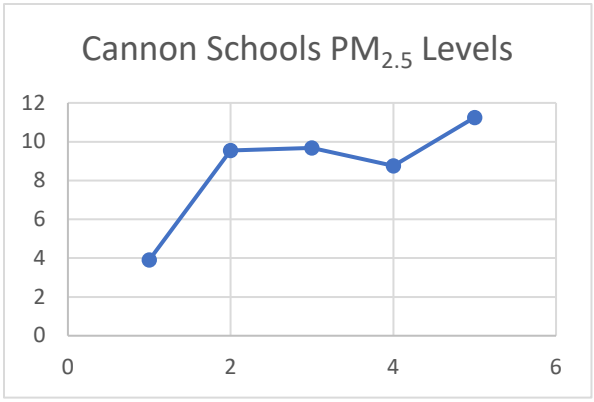

Figure 4. PM2.5 concentrations collected from Cannon School over a 6-week period using a fixed monitor.

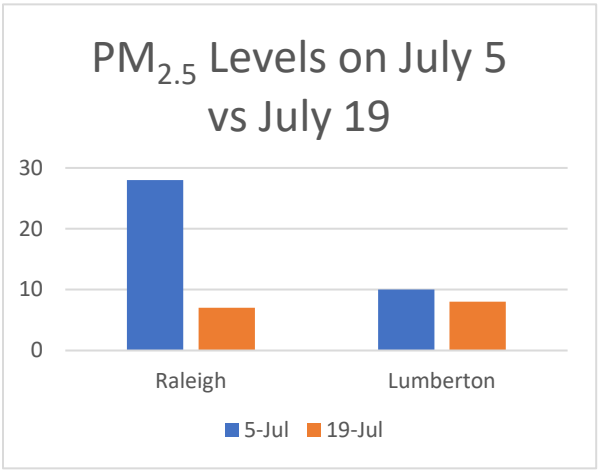

Figure 5. Average concentrations on July 5th compared to average concentrations on July 19th.

Discussion

Raleigh Study Area Traffic Levels

The study area in Raleigh surrounded the neighborhoods of Bethel Park and Maybrook Crossings. The roads that were included in the monitoring sessions consisted of Bethel Rd., Cricket Ridge Rd., S New Hope Rd., Old Poole Rd., and Maybrook Crossing Dr. S New Hope Rd. serves as a major thoroughfare for traffic from I-40 and I-440, which creates a heavy flow of traffic on a consistent basis. Old Poole Rd. intersects with S. New Hope Rd. and can be used as a shortcut for travelers coming from or heading towards I-440. Throughout the span of the monitoring sessions, Old Poole Rd. experienced the second heaviest flow of traffic in the study area. Bethel Rd. branches off from Old Poole Rd. and is often used to enter or exit the neighborhoods of Bethel Park, Maybrook Crossings, and Maybrook Forest. Typically, it experienced a significantly higher flow of traffic than Cricket Ridge Rd. and Maybrook Crossing Dr., but not nearly as much as S. New Hope Rd. and Old Poole Rd. Both Cricket Ridge Rd. and Maybrook Crossing Dr. are roads that fall within the neighborhoods that were monitored and usually have very low levels of traffic.

Lumberton Study Area Traffic Levels

The Lumberton study area is made up of 2.8-mile triangle consisting of Beulah Church Rd., T&P Rd., and Old Whiteville Rd. Old Whiteville Rd. had the heaviest flow of traffic on a consistent basis. Beulah Church Rd. was largely inconsistent in its levels of traffic due partially to road construction toward the end of the monitoring project. The road construction on Beulah Church Rd. caused a slight increase in traffic levels on T&P Rd., as the two roads run parallel to each other. Even with the impact of the road construction, T&P Rd. consistently experienced lower levels of traffic than either of the other two roads in the study area. The traffic levels in Lumberton were significantly less than the traffic levels within the Raleigh study area.

Impact of Precipitation on $PM_{2.5}$ Concentrations

Precipitation was found to significantly decrease levels of $PM_{2.5}$ but only for a short period of time. On June 30th, there was a light rain throughout the entire monitoring session in Raleigh. The average $PM_{2.5}$ concentration was 2 $\mu g \cdot m^{-3}$ and the peak concentration was only 6 $\mu g \cdot m^{-3}$. On July 9th, during a monitoring session in Lumberton, it began to rain toward the end of the session. The $PM_{2.5}$ concentrations ranged between 14 $\mu g \cdot m^{-3}$ and 16 $\mu g \cdot m^{-3}$ before the precipitation occurred. After the rain started the levels of $PM_{2.5}$ dropped as low as 4 $\mu g \cdot m^{-3}$. Monitoring sessions recorded on the days after heavy amounts of rain were found to be impacted very little by the precipitation.

Impact of July 4th Fireworks

The July 5th monitoring session in Raleigh had the highest concentrations of $PM_{2.5}$ out of the entire 6-week monitoring period. The average $PM_{2.5}$ concentration for the session was 28 $\mu g \cdot m^{-3}$ with a peak of 38 $\mu g \cdot m^{-3}$. This spike in levels of $PM_{2.5}$ are believed to be a result of the heavy use of fireworks from the previous night. The monitoring session in Lumberton that was recorded later that same day did not see the same spike in $PM_{2.5}$. Although, it is likely that the Raleigh study area had a larger number of fireworks on the 4th, the amount of time that had passed is

believed to have played a large role in the absence of a $PM_{2.5}$ spike in the Lumberton monitoring area. The Raleigh monitoring session was from 10:30 am-11:08 am and the Lumberton monitoring session was from 1:00 pm-1:52 pm.

Raleigh $PM_{2.5}$ Concentrations

The levels of $PM_{2.5}$ were consistently higher on the three busiest roads in the study area. S New Hope Rd., Old Poole Rd., and Bethel Rd. saw higher levels of $PM_{2.5}$ on a regular basis, most likely due to the higher levels of traffic. The roads located on the interior of the neighborhoods consistently had lower concentrations. The average PM2.5 concentration over the 6-week monitoring period was 10.38 $\mu g \cdot m\text{-}^{3}$. There were three sessions in which the average concentration was greater than 20 $\mu g \cdot m\text{-}^{3.}$ One of these sessions occurred on July 5th and was likely due to fireworks. The other two sessions occurred on July 21st and July 23rd. The peak $PM_{2.5}$ concentration reached 37 $\mu g \cdot m\text{-}^{3}$ on both days. It is unclear what caused the increase in levels on these days.

Lumberton $PM_{2.5}$ Concentrations

The traffic levels in the Lumberton study area had very little to no correlation with the $PM_{2.5}$ concentrations. Old Whiteville Rd. consistently had a heavier flow of traffic than either T&P Rd. or Beulah Church Rd. Throughout most of the monitoring sessions over the 6-week period, T&P Rd. had the highest $PM_{2.5}$ concentrations. Some of the concentrations during these sessions were due to lawn mowers or charcoal grills, but other days it is unclear what caused T&P Rd. to have the higher concentrations. The average $PM_{2.5}$ concentration over the 6-week monitoring period was 9.94 $\mu g \cdot m\text{-}^{3}$. The average concentration of $PM_{2.5}$ was only greater than 20 $\mu g \cdot m\text{-}^{3}$ during one session. That session occurred on July 23rd, the same day as one of the Raleigh monitoring sessions that averaged over 20 $\mu g \cdot m\text{-}^{3}$.

Cannon School Study Area

The data used from the Cannon School in Concord, NC was collected using a fixed monitor from January 24th, 2017-March 1st, 2017. The monitor was placed inside of the building and therefore wasn't impacted by levels of traffic, such as the Raleigh and Lumberton study areas. The average $PM_{2.5}$ concentration for the Cannon School monitoring session was 8.8 $\mu g \cdot m\text{-}^{3}$.

Conclusions

Both study areas had lower concentrations of $PM_{2.5}$ than expected. Although, both areas had some peak concentrations that can be considered unhealthy, the averages for both areas are at a healthy level. The data collected at Cannon School in Concord found that the average $PM_{2.5}$ concentrations were slightly lower than either one of the Raleigh or Lumberton study areas but not by a significant amount. Other impacts that can be taken into consideration are the time of year that each set of data was collected and the differences that can occur between a fixed monitor located indoors compared to data collected from outside using the AirBeam monitor.