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By

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A thesis submitted to the faculty of The University of Mississippi in partial fulfillment of the requirements of the Sally McDonnell Barksdale Honors College.

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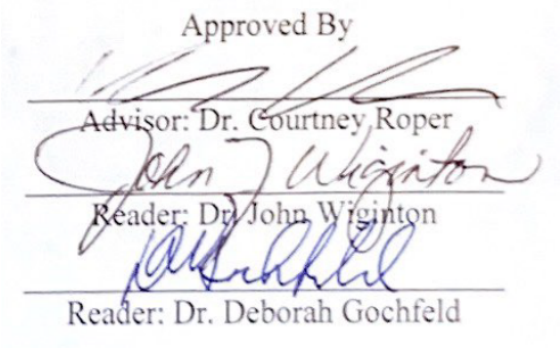

DEDICATION

To my wonderful and supportive family,

I would never have been able to push through my undergraduate education without all of your amazing support and love.

ACKNOWLEDGEMENTS

I would like to thank all of the members of Roper Lab. You were all so supportive through every step of my researching journey. I am so thankful that I have been surrounded by people who were always willing to set aside their own time to help with any question I asked. I would like to specifically thank Maggie Craze for always being willing to help me with even the smallest questions. Thank you for helping me navigate SigmaPlot every time that I used it.

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ABSTRACT

Black Carbon, which is a component of fine particulate matter, is a known pollutant that has been linked to the development of several diseases including cardiovascular disease. This pollutant can be measured by taking samples of air within a certain region and analyzing them using a transmissometer. It is known that black carbon concentrations tend to be higher in urban areas when compared to rural areas within a region. Black carbon concentrations can also vary depending on certain meteorological parameters such as temperature and humidity. There were no current studies that analyze the air quality in northern Mississippi due to samplers being located densely in the southern portion of the state. Our study sought to determine black carbon concentrations present in fine particulate matter throughout an entire calendar year and compare these concentrations at two locations in Northern Mississippi. We analyzed samples from a location on the University of Mississippi campus and in a more rural, wooded area in Abbeville, Mississippi. We also collected meteorological data at both locations and compared these data to the black carbon concentrations at each location to determine any possible correlations. Our results indicated that the concentration of black carbon was higher at Anderson Hall than the Field Station, and black carbon concentrations were higher across both locations during the winter months. There was also a slight negative correlation between black carbon concentrations and the relative humidity at each location. Overall this study provided information about air quality in Northern Mississippi and highlighted differences in concentration between seasons and locations.

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LIST OF ABBREVIATIONS

BC	Black Carbon
$PM_{2.5}$	Fine Particulate Matter
WHO	World Health Organization
EPA	Environmental Protection Agency
UM	University of Mississippi

INTRODUCTION

Exposure to air pollution is deemed to be a serious health threat to populations across the world. This threat has grown so much that the World Health Organization (WHO) has estimated that 4.2 million people die each year due to exposure. They also predict that every 9 out of 10 people are breathing in excessive amounts of air pollutants, especially in lower-income areas (Air Pollution, WHO). Air pollution can come in liquid, gas, and solid forms. Solid forms are much smaller than the width of a human hair, making them undetectable by the human eye. There are six main pollutants, also called "Criteria Pollutants" by the Environmental Protection Agency (EPA), that are of interest to researchers according to the Center for Disease Control (US EPA, 2016). These include carbon monoxide, lead, nitrogen gas, ozone, sulfur dioxide, and particulate matter. These are of interest due to studies that have linked these agents to adverse health effects such as respiratory distress and cardiovascular disease (Chen et al. 2007, Weaver 2009).

Fine Particulate Matter ($PM_{2.5}$)

When analyzing the particulate matter category, one component that has been linked to health effects is fine particulate matter ($PM_{2.5}$). According to the EPA, $PM_{2.5}$ is a mixture of solid particles and liquid droplets found in the air (US EPA, 2016). It can be collected onto filters by using air pumps that pull air across a cassette of filters, one of which collects PM_{10} while another collects the smaller $PM_{2.5}$ particles. Impaction is a method of sample collection that allows for the separation of PM_{10} and $PM_{2.5}$ by using a filter coated in an oil that traps particles that are 10 microns or greater while allowing smaller particles to pass through. These differences in size are based on the aerodynamic diameter of the particles, where PM_{10} has a diameter of 10 μm or less while $PM_{2.5}$ has a diameter of 2.5 μm or less. $PM_{2.5}$ is also small enough to potentially enter the bloodstream following inhalation (US EPA, 2016). Meteorological factors such as temperature and humidity also play a role in the amount of $PM_{2.5}$ that could be present and collected on a filter on a given day. In a study performed in a variety of cities in China, humidity and temperature were often positively correlated with $PM_{2.5}$ concentration (Chen et al., 2020). This study did show, however, that increased humidity in some locations led to increased precipitation and therefore a decrease in the $PM_{2.5}$ present when sampled.

$PM_{2.5}$ can be a result of several different sources, both human-generated and natural. Examples of human-generated sources are vehicular emissions, construction emissions,

and controlled burnings of organic material (Daellenbach et al., 2020). These sources all release particulate matter into the atmosphere through combustion. Natural sources of particulate matter do not seem to be the majority of what is found in the atmosphere, but possible sources include dust from arid regions and sea salt carried by wind.

Components of $PM_{2.5}$

Fine particulate matter is an umbrella term that includes the particles themselves as well as any possible components attached to these particles. These components include black carbon, organic matter, and heavy metals (US EPA, 2016).

Black carbon, a component of $PM_{2.5}$, is a mixture of organics and inorganics that have carbonaceous material. It is often released into the atmosphere as a result of incomplete combustion, commonly of biomass, and it can be the major component of $PM_{2.5}$ in areas with high amounts of vehicular traffic (Krecl et al., 2018). To measure black carbon an air pump can be used to push air across a size-specific filter's surface. It can be quantified by measuring the absorbance of a filter against a blank and comparing the two, and it allows for a better understanding of the composition of the $PM_{2.5}$ in a specific region. This form of black carbon analysis is a non-destructive form that allows for the filter to be used for multiple analyses. Often, these data will vary across seasons due to differences in climate conditions or the amount of emissions present. In a one-year study performed across China, the black carbon concentrations were seen to be highest in the winter and least in the summer in a majority of the cities, and this was linked to the

increased amount of biomass burning in these months from exporting and heating (Cui et al., 2021).

Health Effects of $PM_{2.5}$ and Black Carbon

$PM_{2.5}$ exposure has been linked to a variety of health effects including cardiovascular disease and respiratory issues such as chronic obstructive pulmonary disease (COPD) and asthma (Feng et al., 2016). In zebrafish models, there have been studies conducted showing that $PM_{2.5}$ exposure can cause developmental issues within the embryos of this animal model (Zhang et al., 2018).

BC has been studied to determine if it specifically has any negative health effects, and extended exposures have been linked to an increase in cancer incidence, especially lung cancer (Lequy et al., 2021). Because these particles are so small, they have the ability to enter the lungs and the potential to enter the bloodstream. BC has also been associated with an increased risk of developing cardiovascular disease when exposure levels are increased (Kirrane et al., 2019).

$PM_{2.5}$ and Black Carbon in Mississippi

Air quality in the Mississippi is monitored by the Mississippi Department for Environmental Quality, but these data are taken from sites in the state that are not necessarily representative of the entire state (Berkowicz et al., 1996). They monitor the particulate matter concentrations at seven locations in the state, with three of these

locations being located on the coastal region. There have been studies that demonstrate that pollen and $PM_{2.5}$ concentrations are positively correlated (Rahman et al., 2019), yet MDEQ does not have any pollen monitoring sites, according to their report (Ambient Air Quality – MDEQ). According to their monitoring, the state's $PM_{2.5}$ concentrations have not exceeded the recommended 12 $\mu g/m^3$ that is a standard set by the EPA (Ambient Air Quality – MDEQ). There is still, however, the potential for levels below this standard to cause harm, such as respiratory and cardiovascular diseases (Makar et al., 2017). This monitoring, however, does not have much data regarding the northern region of the state, and does not have any data for the area of Oxford, which has large amounts of traffic due to the presence of the University of Mississippi.

Study Goals

The goal of our data collection was to develop a greater understanding of the composition of the air in northern Mississippi. We collected weekly $PM_{2.5}$ samples from a site on the University of Mississippi – Oxford campus and the University of Mississippi Field Station for a twelve-month period. Black carbon concentrations were determined for all samples and meteorological data, including humidity and temperature, were collected at each location. My hypothesis was that black carbon concentrations will differ between seasons and locations, with the highest concentrations observed during the winter at Anderson Hall on the University of Mississippi campus.

METHODS

1. Air Sampling Locations

Samples for this study were collected at two locations: The University of Mississippi (UM) Field Station (34.477530, -89.361050) and Anderson Hall (34.363680, -89.535230) on the UM Oxford campus. The Field Station is approximately 10 miles away from Anderson Hall. Anderson Hall is a location that is central to campus while the Field station is located in a more rural area in Abbeville, MS. In addition to being located on the University of Mississippi campus, Anderson Hall is also adjacent to a major bus stop for the public transportation system of Oxford, and it is near a large commuter parking zone. The Field Station, however, is not adjacent to any major highways or areas with high amounts of vehicular traffic. *Figure 1* shows the locations of these two sampling sites.

Figure 1: Map of the sampling locations Anderson Hall is represented by the red marker in the lower left, and the Field Station is represented by the yellow marker in the right corner. Map was created using Google Maps.

2. Sample Collection

To obtain our samples, a Deployable Particulate System (DPS, SKC Inc.) was used. This equipment contains a weatherproof case that protects the air pump that is connected to the filter cassette to ensure proper function. The IMPACT Sampler was outside of this DPS and was housed within a weatherproof shield that allows for the filter to be kept dry while remaining outside. The pump actively pulled air into the IMPACT Sampler cassette chamber and across two filters, one PM_{10} filter that captured particles that are larger than our desired particles onto an impaction disc, which was collected and stored in the lab.

The $PM_{2.5}$ filter is a 47mm Pallflex® Emfab™ Air Monitoring filter composed of polytetrafluoroethylene (PTFE) that is housed over a mesh support within the cassette.

The DPS consists of a pump that pulls approximately 10 liters of air per minute (lpm). The first 15 minutes of each hour were sampled, and filters were collected weekly on Thursdays from January 2021 to December 2021. Throughout this 12 month period there were 13 weeks missing at the Field Station and 6 weeks missing at Anderson Hall due to equipment malfunctions, inclement weather, or a lack of student availability. On average, sampling periods were 2547 minutes, which lead to approximately 25.37 m^3 of air being sampled per filter on a typical week. Blank samples were collected by traveling with an additional filter, opening it at the sampling location for approximately 10 minutes and returning it to the lab. This blank served to control for any contamination that occurred during sample preparation, transport, or deployment at the sampling location.

3. Meteorological Data

Meteorological data was collected at each sampling site by using a SensorPush sampling device that recorded the temperature and humidity every minute in that location for the entire sampling period. These values could be accessed during filter retrieval, and were saved in weekly periods that reflected the sampling period. The values were saved starting with the filter deployment time and ending with the filter retrieval time in order to accurately reflect the atmospheric conditions that influences that particular filter. These

data were then retrieved and averaged to yield the average temperature and humidity at a location during a sampling period.

4. Black Carbon Analysis (SootScan)

After the samples were collected, the filters were analyzed for the presence and concentration of black carbon present. To accomplish this, a SootScan Model OT21 Optical Transmissometer was used. The SootScan is an optical transmissometer that analyzes two wavelengths: one that quantitates the amount of Black Carbon (880nm) and one that can give qualitative information about aromatic compounds that can help identify potential fuel sources present (370nm) ("SOOTSCAN™ MODEL OT21 OPTICAL TRANSMISSOMETER"). Blank filters were compared to the sample and run in triplicate through the SootScan. After attenuation was measured, precise sampler summary logs allowed for the calculation of the black carbon concentrations of each filter relative to total time and volume of air collected during sampling.

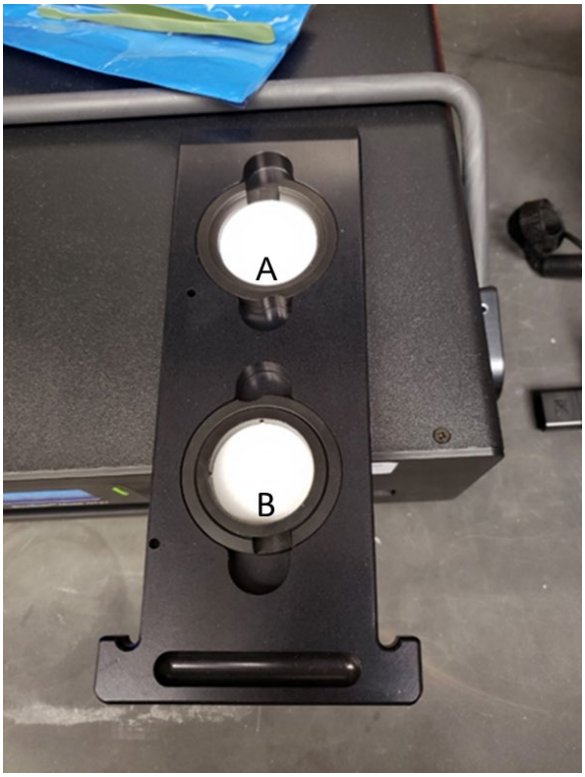


Figure 2: Sampling tray for the SootScan Transmissometer Blank filters (A) were compared to the sample filters (B*)* in this holding tray that was placed into the SootScan instrument for black carbon analysis at 880 nm.

5. *Statistical Analysis*

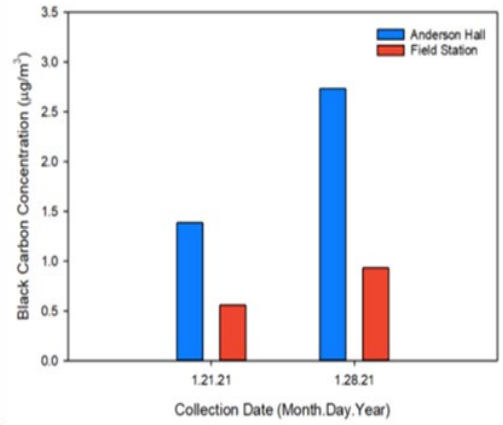
Trial averages and standard deviations were first placed into Microsoft Excel for initial organization based on site and date. The statistical significance of these results was determined by using SigmaPlot 14.0 (Systat Software, San Jose, CA) for one-way and two-way ANOVA testing as well as linear regression statistics. The p-value for the ANOVA testing was significant if $p \leq 0.05$.

RESULTS

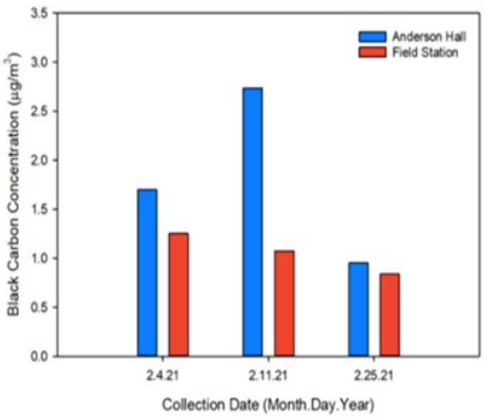
1. Black Carbon by Location

The concentration of black carbon on each filter was sampled and compared for monthly averages based on location of sample collection. Figure 3 shows the weekly black carbon concentration values for 2021 in each month sampled January – December (Figure 3 A-L). January (Figure 3A) and February (Figure 3B) had concentrations for Anderson Hall that were consistently higher than the Field Station. The highest black carbon concentration for both locations was seen during the week of March 4, 2021, and the values were very similar across locations during this month (Figure 3C). April (Figure 3D), May (Figure 3E), and June (Figure 3F) all had a consistent trend of Anderson Hall having higher weekly concentrations than the Field Station. There are no values for the Field Station in late July (Figure 3G) and the entirety of August (Figure 3H) due to a sampling pump malfunction that caused the air monitor to be out of service. September (Figure 3I) and October (Figure 3J) again followed a trend where Anderson Hall had higher weekly concentrations than the Field Station. November (Figure 3K) and December (Figure 3L) were missing some dates due to filter abnormalities and scheduling conflicts that did not allow for collection. Zero values were placed in the table where the concentrations were observed as a negative number which can occur if the sample filter contains less black carbon than the field or lab blank filter, indicating the black carbon is below the detection limits of the instrument.

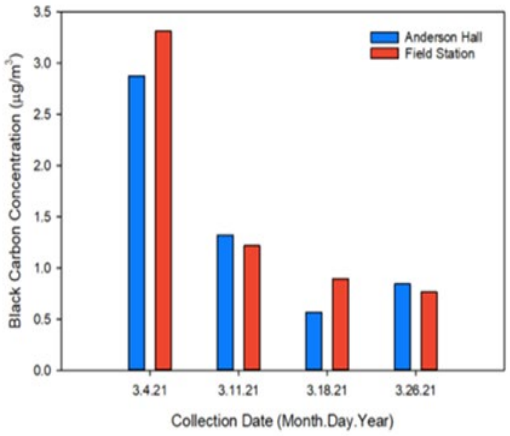
A.


January 2021 Black Carbon Concentrations
Anderson Hall
Field Station
Black Carbon Concentration (µg/m³)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.21.21
1.28.21
Collection Date (Month.Day.Year)

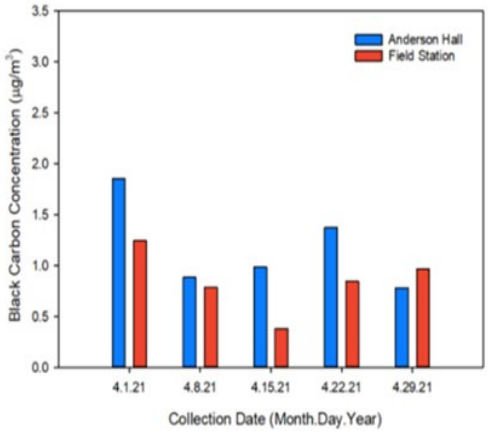
B.

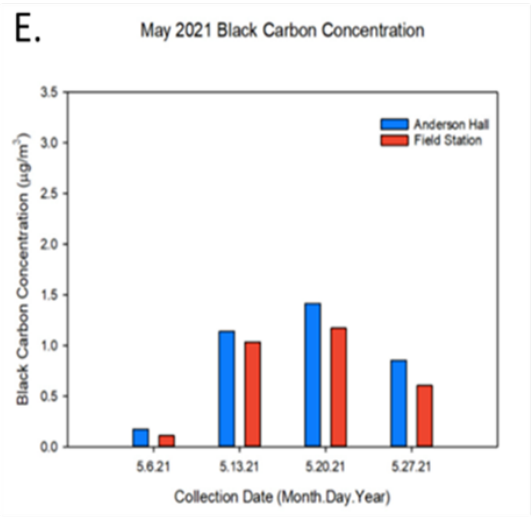

February 2021 Black Carbon Concentration
Anderson Hall
Field Station
Black Carbon Concentration (µg/m³)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.4.21
2.11.21
2.25.21
Collection Date (Month.Day.Year)

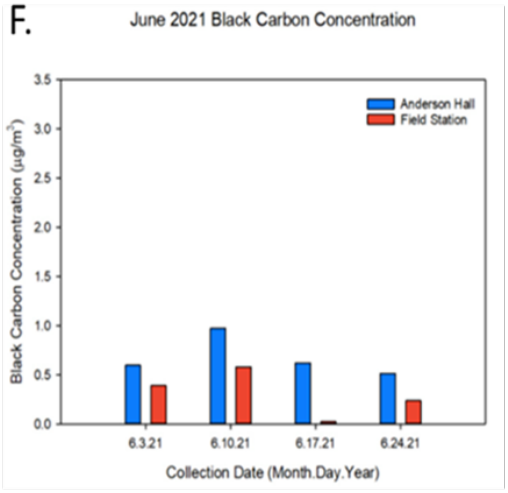
C.

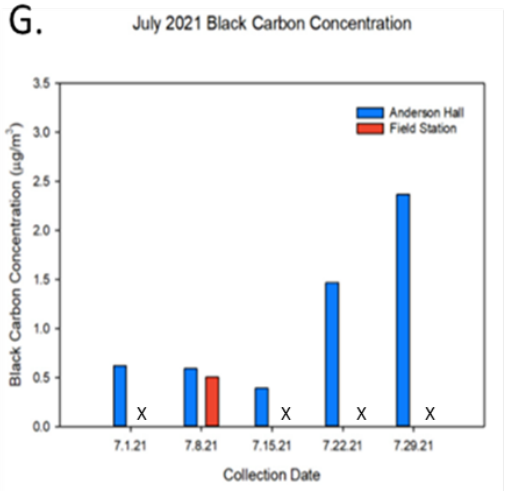

March 2021 Black Carbon Concentration
Anderson Hall
Field Station
Black Carbon Concentration (µg/m³)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.4.21
3.11.21
3.18.21
3.26.21
Collection Date (Month.Day.Year)

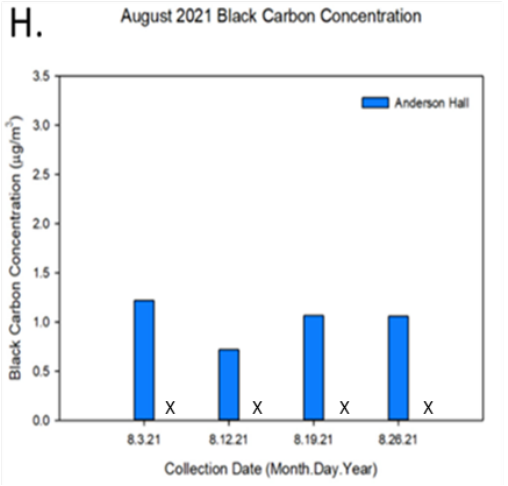
D.


April 2021 Black Carbon Concentration
Anderson Hall
Field Station
Black Carbon Concentration (µg/m³)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4.1.21
4.8.21
4.15.21
4.22.21
4.29.21
Collection Date (Month.Day.Year)


E.
May 2021 Black Carbon Concentration
Anderson Hall
Field Station
Black Carbon Concentration (µg/m³)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5.6.21
5.13.21
5.20.21
5.27.21
Collection Date (Month.Day.Year)


F.
June 2021 Black Carbon Concentration
Anderson Hall
Field Station
Black Carbon Concentration (µg/m³)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6.3.21
6.10.21
6.17.21
6.24.21
Collection Date (Month.Day.Year)


G.
July 2021 Black Carbon Concentration
Anderson Hall
Field Station
Black Carbon Concentration (µg/m³)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
X
X
X
X
7.1.21
7.8.21
7.15.21
7.22.21
7.29.21
Collection Date


H.
August 2021 Black Carbon Concentration
Anderson Hall
Black Carbon Concentration (µg/m³)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
X
X
X
X
8.3.21
8.12.21
8.19.21
8.26.21
Collection Date (Month.Day.Year)

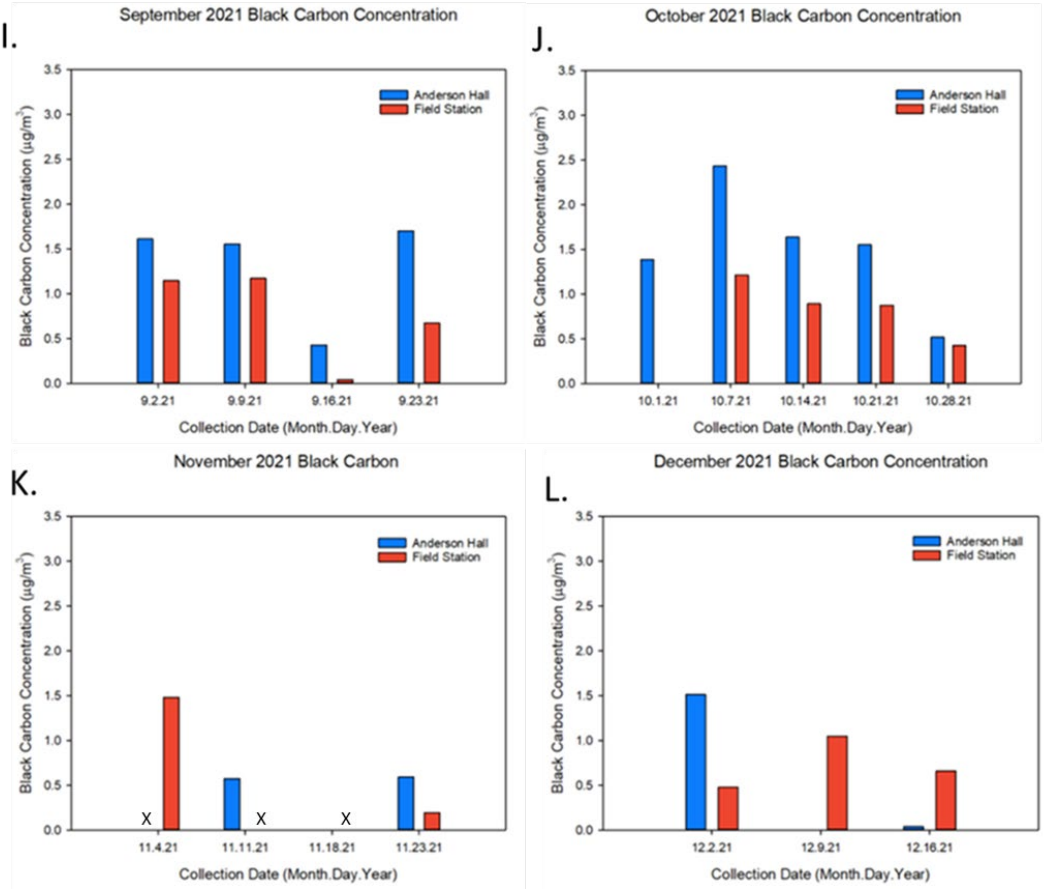


Figure 3: Weekly black carbon data organized by location and month. Anderson Hall is represented in blue, and the Field Station is represented in red. Months are ordered chronologically and each labelled with letters ranging from A-L. X was placed in areas where there was no filter collected for a location during that week.

1B. Monthly Black Carbon Concentrations

The black carbon concentrations at the Field Station ranged from 0 µg/m^3 to 3.31 µg/m^3, and Anderson Hall had values ranging from 0 µg/m^3 to 2.87 µg/m^3. The

concentration of 0 was observed when the collected filter was not different from the absorbance measured on the blank filter, indicating that the value was below the limit of detection for the instrument. For each location, each month was averaged to yield the values that are represented in Figure 4 (Field Station) and Figure 5 (Anderson Hall).

Figure 4 shows the monthly averages and standard deviations for black carbon concentrations at the Field Station. There was no significant difference between monthly values (P=0.638). There was a trend that the winter and fall months had higher average concentrations than the summer months. The month with the highest average concentration was March (1.24 ± 1.24 $\mu g/m^3$), and the month with the lowest average concentration was June (0.31 ± 0.24 $\mu g/m^3$). August had no concentration values due to a malfunction in the sampling pump. The average black carbon concentration for the sampling period at the Field Station was 0.81 ± 0.58 $\mu g/m^3$

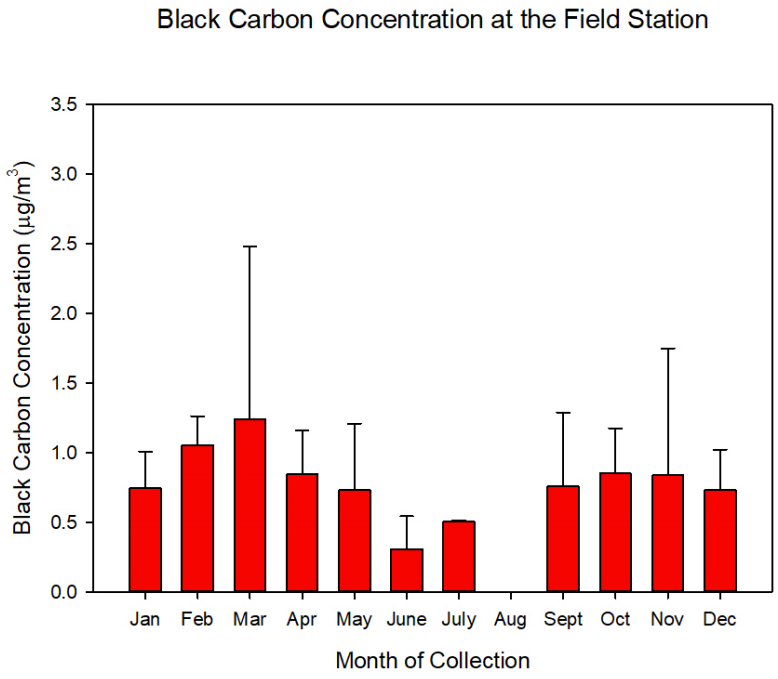


Figure 4: Black carbon concentration averages for the Field Station during the year 2021. August has no values due to a pump malfunction that did not allow for sample collection.

Figure 5 shows the monthly black carbon concentration averages and standard deviations. There was no significant difference between months at Anderson Hall (P=0.124). There was a trend that the winter and fall months had higher average concentrations than the spring and summer months. The month with the highest average concentration was February (1.79 ± 0.89 µg/m^3), and the month with the lowest average concentration was November (0.39 ± 0.34 µg/m^3). There were only two viable samples during the month of

November. The average black carbon concentration for the entire sampling period at Anderson Hall was 1.14 ± 0.72 µg/m^3.

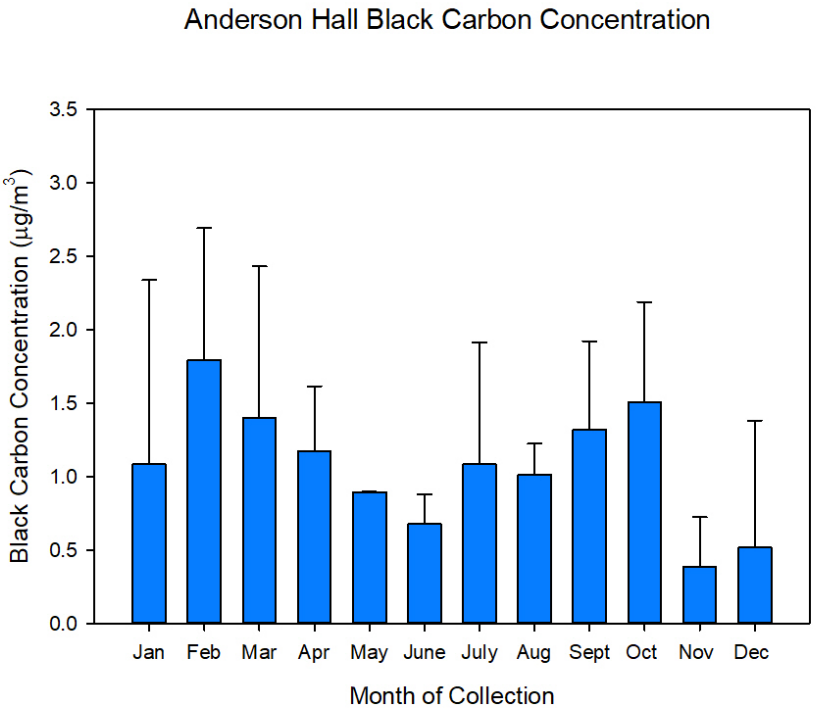


Figure 5: Black carbon concentration values for Anderson Hall for the year 2021.

1C. Seasonal Black Carbon Concentrations

Black carbon was also compared seasonally across locations, represented in Figure 6. Anderson Hall black carbon concentrations were found to be significantly different from the Field Station concentrations as a whole when comparing the locations over the entire year (P=0.012).

Across both sampling locations, Winter was significantly different from all other seasons sampled (Spring P=0.008, Summer P=0.019, Fall P=0.020). No other seasons were significantly different from one another. When specifically looking at differences between seasons at Anderson Hall, winter and spring were significantly different (P=0.038). For the Field Station, there were no statistically significant differences between seasons.

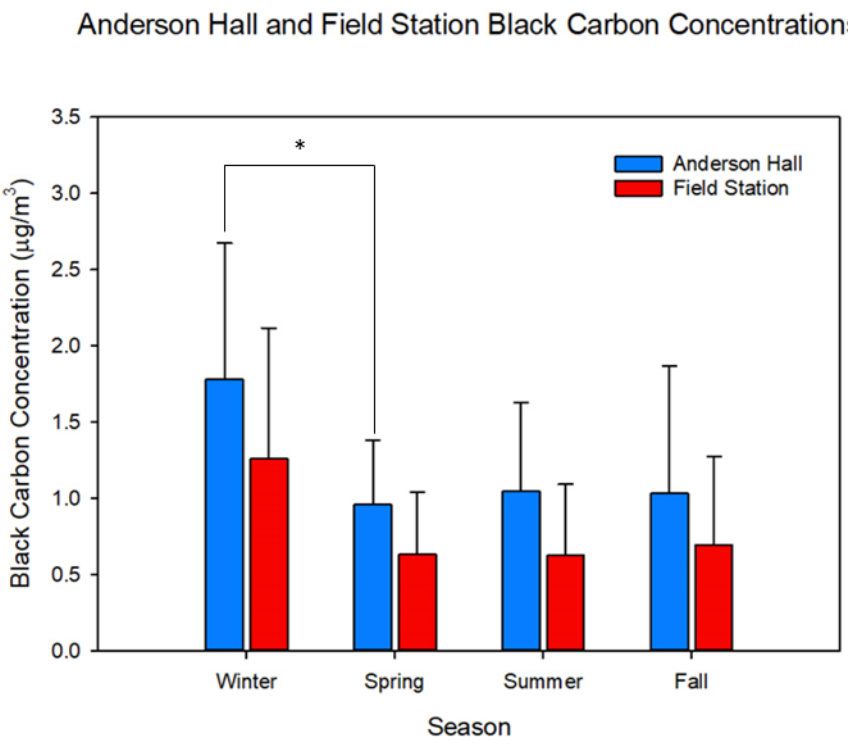


Figure 6: Seasonal averages of black carbon by location. Anderson Hall is represented in blue, and the Field station is represented in red. * represents statistical significance (P<0.05)

Weather Data

Temperature and humidity data were recorded for each sampling period at the Field Station (Figure 7) and Anderson Hall (Figure 8).

Figure 7A shows the monthly temperature averages and standard deviations for the Field Station. These temperatures ranged from 23.7 to 84.2 °F. February was the month with the lowest average temperature (41.31 ± 16.03 °F) while August was the month with the highest average temperature (81.19 ± 1.42 °F). Figure 7B shows the average relative humidity and standard deviations at the Field Station. The humidity ranged from 45.3 to 84.5%, with the lowest average occurring in December (58.87 ± 19.15 %) and the highest in July (79.08 ± 3.25 %).

A. **B.**

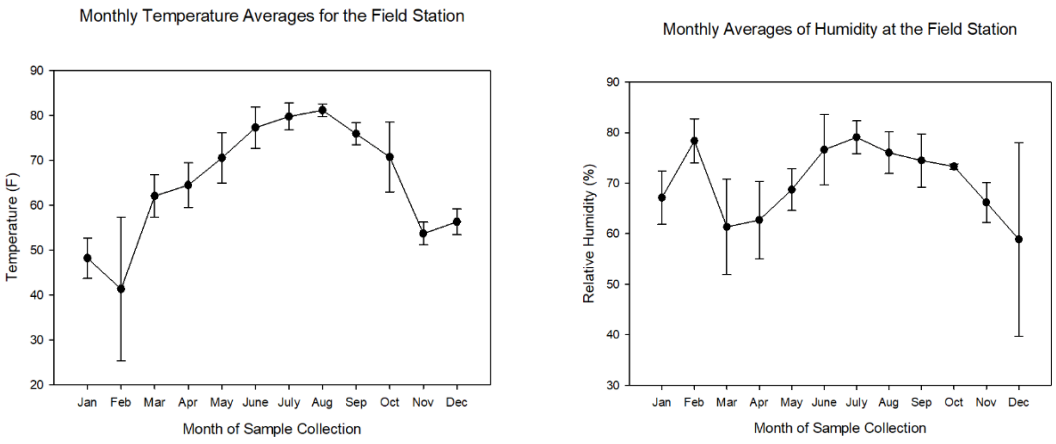


Figure 7: A. Monthly temperature averages and standard deviations for the Field Station, and B. monthly humidity averages and standard deviations for the Field Station.

Figure 8A shows the monthly temperature averages and standard deviation for Anderson Hall. The temperature at Anderson Hall ranged from 22.5 to 88.5°F. This location had a similar trend to the Field Station in that the month with the lowest average temperature was February (40.7 ± 16.6 °F). The month with the highest average temperature at Anderson Hall was July (83.3 ± 3.7 °F). Figure 8B shows the average monthly humidity and standard deviations for Anderson Hall. Relative humidity ranged from 40.4 to 94.2% with the lowest average occurring in February (58.8 ± 9.4 %) and the highest in October (79.2 ± 9.2 %).

A. **B.**

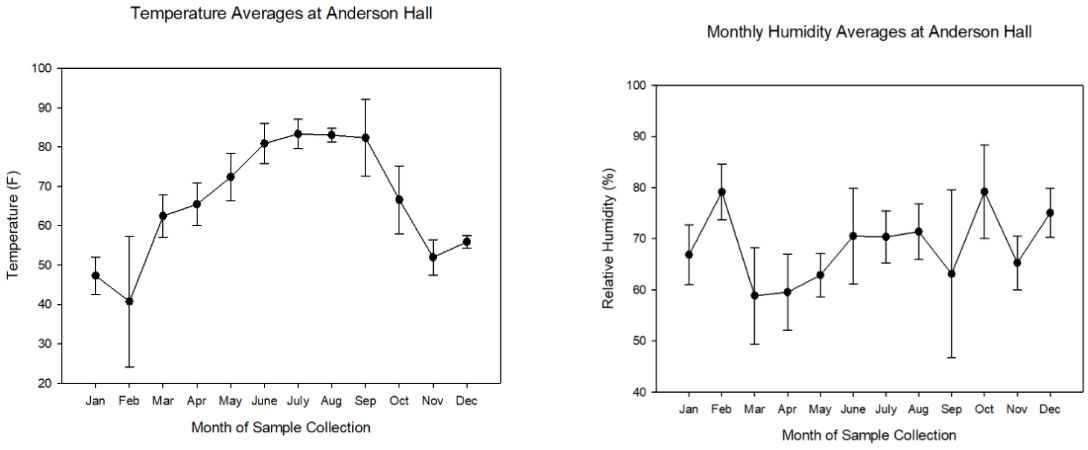


Figure 8: A. Monthly temperature averages at Anderson Hall for the weeks of sample collection. B. Monthly humidity averages for sampling dates during weeks of sample collection.

At both locations, there was a spike in February of lower temperatures. Anderson Hall had an overall average temperature of 68.7 °F and an average relative humidity of 68.4%. The Field Station had an overall average temperature of 66.6 °F and an average relative humidity of 70.4%. Anderson Hall had a higher average temperature than the Field Station, but the Field Station had a higher relative humidity than Anderson Hall.

3. Associations between Black Carbon Concentrations and Meteorological Data

A Pearson's Correlation test was conducted to determine associations between the meteorological data (temperature and humidity) and black carbon concentrations. Humidity at both locations had a slight significant negative correlation with black carbon concentration (P=0.0165). The correlation coefficient for humidity and black carbon concentration was -0.269. Temperature was also slightly negatively correlated with black carbon concentration, but this was not a significant finding statistically (P=0.313). The correlation coefficient for temperature and black carbon concentration was -0.115. Figure 9 shows the slight negative correlation that temperature and humidity both have with black carbon concentration. As temperature and humidity rose, black carbon concentration decreased. Figure 10 shows this relationship at the Field Station with black carbon concentration still having a negative correlation with temperature and humidity. The relationship of black carbon concentration and humidity was much more consistent at the Field Station with the graph having a much smoother slope.

A. **B.**

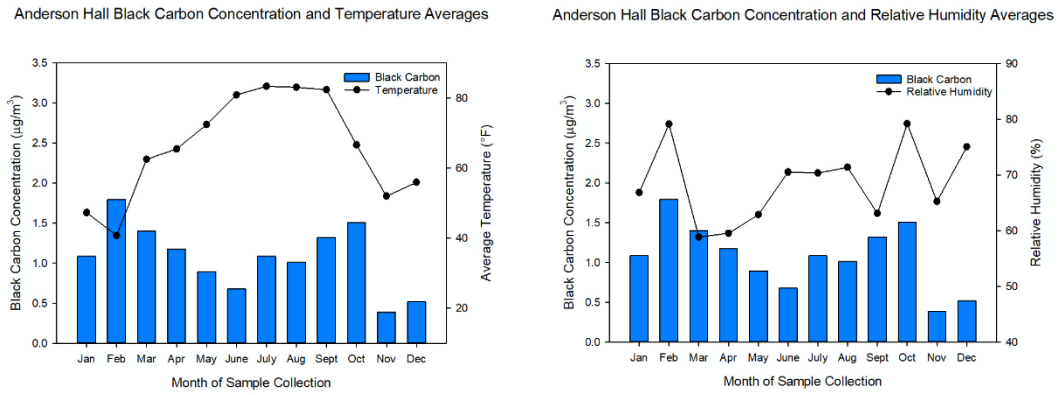


Figure 9: Black carbon concentrations and meteorological parameters for Anderson Hall plotted on the same graph with A. temperature, and B. relative humidity.

A. **B.**

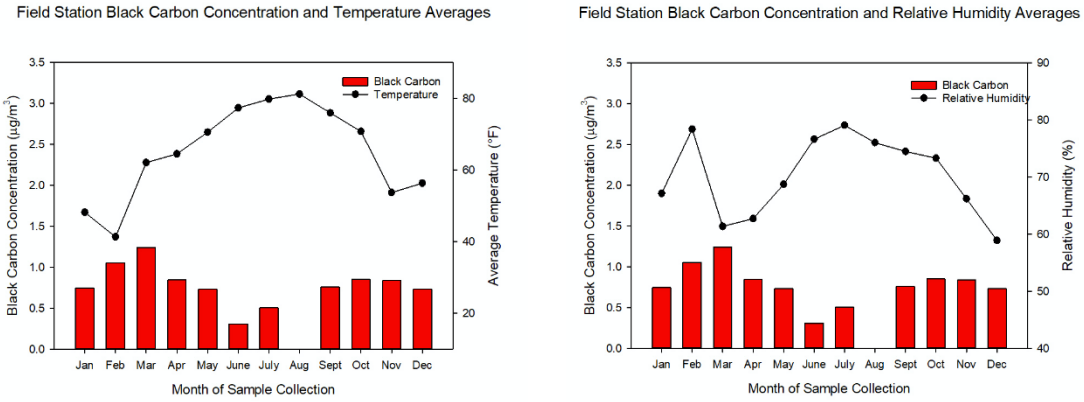


Figure 10: Black carbon concentration and meteorological parameters for the Field Station are represented on the same graph with A. temperature and B. relative humidity.

DISCUSSION

Black Carbon Sources

Black carbon analysis of the filters revealed that there was a significantly higher concentration of black carbon at the Anderson Hall sampling site when compared to the Field Station. Anderson Hall had an overall average of 1.14 $\mu g/m^3$ while the Field Station had an overall average of 0.81 $\mu g/m^3$. This could be due to the high amount of vehicular traffic that Anderson Hall is exposed to throughout the year. Anderson Hall is located adjacent to a bus stop for the University of Mississippi's public transportation system, and is also near a large commuter parking zone. The Field Station, however, is located in a rural area that is not surrounded by any busy highways, leading to less vehicular emissions.

During the Spring semester of 2021, many students were completing their coursework remotely due to the COVID-19 pandemic. This caused a severe decline in the amount of vehicular traffic when compared to previous years. Many students even stayed at their family homes that were located in different states. In months such as May and June, average concentrations for both locations are some of the lowest concentrations, and that could be due to students leaving the campus after the semester has finished. The

bus system also runs on an abbreviated schedule during the summer, with many lines not in service. Many permanent residents of Oxford also leave during these months and travel to vacation destinations, which further contributes to a decline in vehicular traffic. This diminished amount of vehicular traffic could be the cause of this decline in black carbon concentrations.

At the Field Station, one additional source of black carbon could be the burning of organic materials in rural areas. Many people in this region dispose of foliage on their property through controlled burning. The burning of this biomass can cause black carbon to be released into the atmosphere, and it can pose a threat to the health of those around the area (Briggs & Long, 2016). Because of the location of the Field Station, it would experience much more black carbon from this source than Anderson Hall would. Black carbon from this source has been included in studies involving the risk of the development of diseases, such as cardiovascular or respiratory disease, after prolonged exposure.

Seasonal Black Carbon

Overall, Anderson Hall and the Field Station followed similar patterns for monthly average concentration values. Winter and fall months had higher averages than the spring and summer months for both locations, with winter being significantly different from all other seasons. This trend is similar to the findings of a study looking at black carbon concentrations across Northeastern China, which found winter to have the

highest average concentrations when compared to other seasons (Cui et al., 2021). This increase during the winter season could be due to an increase in the need for heating of homes and business, which could cause an increase in black carbon emissions due to the burning of natural gases. Another reason for this increase in black carbon concentration during winter months could be that these months have many more days with cloudy weather, leaving black carbon particles trapped in the lower atmosphere.

During the months of January and February, Anderson Hall had higher concentrations than the Field Station every week sampled, but the concentrations were most similar during the week of February 25th. In March, both locations saw their highest weekly concentrations during the week of March 4th. Anderson Hall had a concentration of 2.87 $\mu g/m^3$, and the Field Station had a concentration of 3.31 $\mu g/m^3$. This is one of the few weeks that the Field Station yielded a higher concentration than Anderson Hall. Anderson Hall concentrations were higher than Field Station concentrations for every date sampled in April with the exception of the 29th when the Field station was 0.2 $\mu g/m^3$ higher than Anderson Hall. May and June both showed Anderson Hall being consistently higher than the Field Station, but both locations follow similar weekly concentration patterns. July only has one sample from the Field Station, and August does not have any samples from this location due to a malfunction of the pump that was caused by water damage. September and October return to the pattern of Anderson Hall having the higher weekly concentrations, and both locations seem to follow similar patterns. In November, there are two dates that do not have samples for Anderson Hall and one that does not

have a sample for the Field Station. This was due to the availability of lab members to collect samples. In December, the filter that was used during the week of December 9th was unusable.

Weather Data

Both locations had temperature and humidity data that was collected for the sampling periods. Anderson Hall's highest average weekly temperature was 88.5 degrees Fahrenheit while the Field Station only reached 84.2 degrees Fahrenheit. This could be due to the fact that the Anderson Hall sampling location is on the top of a large, black roof that draws more heat than the Field Station sampling location. Anderson Hall also had generally higher relative humidity percentages than those observed at the Field Station. On both temperature graphs (Figures 6A and 7A), there is a significant drop in temperature during the month of February. This was due to a snowstorm that impacted the north Mississippi region and caused school cancellations regionally. This occurred during the week of February 11th.

Humidity was significantly negatively correlated with black carbon concentrations at both locations. There are not many studies that look at BC concentrations and weather data, but there are studies on $PM_{2.5}$ concentrations and their correlations with weather data. In a study performed in Japan, relative humidity and $PM_{2.5}$ are strongly negatively correlated across a majority of the sampling sites and have weak positive correlations at few sites (Wang & Ogawa, 2015). Temperature was not

significantly related to black carbon concentrations in our study, but it has been seen to be negatively correlated in some studies due to atmospheric convection (Chen et al., 2020). These studies included areas that were much more populated than Oxford and Abbeville, Mississippi. Both of the studies listed above, however, only looked at the $PM_{2.5}$ concentration and not the black carbon concentration specifically. The values and trends that we observed could be due to a difference in the industries that are located near these areas. There are many industries that are located in China and Japan that are not the same as those located in northern Mississippi. In northern Mississippi, the industries that would contribute to increased concentrations in $PM_{2.5}$ are more dispersed than those in China and Japan. Industries located in the northern region of Mississippi include a Toyota manufacturing plant located in Tupelo, Mississippi and the Olin corporation that produces Winchester ammunition located in Oxford, Mississippi. These industries could be responsible for releasing a larger amount of $PM_{2.5}$. All of these locations are located in different climates as well, leading to another factor that could lead to the differences in the data that was observed.

Future Directions

The filters that were sampled can now be further tested in future research for oxidative potential as well as elemental composition via ICP-MS. These analyses will help us to gain a more complete understanding of what the $PM_{2.5}$ in our area contains. Filters from this period can also be subjected to an extraction process and then tested on zebrafish or

other animal models to determine the toxicity of the $PM_{2.5}$. There were also pollen samples taken at each site during each sampling period, and they can be analyzed for correlations between pollen concentration and other $PM_{2.5}$ factors.

CONCLUSION

Our study found that the black carbon concentrations at Anderson Hall were on average significantly higher than those observed at the Field Station. This was seen when conducting a monthly comparison as well as a seasonal comparison. Black carbon concentrations were also significantly higher at both locations during the winter seasons when compared to other seasons sampled. Anderson Hall did see a significant difference specifically when comparing winter and spring, but the Field Station did not share this result. The black carbon analysis results do support my original hypothesis. Overall, there is a significant difference between the black carbon concentrations at rural and urban locations within northern Mississippi, and there are also seasonal differences. We will continue to collect weekly samples from both Anderson Hall and the Field Station to perform further studies, and these data will help us to gain a better understanding of the air quality in the northern Mississippi region for both rural and urban areas. We have also continued to sample at both locations for the 2022 year and hope to use those data to gain a more complete understanding of the $PM_{2.5}$ concentration through multi-year analyses.

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