Outdoor & Indoor Air Quality Monitoring and Assessment from Wildfire Smoke in Phoenix and Talent, Oregon

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In partnership with
Unite Oregon Rogue Valley Chapter

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Introduction of Partner Organizations

Beyond Toxics is a multicultural, multi-gendered, intergenerational team dedicated to environmental justice and centering leaders from frontline communities. The Staff is >50% BIPOC. Beyond Toxics is a founding member and serves on the steering committee of the Oregon Just Transition Alliance, a coalition of racial and environmental justice nonprofits from across Oregon's landscape. With offices in both Phoenix and Eugene, Beyond Toxics has relationships and projects with 7,000+ members statewide. Beyond Toxics' mission is to ensure that everyone regardless of race, income, class, gender, and citizenship status lives in healthy, regenerative environments free of pollution and toxic chemicals.

Brief Project Summary

The main objective of the project is to mitigate the negative health impacts of the air, water, and soil pollution resulting from the Almeda Wildfire of 2020. The small towns of Phoenix and Talent were heavily impacted by the wildfire in Jackson County. Between the two towns, 20% of the residents identify as Latinx. Many of the residents also identify as low-income. Some of the community members work outdoors in the agricultural or forestry field and are considered essential workers. They are the ones who have to work in air quality conditions that are unhealthy. Many of the residents were further impacted by poor air quality days, which is why the focus of the project was to provide the community with community science training, education, and participation opportunities on the health impacts of wildfire.
The Project aimed at engaging community members who are in wildfire-impacted areas to increase the community's knowledge of air quality related to wildfire smoke and particulate matter and take health preventative measures in their daily lives during poor air quality days.

This was achieved by:

- Installed of air quality monitoring system outside and inside the homes of 10 participants in Phoenix and Talent, Oregon
- Conducted soot testing at 10 homes that were impacted by the Alameda fire of 2020
- Canvassed over 50 homes to further understand the health impacts during and after the fire took place.
- Held 4 Community Science meetings to better prepare the community for poor air quality days and wildfires.

Project Objectives

The objective of the project was to compare the effects of indoor air quality and outdoor air quality in newer well-ventilated homes and older homes with poor ventilation. Indoor air quality is neither well-regulated nor well-understood. This knowledge gap is critical because people spend more than 90% of their time indoors.[1]The data obtained in the study is used to provide air quality data that residents can use to modify their behaviors to be more health-protective during elevated events of harmful air pollution, such as wildfire. The increased need for wildfire preparedness to protect public health and provide consistent messages across the state has been crucial for local community members to gain knowledge and become proactive about wildfire preparedness.

The project includes two types of environmental monitoring that are associated with public health outcomes. The first was measuring particulate matter in indoor residential air and the second was soot testing in areas affected by the fire. Air monitoring, and residual soot from wildfire look at Particulate Matter 2.5 (PM 2.5). PM 2.5 is known to be one of the single largest environmental risk factors for human health in the United States. Airborne soot particles can be a serious health hazard that, at 2021 U.S. standards for allowable exposure to airborne soot (12 mcg/L), is associated with 45,000 deaths yearly.

For this study, we hypothesized that older homes that were exposed to intense wildfire smoke have a higher infiltration of soot particles or wildfire smoke due to poor ventilation or larger leakage than newer houses. [2]

Sampling Design

The sample design included the 10 residences for air monitoring and the 10 residences for soot testing. Five of the residents participated in both air monitoring and soot testing. The air monitor was installed using the criteria stated below to further assess the best location for the air monitor inside and outside the house:

- Houses with older builds and poorly maintained ventilation systems
- Houses that were newer builds and well-maintained ventilation systems

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[1] U.S. Environmental Protection Agency. 1989. Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C. Washington, DC.

[2] W. R. Chan, W. W. Nazaroff, P. N. Price, M. D. Sohn, A. J. Gadgil, Analyzing a database of residential air leakage in the United States. Atmos. Environ. 39, 3445–3455 (2005).

- Used a map to identify where no Purple Air monitors were present to avoid installation near where existing PA monitors are present. (See Appendix A for reference to the map).

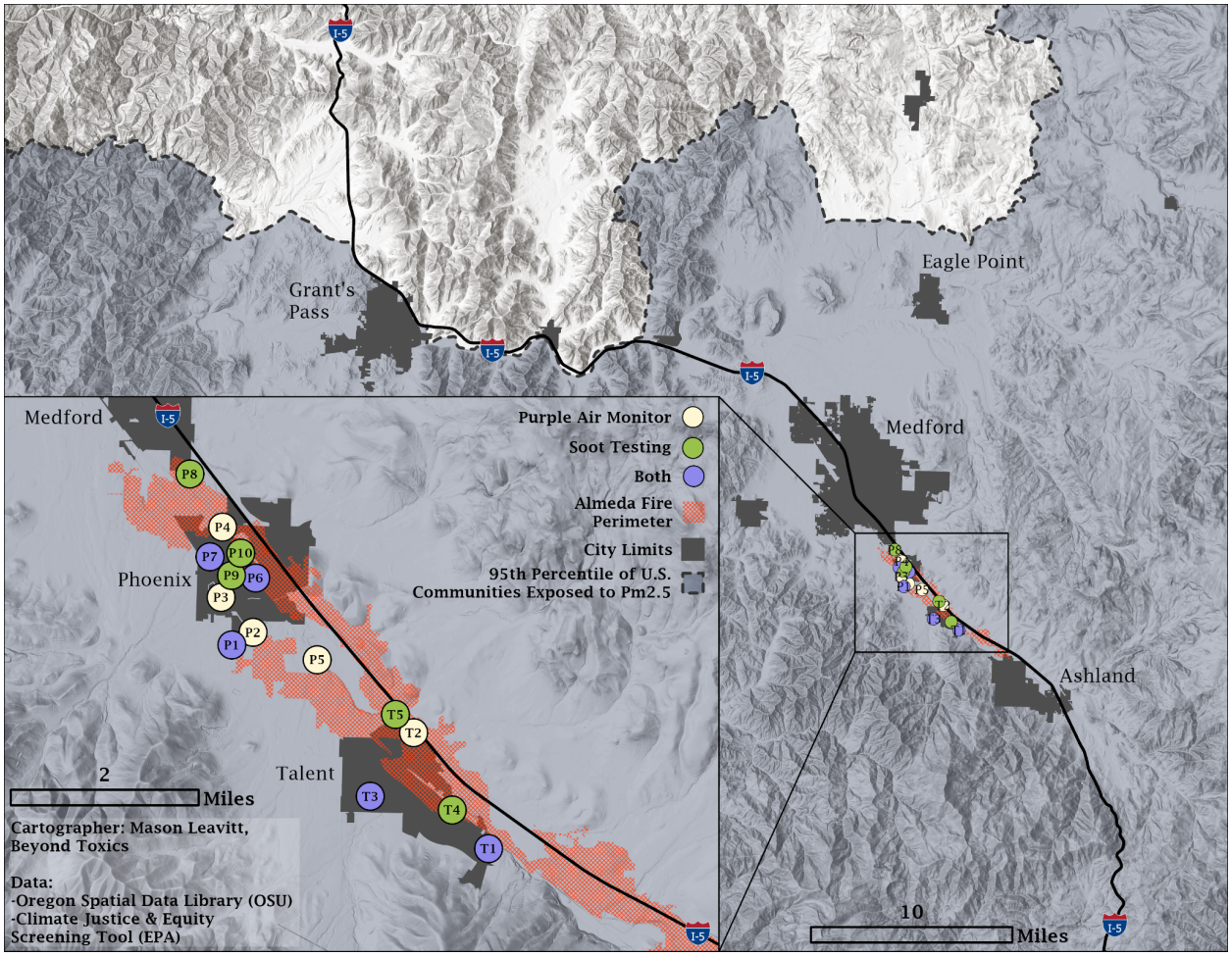


Figure 1. Map of the geographic location of the deployment of Purple Air monitors and soot testing done in Phoenix and Talent, Oregon.

Purple Air

The installations took place on October 17th, 18th, 19th, and November 11th of 2022. After the ideal location was assessed for the two air monitors (indoor and outdoor), the air monitors were secured outside and inside the home. A reliable internet connection was ensured. After the air monitors were secured and an internet connection had been established, the air monitors were registered for the data to be captured and stored on a public domain website of Purple Air.

The model device identification number and model number were captured and recorded before installation. The homeowners were orally surveyed on whether they had a centralized air

conditioning system, or an air purifier, and the age and build of their home.

The air monitor team walked the homeowners through how to access the real-time data from the PurpleAir website. The homeowner was shown the Airwyn app and how to navigate the PurpleAir website to look at the air monitors on the real-time map. Airwyn is a free app that allows anyone to monitor PurpleAir sensors and supports AQI conversion formulas from US EPA and Lane Regional Air Protection Agency (LRAPA). The app sends the homeowner alerts whenever the air quality improves or worsens.

The homeowners were given instructions on how the data could be interpreted and people could make decisions about their daily activities based on the readings. Daily activities may include: opening the windows, exercising outside, and any other outdoor activities. If an air alert is received that the air quality has worsened, then the homeowner can: close the windows to avoid unhealthy air coming into the home, limit outdoor activities, or use an air purifier.

For soot sampling, the community organizers and the soot samplers obtained permission from homeowners to conduct sampling at the homes. Some of the homes tested for soot were at the same location where the air monitor deployment was conducted. Ideal sites for sampling were homes that were impacted by wildfire or near wildfire smoke. A survey was conducted while testing for soot in participants' homes to collect information on whether or not they had air conditioning, the type of air conditioning, the frequency the air filter was serviced, and the build of the home occupied. Other relevant questions for residents from the samplers were to find out whether their living habits, such as smoking, fireplace use, and candle use, were recorded and analyzed.

Soot Testing

The soot samplers identified, recorded, and considered if the residents had done a clean-up after the wildfire smoke or not. Visual observations were also made, to collect any visual evidence of a fire event such as heat and smoke damage which could be identified via visual inspection and visible combustion particles. Smoke odors would be acknowledged. A tracking sheet was used to track the household address, the samples taken from each house, the description of the sample size, the sampling method used, and any additional notes. Another relevant question for residents is whether their living habits, such as smoking, fireplace use, incense, and candle use, were recorded. Refer to Appendix B for more details on the Survey.

There were two types of surface sampling methods used, tape lifts and wet wipes. A Transparent Office Tape was used for the tape lifting method due to its advantages of being a quick and simple sampling procedure. This sampling method determined the number of target analytes present on surfaces. It was an efficient sampling method for collecting particles from

relatively smooth non-porous surfaces with typical monolayer loading such as desks, furniture, glass, and hard floors. The sampling method preserved the relative positions of the particles on the original surface and the population per unit area. A variety of optical microscopy methods could have been used in the identification analysis, with minimal preparation. Packing tape was avoided since these products have a thick layer of adhesive that can trap particles hence hindering analysis. Non-transparent and industrial tapes, such as duct tape were not used for sampling. The surfaces for sampling included the main living areas, the interior of the door frame, corners of floors, door tracks, and attic areas.

The alcohol prep wipes method was used on small surface areas so particles could be easily extracted for analysis. The method recommended avoiding water-based moistening agents because many common particles such as soot and ash are water-soluble. The advantages of wet wipe/alcohol prep wipes were also quick and simple sampling procedures. It is an efficient sampling method for collecting particles from relatively smooth non-porous surfaces. A variety of optical and electron microscopy methods can be used in the identification analysis. The surfaces for sampling included TVs, computer displays, plastic surfaces, furniture, windows, and refrigerators. This method recommends avoiding painted surfaces due to the transfer of paint on the wipe.

A sample from three houses was obtained as a control sample from locations that were identified as not impacted by the Jackson County Fire Damage Assessment Dashboard Map.[3] The other 7 identified homes were within the wildfire perimeter. The Jackson County Fire Damage Assessment Dashboard Map indicated and recorded which homes were affected by the wildfire in 2020.

Field Activities

The community organizers and air monitor installers obtained permission from the homeowners to conduct the study at the houses. The homeowners participating in the study agreed to host the air monitor inside and outside of the residences. The homeowner has agreed to the terms and conditions of hosting an air sensor by signing an agreement.

Both organizations worked with the homeowner on the day of installation to establish a location that allowed the Purple Air Monitor to accurately record ambient air quality, and ensure reliable power and an internet connection. The installers made sure to protect the Purple Air Monitor

[3] Jackson County GIS. [basemap] “Jackson County Fire Damage Assessment Dashboard”. [1 in: 4 mi] “Jackson County Wildfire Information Wildfire Activity” https://www.arcgis.com/apps/dashboards/9c9c796ff7ff44c0b1e5d21f2d71c9fb (December 16th, 2022).

from weathering or damage from precipitation, maintain a distance from sources of pollution, and help the participants avoid any actions that would damage the monitor. Further explanation was provided to the homeowner, about the location of the air monitor on the PurpleAir public map. That information is shared via a public online website so the homeowner could view the data in real-time. The registered location of the device was slightly obscured to protect the knowledge of its exact location.After all of these actions had taken place, the air monitor installation team installed the two air monitors inside and outside of the home on their property.

For the soot testing, the community organizers and the soot samplers obtained permission from homeowners to conduct sampling from the residences. The homeowner's shared their knowledge of where the residence was affected by wildfire smoke. Ideal sites were where a house was impacted with wildfire smoke and had potential residue from the wildfire in 2020. Statements from identified residents/occupants and other observers were helpful and provided information that supplemented the collected observations and samples. We identified houses where there is poor air circulation and are also without air filtration systems. The samplers also identified, recorded, and considered if the residents had done a clean-up after the wildfire smoke or not. Other relevant questions for residents is whether their living habits, such as smoking, fireplace use, and candle use, will be included/recorded when feasible.

Results & Findings

Purple Air Quality Monitoring Results

The Purple Air quality monitoring study was conducted over two months from November 11, 2022, to January 11th, 2022. The data was recorded on a 6-hour average. The time at which data was collected was 10 a.m., 4 p.m., 10 p.m., and 4 a.m. every day over the two months. The Data was exported in an Excel spreadsheet and graphs were plotted using the recorded data.

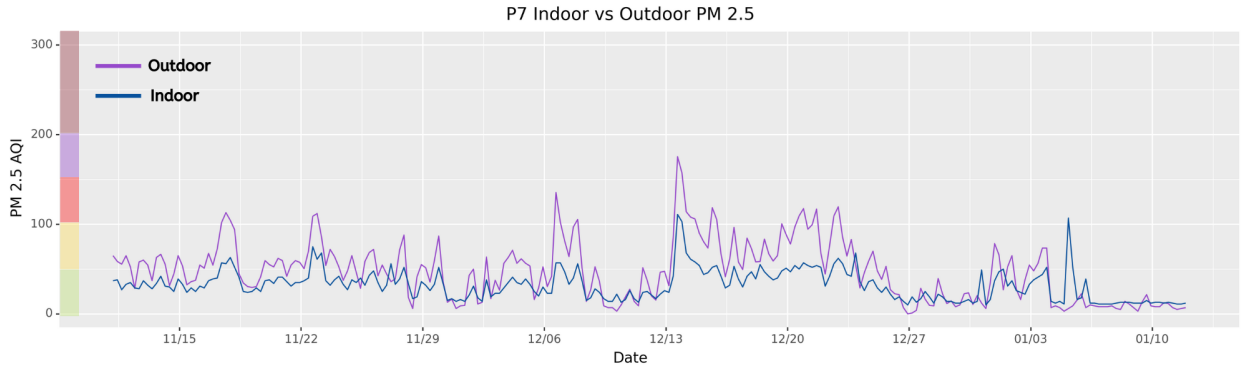


Figure 2. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled P7.

P7 Location: Single Family Residential Home in Phoenix
Average Indoor Air Quality:32.4 AQI
Average Outdoor Air Quality: 47.5 AQI
House Quality (rated by resident): Moderately Good

Figure 2 shows a graph of the indoor and outdoor air monitor readings of PM 2.5 over two months from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5. The blue line shows the indoor air monitor readings of PM 2.5. The indoor and outdoor levels of PM 2.5 were tracked very closely showing a relationship between outdoor and indoor air quality. When the outdoor air monitor readings increase there is a simultaneous increase in the indoor air monitor reading. The outdoor air monitor levels are higher overall than the indoor air monitor levels. A few data points on the graph show the outdoor air monitor readings are lower than the indoor air monitor readings. Factors that may have influenced the spike in the indoor air monitor readings are the use of candles and when the residents were cooking. Though, there was not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

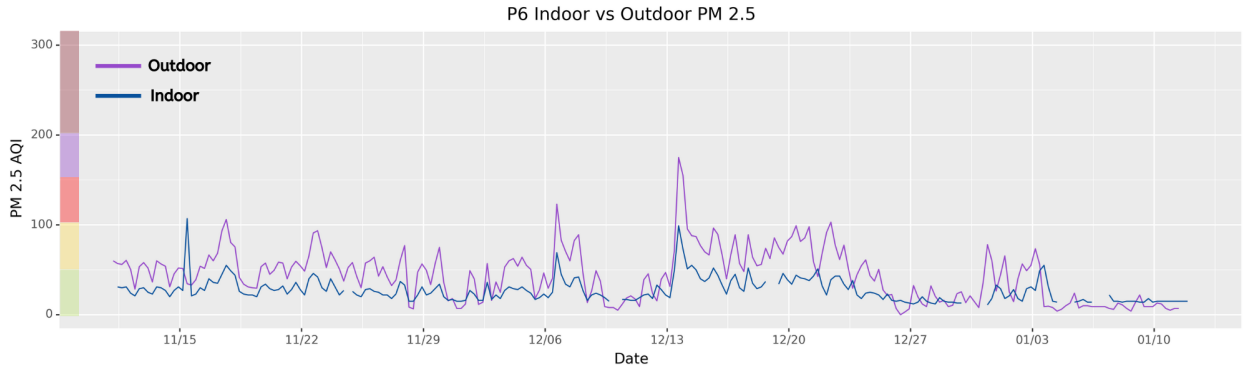


Figure 3. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled P6.

P6 Location: Single Family Residential Home in Phoenix
Average Indoor Air Quality: 25.7 AQI / 150 (is it ppm?)
Average Outdoor Air Quality: 43.8 AQI
House Quality (rated by resident): Fair

Figure 3 shows a graph of indoor and outdoor air monitor readings of PM 2.5 over the two months from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5. The blue line represents the indoor air monitor readings of PM 2.5. Between December 5th to December 9th, the data is missing. The loss of

data is due to the temporary loss of power to the monitor and the air monitor must restart to collect the data. The indoor readings for the house were above 150, which is unhealthy if long-term exposure to such levels were more frequent. The outdoor air monitor levels are higher overall than the indoor air monitor levels. Factors that may have influenced the spike in the indoor air monitor readings are the use of candles and the time at which cooking occurred. There was not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

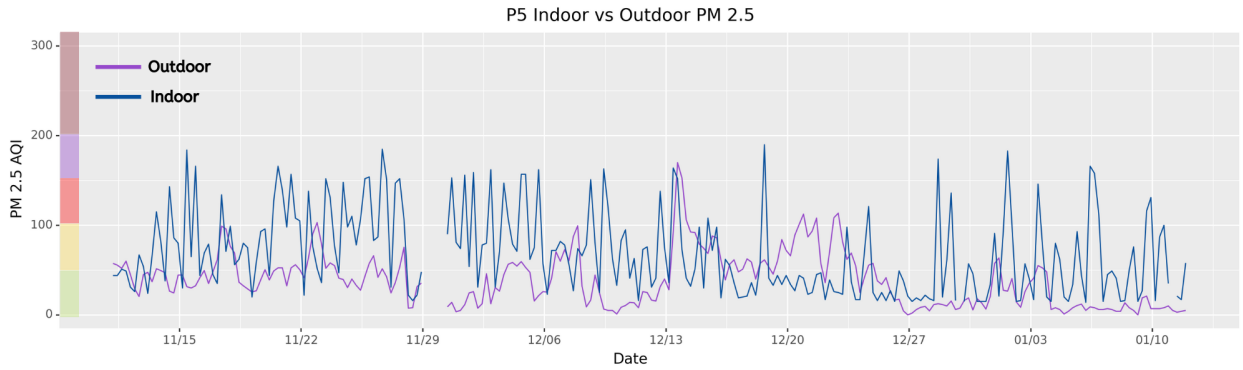


Figure 4. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled P5.

P5 Location: Single Family Residential Home in Phoenix
Average Indoor Air Quality: 66.8 AQI
Average Outdoor Air Quality: 38.4 AQI
House Quality (rated by resident): Fair

Figure 4 shows a graph of indoor and outdoor air monitor readings of PM 2.5 over two months from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5 and the blue line shows the indoor air monitor readings of PM 2.5. The indoor air monitor readings are varied in nature. The indoor readings on numerous days were above 150 AQI, which is unhealthy if long-term exposure to such levels were more frequent. A factor that may have influenced the spike in the indoor air monitor readings is living in close proximity to a road or the placement of the air monitor near the front door of the home. There was not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

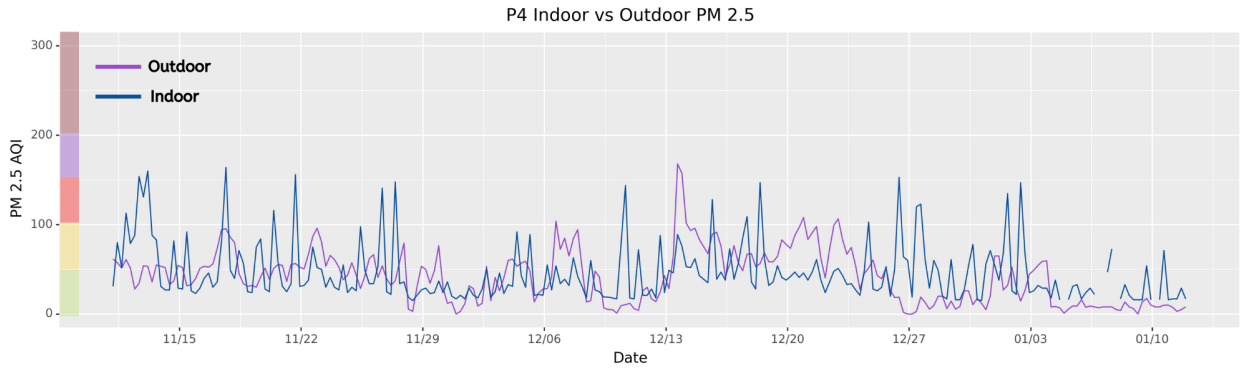


Figure 5. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled P4.

P4 Location: Single Family Residential Home in Phoenix
Average Indoor Air Quality:46.6 AQI
Average Outdoor Air Quality: 42.2 AQI
House Quality (rated by resident): Moderately Good

Figure 5 shows a graph of the indoor and outdoor air monitor readings of PM 2.5 over two periods from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5. The blue line represents the indoor air monitor readings of PM 2.5. There were more than 12 days when the indoor air quality readings were higher than the outdoor air quality readings. Five of the 12 days had indoor air monitor readings over 150. The air quality index (AQI) states that any number over 150 AQI is considered unhealthy air quality.[4] The data shows that on a few days in the home, the air quality was considered more unhealthy in the home than outdoors. There are a few data gaps between data points, this can be due to the temporary loss of power to the monitor which causes data loss. A Factor that may have influenced the spike in the indoor air monitor readings is the time cooking occurred in the house. There was not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

[4] AQI Basics, AirNow.gov. (n.d.). https://www.airnow.gov/aqi/aqi-basics/

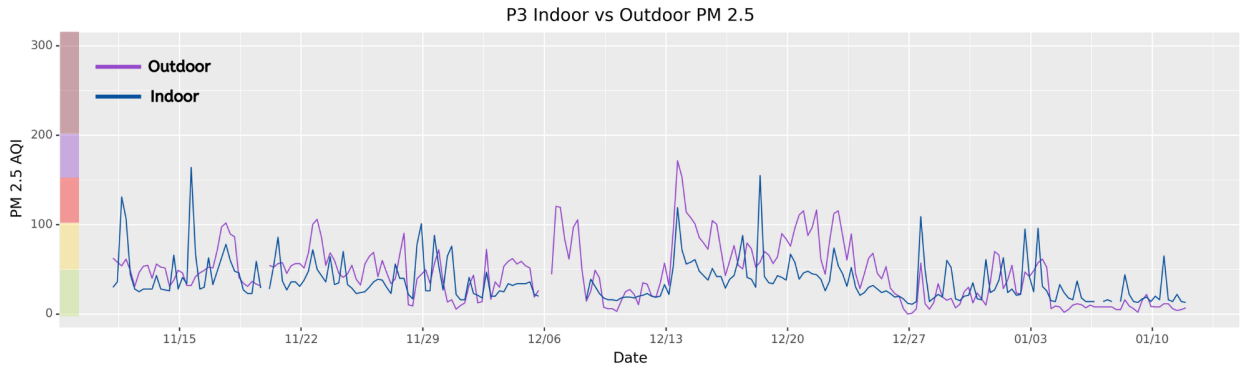


Figure 6. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled P3.

P3 Location: Single Family Residential Home in Phoenix
Average Indoor Air Quality: 45.2 AQI
Average Outdoor Air Quality: 37 AQI
House Quality (rated by resident): Moderately Good

Figure 6 shows a graph of the indoor and outdoor air monitor readings of PM 2.5 over two periods from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5. The blue line represents the indoor air monitor readings of PM 2.5. The indoor air monitor readings were higher towards the monitoring duration. There are a few data gaps between data points, this can be due to the temporary loss of power to the monitor which causes data loss. Factors that may have influenced the spike in the indoor air monitor readings are the use of candles and the time when cooking occurred. There was not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

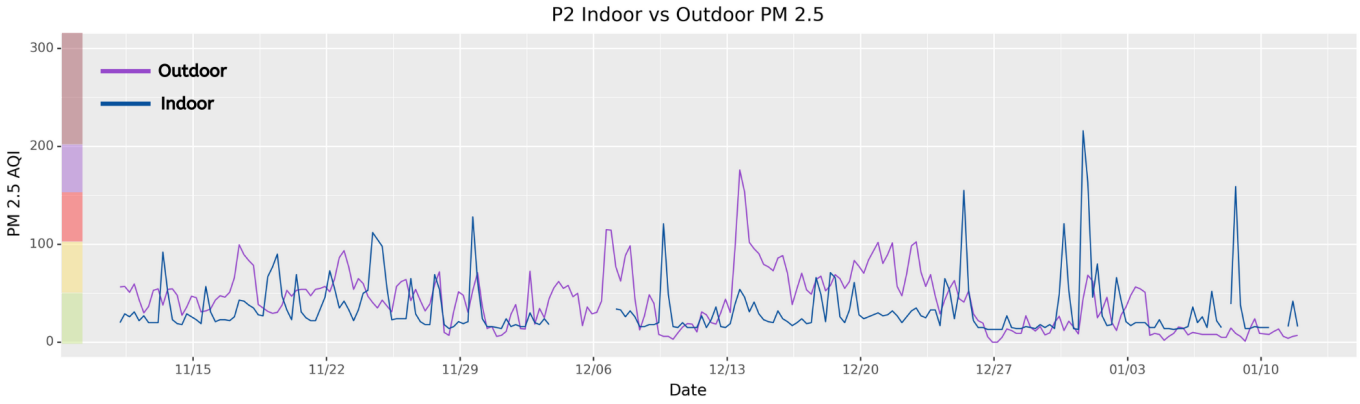


Figure 7. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled P2.

P2 Location: Single Family Residential Home in Phoenix

Average Indoor Air Quality: 42.5 AQI
Average Outdoor Air Quality: 33.3 AQI
House Quality (rated by resident): Excellent

Figure 7 shows a graph of the indoor and outdoor air monitor readings of PM 2.5 over two periods from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5. The blue line represents the indoor air monitor readings of PM 2.5. The highest outdoor air quality reading was over 176 AQI. At the same time this data was recorded, the indoor air quality reading was under 50 AQI. There are multiple points on the graph where the outdoor air quality is higher than the indoor air quality. The indoor air quality readings could have been lower than outdoor air quality due to air circulation throughout the home, the frequency of air filters changed, or the newer age of the house. There are 6 data points on the graph where the indoor air quality readings are higher than the outdoor air quality readings. There are a few data gaps between data points, this can be due to the temporary loss of power to the monitor which causes data loss. There was not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

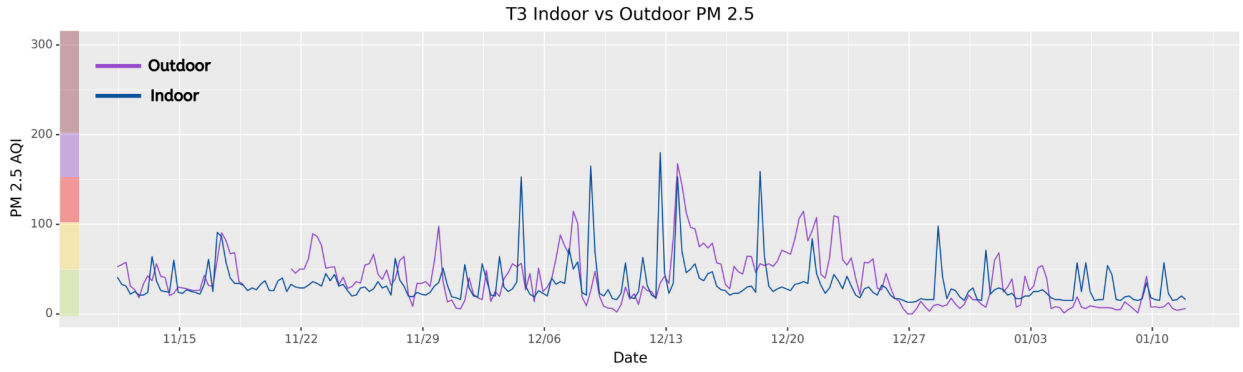


Figure 8. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled T3.

P2 Location: Single Family Residential Home in Talent
Average Indoor Air Quality: 33.1 AQI
Average Outdoor Air Quality: 36.9 AQI
House Quality (rated by resident): Moderately Good

Figure 8 shows a graph of the indoor and outdoor air monitor readings of PM 2.5 over two periods from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5. The blue line represents the indoor air monitor readings of PM 2.5. Between December 3rd and December 17th. 4 data points showed higher indoor air quality readings than outdoor air quality readings. The indoor air quality readings could have been impacted by the time of day when cooking or other daily activities in residence to impact the air monitor readings. There are a few data gaps between data points. This can be

due to the temporary loss of power to the monitor which causes data loss. There was not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

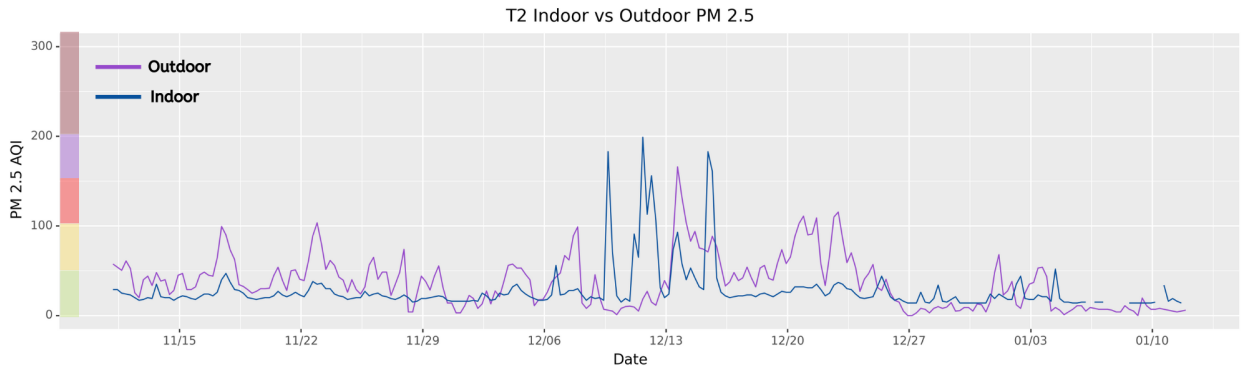


Figure 9. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled T2.

T2 Location: Single Family Residential Home in Talent
Average Indoor Air Quality: 28 AQI
Average Outdoor Air Quality: 36.6 AQI
House Quality (rated by resident): Excellent

Figure 9 shows a graph of the indoor and outdoor air monitor readings of PM 2.5 over two periods from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5. The blue line represents the indoor air monitor readings of PM 2.5. The indoor air quality is consistently below the outdoor air quality except around December 9th to December 17th, the indoor air quality exceeded the outdoor air quality by 3 times. There are a few data gaps between data points, this can be due to the temporary loss of power to the monitor which causes data loss. There is not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

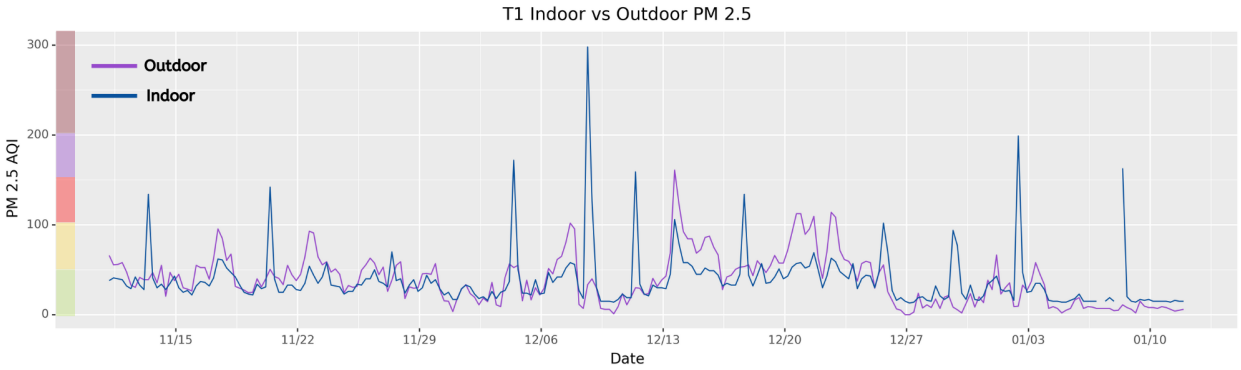


Figure 10. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled T1.

P2 Location: Single Family Residential Home in Talent
Average Indoor Air Quality: 33.3 AQI
Average Outdoor Air Quality: 32.5 AQI
House Quality (rated by resident): Moderately Good

Figure 10 shows a graph of the indoor and outdoor air monitor readings of PM 2.5 over two periods from one of the locations where an air monitor was placed. The purple line represents the outdoor air monitor readings of PM 2.5. The blue line represents the indoor air monitor readings of PM 2.5. There are 6 data points that show an increase in the indoor air quality readings in the home. Many of these readings could have been impacted by the time of day at which specific daily activities occur. These activities include using a stove fireplace, candles, and cooking. The overall trend shows that the air quality readings outdoors were higher than the indoor air quality readings. There are a few data gaps between data points, this can be due to the temporary loss of power to the monitor which causes data loss. There is not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

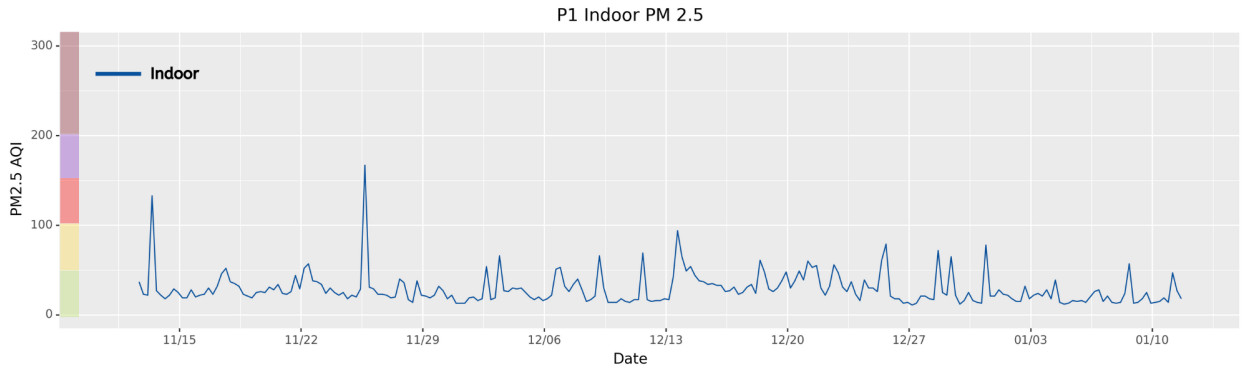


Figure 11. Line graph comparing the indoor and outdoor air quality readings of PM 2.5 at residence labeled P1.

P1 Location: Single Family Residential Home in Phoenix
Average Indoor Air Quality: 29.1 AQI
House Quality (rated by resident): Moderately Good

Figure 11 shows a graph of the indoor and outdoor air monitor readings of PM 2.5 over two periods from one of the locations where an air monitor was placed. The blue line represents the indoor air monitor readings of PM 2.5. The outdoor air monitor installed at this residence had connectivity issues and was connecting and reconnecting numerous times throughout the two-month period. The data was not included in the graph. The indoor air monitor shows two indoor air quality readings over 100, which could have been influenced by the time when cooking occurred. There is not enough conclusive data to determine whether or not these factors correlate to the increase in PM 2.5.

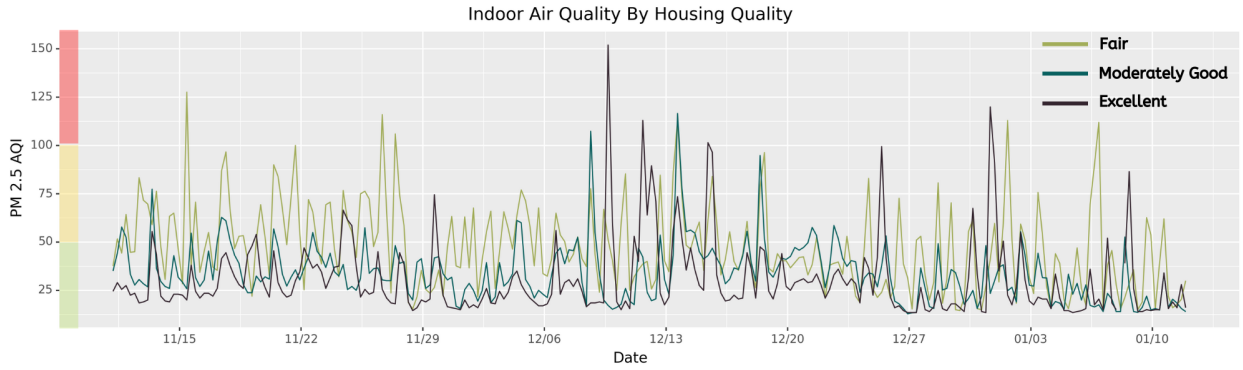


Figure 12. Graph comparing the ranking of the build quality of the house to the indoor air quality within the house.

This graph shows the relationship between the indoor air quality PM 2.5 readings in the home and the impact the build quality of the home would have on the air quality. Participants ranked the build quality of their homes as poor, fair, moderately good, and excellent. Each rank correlates with a number 1 through 4 that was then coded into the graphing system used. The houses that were ranked a fair build quality had 7 indoor air quality readings over 100. An air quality reading over 100 is considered unhealthy for sensitive groups of the population on the Environmental Protection Agency's Air Quality Index. The houses that were given a build quality ranking of moderately good had 2 days with an air quality reading over 75. The houses that were given a ranking of excellent had 4 days of air quality readings over 75. The houses given a ranking fair for the build quality of the house had more days of indoor air quality that was unhealthy for sensitive groups than houses ranked moderately good or excellent. The outlier in this graph would be the data point of the homes that were given a ranking of excellent for the build quality of the home because it was over 150 on the air quality index. Any air quality readings over 150, are considered unhealthy for everyone. There is not enough conclusive data to determine the increase in air quality over a short period of time. Factors to be considered include if cooking occurred, and the use of a fireplace or candles.

Brief Observations on the study of Indoor versus Outdoor Air Quality

Overall the average indoor air quality was lower than the average outdoor air quality in the homes. On December 13th, all of the outdoor air monitors recorded readings over 100 AQI in Phoenix and Talent. The houses that had many days with higher indoor air quality readings of PM 2.5 than outdoor air quality readings of PM 2.5 may have been influenced by a variety of factors such as the use of fireplaces or candles, the time when cooking occurred, and other environmental factors. There was not enough conclusive evidence to correlate the build quality of the home impacting the indoor air quality readings in the home.

Soot Testing

All samples for Soot were taken on a single day 17th December. There were a total of 10 Soot samples collected. The soot samples were sent to the Lab for analysis after their collection. The lab would send back a report of its Char, Ash, and Soot concentrations. The data from the lab was later exported in an excel spreadsheet and graphs were plotted using the recorded data. The lab results were received electronically on January 12, 2023. The data represented below is from the adhesive tape lift samples. The households were asked questions such as the ranking of ventilation, factors such as smoking or fireplace or use of candles, or whether the houses were impacted by smoke damage or fire damage. Refer to Appendix C for Lab analysis.

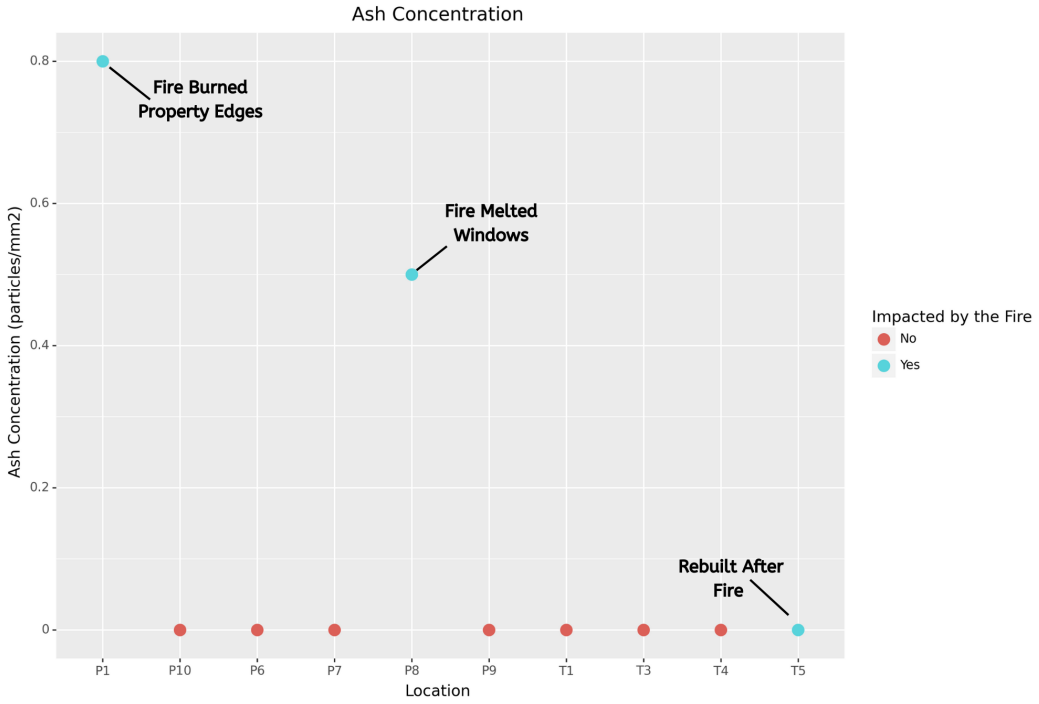


Figure 13. Graph comparing the ash concentrations tested in each house to the impact the fire had on houses.

Figure 13 shows a graph comparing all the ash concentrations found in all the homes and whether or not the house was impacted by wildfire. The ash particle size is denoted in particles/mm2. There were only two homes where ash concentrations were 0.5 and 0.8 and both houses had some damage to their homes. Other houses such as P10, P6, and P7 have 0 concentration of ash as no particles were discovered on the samples and these houses were not damaged by fire. House T5 was rebuilt after the wildfire but had 0 concentration of ash.

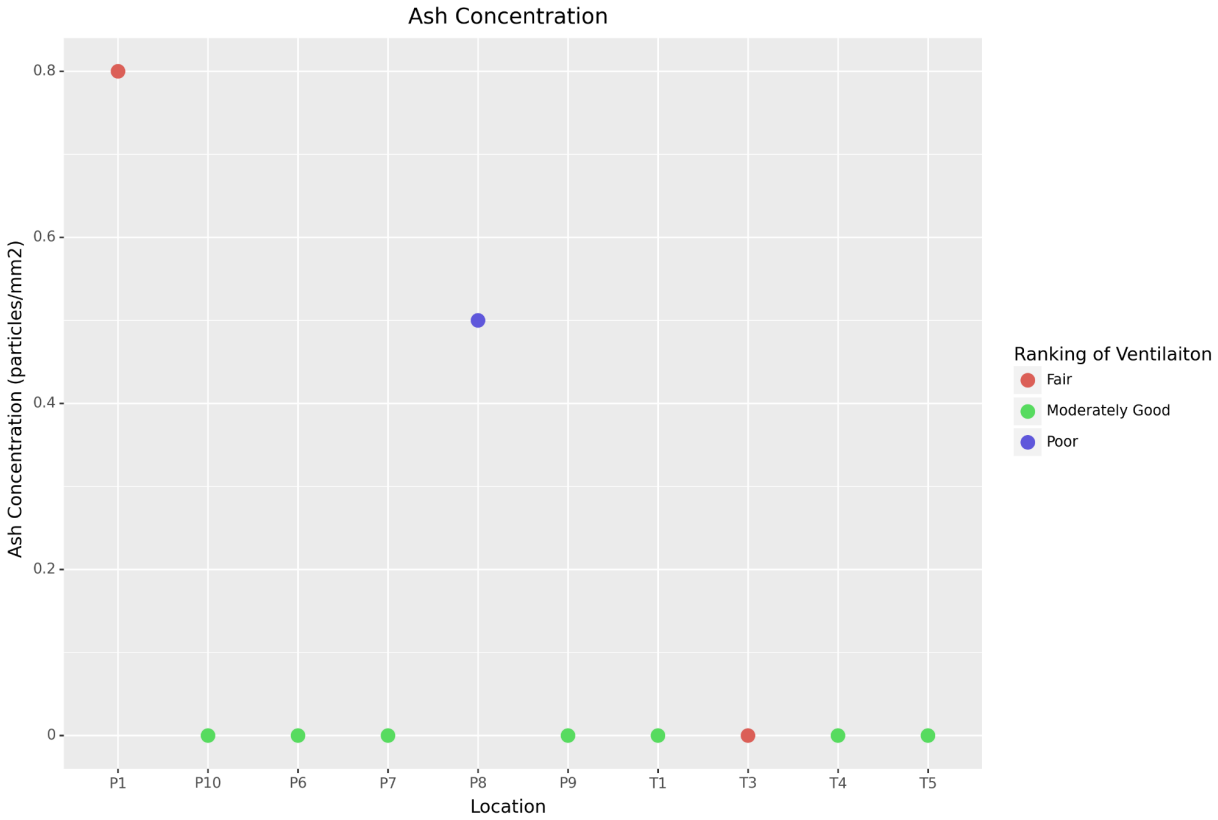


Figure 14. Graph comparing the ash concentrations tested in each house to the ranking of ventilation.

Figure 14 shows the graph of all the ash concentrations found in all the homes and if the ranking of the ventilation had any effect on the concentrations. The ash particle size is denoted in particles/mm2. House P1 ranked their ventilation as fair and the ash concentration found in their sample was 0.8 particles/mm2. House P8 also had a concentration of 0.5 particles/mm2 and the ranking it got was poor. Houses that ranked moderately good had 0 concentrations of ash particles or they were not discovered.

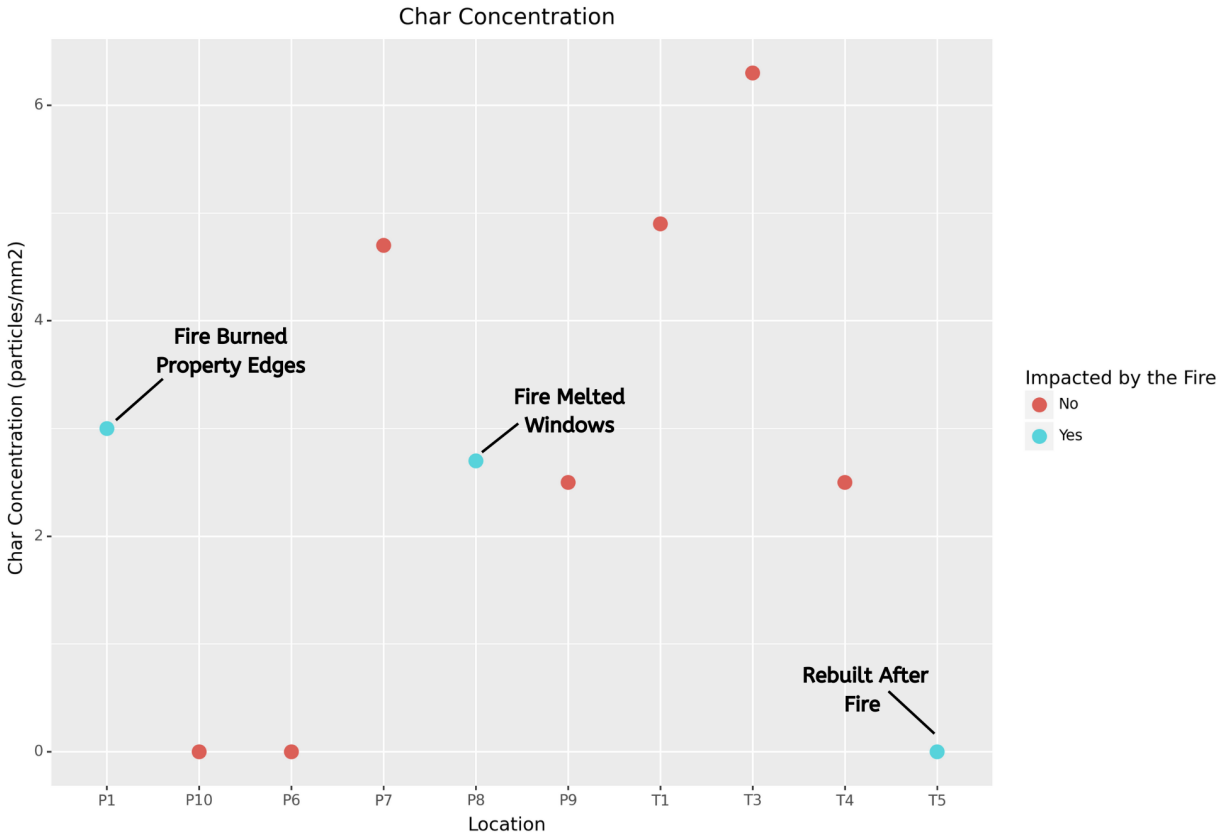


Figure 15. Graph comparing the char concentrations tested in each house to the impact the fire had on the houses.

Figure 15 shows the graph of all the char concentrations found in homes and if the homes were impacted by wildfire. The char particle size is denoted in particles/mm2. House P1 and P8 were impacted by the wildfire and the concentration of Char found were 3 and 2.8. The highest concentration of Char was found at T3, this house was not impacted by the fire. 5 houses were not impacted by the wildfire but there were some concentrations of char present.

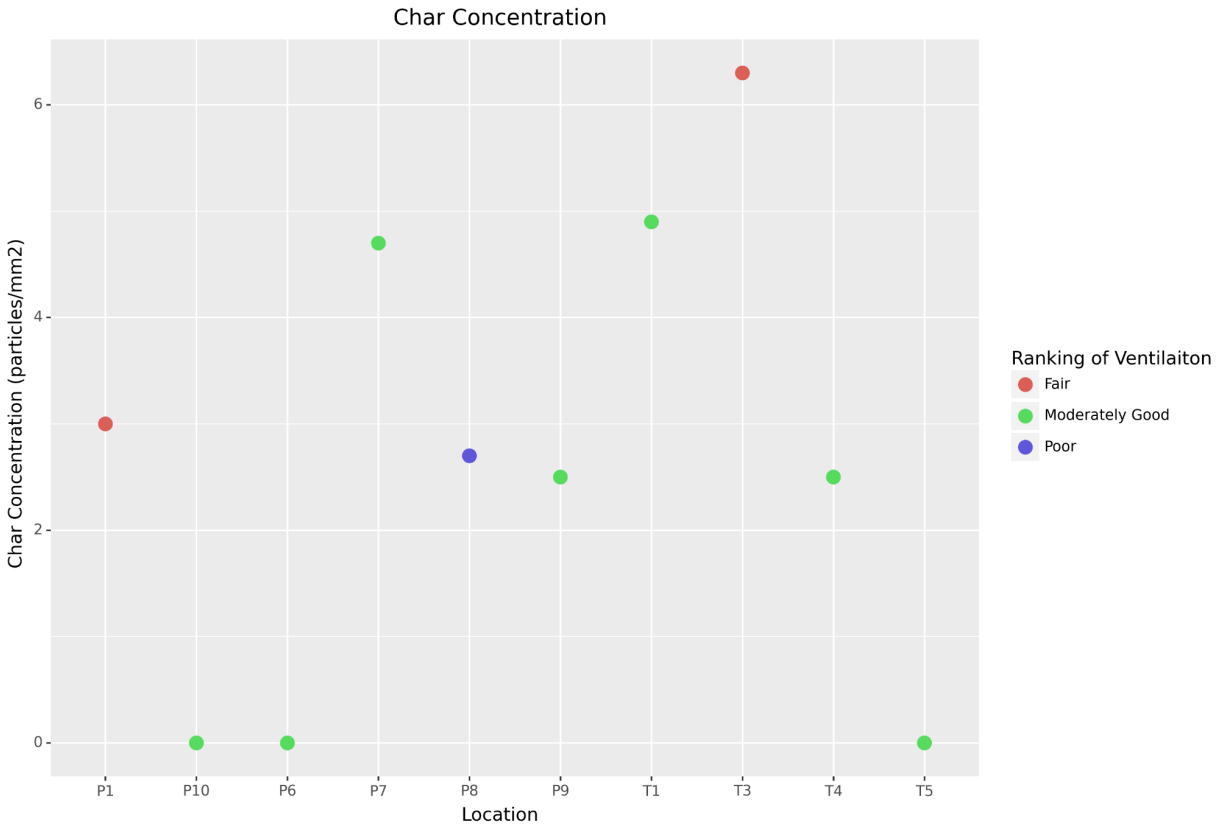


Figure 16. Graph comparing the char concentrations tested in each house to the ranking of ventilation.

Figure 16 shows the graph of all the char concentrations found in homes and if the ranking of the ventilation had any effect on the concentrations. The char particle size is denoted in particles/mm2. T3 ranked its ventilation fair and had a char concentration of 6.3 particles/mm2. Houses that were ranked moderately good have slightly lower concentrations than the ones ranked fair. P8 was ranked poor and had a char concentration of 2.7 particles/mm2. Only 3 houses that ranked moderately good had 0 char particles or were not discovered.

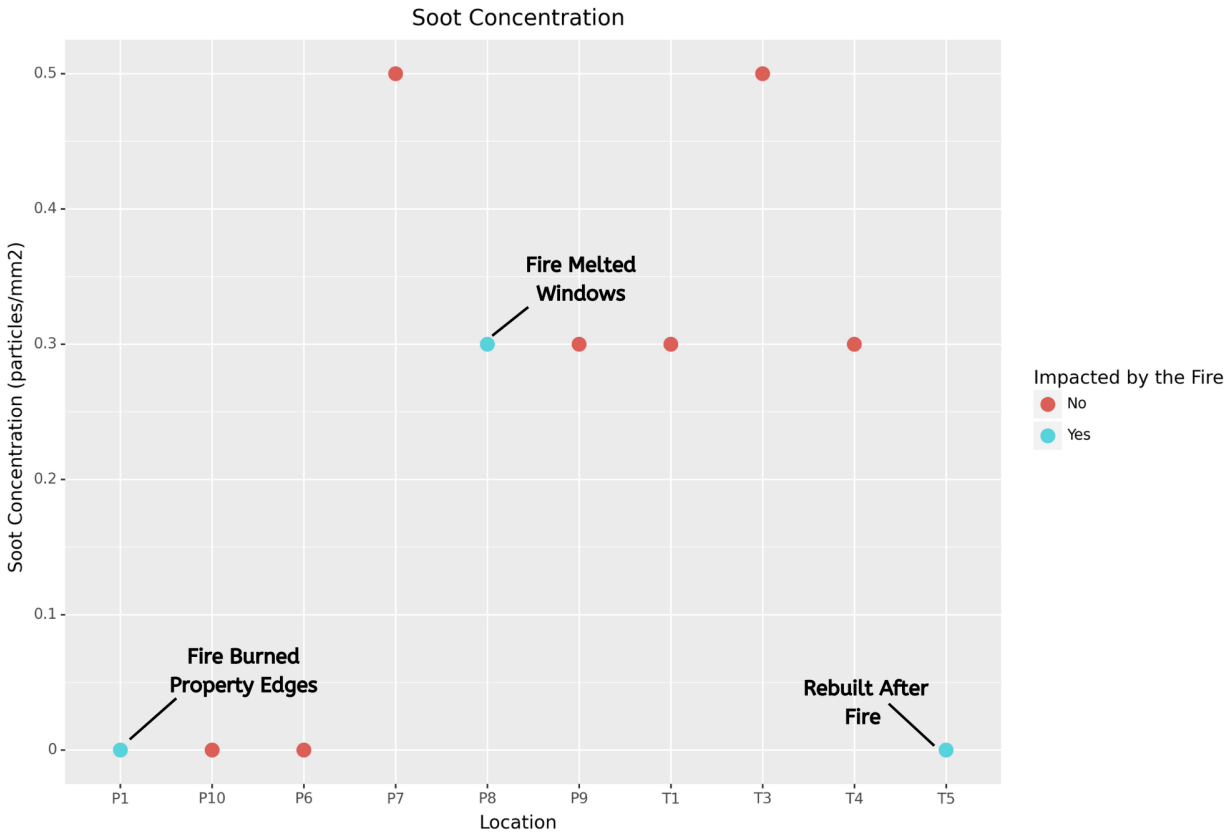


Figure 17. Graph comparing the soot concentrations tested in each house to the impact the fire had on the houses.

Figure 17 shows the graph of all the soot concentrations found in homes and if the homes were impacted by wildfire. The soot particle size is denoted in particles/mm2. P1 which was impacted by wildfire had zero concentrations of soot or the soot particles were not discovered. Houses that were not impacted by wildfire reported some soot concentrations of 0.3 to 0.5 particles/mm2. T5 was impacted by wildfires but their house was rebuilt hence no soot concentration was found.

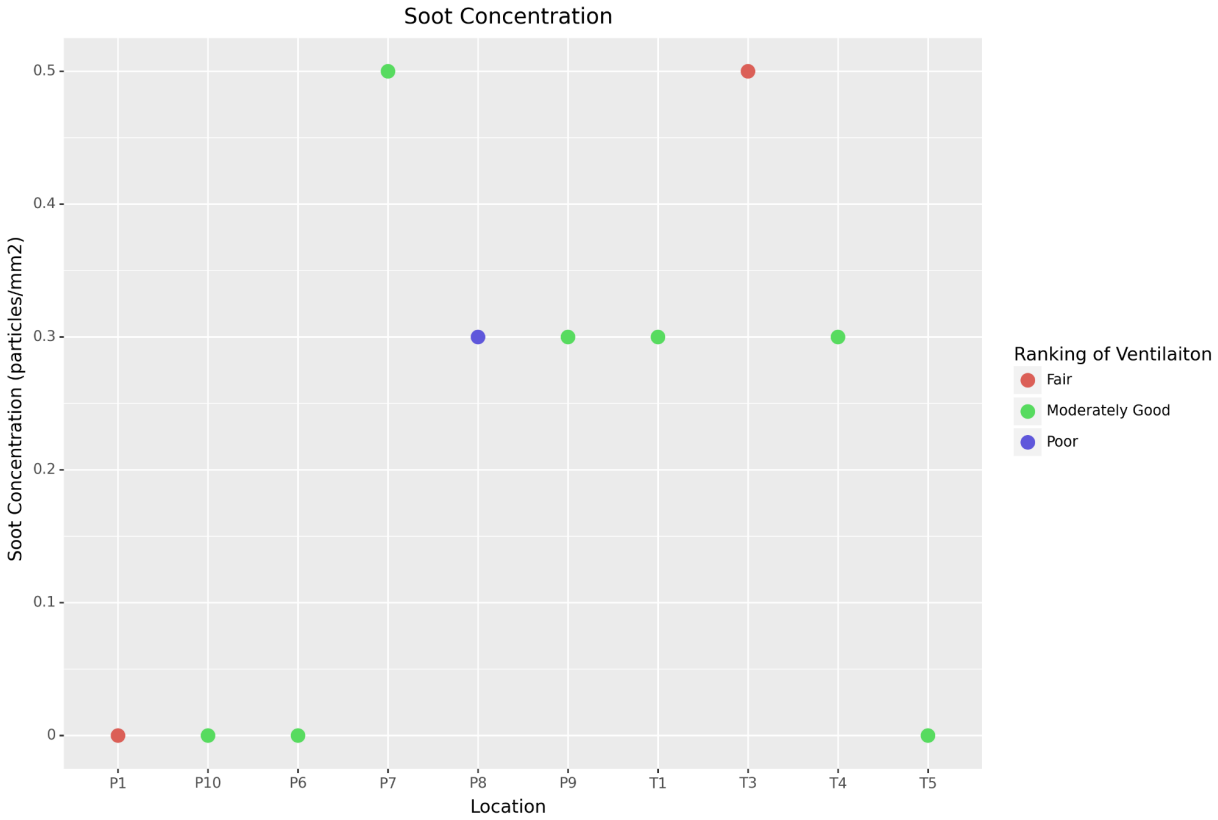


Figure 18. Graph comparing the char concentrations tested in each house to the ranking of ventilation.

Figure 18 shows the graph of all the soot concentrations found in homes and if the homes were impacted by wildfire. The soot particle size is denoted in particles/mm2. P7 and T3 are where the highest concentration of soot was 0.5 particles/mm2. Houses that were ranked moderately good have slightly lower concentrations than the ones ranked fair. P8 was ranked poor and had a soot concentration of 0.3 particles/mm2. Only 3 houses that ranked moderately good had zero char particles or they were not discovered. Houses that ranked moderately good had a soot concentration of 0.3 particles/mm2.

Brief Observations on the Soot Study

Soot particles were the primary focus of this study but the lab was also able to analyze char and ash particles from the samples collected. The overall observation was that ash particles were only found in 2 houses, while char was present in 7 houses and soot particles were present in 6 houses out of 10. There was a pattern of houses with poor and fair ventilation where the home was impacted or damaged by the fire. Overall, this could have increased the likelihood of these houses experiencing any concentrations of toxic residue left over from the wildfire.

Overview of Findings

The focus of this study was to understand how healthy the indoor air quality is on poor outdoor air quality days. Traditionally, people have been told to stay indoors in the event of poor air quality. Though, the study of indoor air quality tends to be overlooked in the study of exposure to air pollutants. Studies must consider how the infiltration of outdoor air pollutants impacts the quality of indoor air in people's homes. The American Lung Association stated in a 2022 report that the Medford-Grants Pass Metro area is rated in the top five cities in the United States for worse air quality.[5] The risk of particulate matter affecting people's health during wildfire days can cause ever-lasting health consequences such as mortality, respiratory morbidity, asthma, etc.

From the findings, one can observe that the overall indoor AQI for all houses was higher than the outdoor. The highest Indoor AQI was 298 for the T1 house. P2 had a build quality rating as excellent and the indoor AQI was recorded 9 times above 100 AQI. On the other hand, P5 rated the build quality as fair, and the indoor AQI was recorded 52 times above 100 AQI. P2 had fewer reports of unhealthy indoor quality compared to P5. The build quality of the home may have a relationship with the increase in indoor air quality readings of PM 2.5 in the homes. Other factors to consider include the time at which cooking occurred, the type of air ventilation in the home, and the use of a fireplace. There are parallel patterns between the trends of PM 2.5 for indoor and outdoor air quality monitors. A region that is prone to have many unhealthy air quality days from wildfires, it is important local and state governments should help residents invest in indoor air purifiers to improve indoor air quality and the health of the living in the Rogue Valley.

Soot testing looked at the concentrations of ash, char, and soot in the house to look at potential toxic residues that were left as residuals from the fire. It is essential to improve our understanding of exposure to Particulate Matter 2.5 in residences because of associated health risks. Wildfire smoke comprises a complex mixture of gasses and fine particles produced when wood and other organic materials burn. The biggest health threat from smoke is from fine particles. Fine particles also can aggravate chronic heart and lung diseases - and even are linked to premature deaths in people with these conditions

In the Ash concentration analysis, one can see that homes that were affected by wildfire did have the presence of all three analysts, ash, char, and soot. One can also observe that T5 was a rebuilt home after the wildfire, hence it is likely that there were no concentrations of ash, char or soot found. This house rated its ventilation to be moderately good which can be another factor to consider for not having any particles of ash, char, and soot. Homes where soot concentrations

[5] *Most Polluted Cities . State of the Air*. (n.d.). https://www.lung.org/research/sota/city-rankings/most-polluted-cities

were found, were not affected by the wildfire. Another observation was that T3 ranked its house ventilation fair. Soot and char concentrations for T3 were the highest. This home was also not impacted by the wildfire. The house ventilation being poor could be a factor for a high concentration of particles. P8 was a house that was impacted by fire, had concentrations of ash, char, and soot present, and had a poor ventilation ranking. There was a pattern of houses with poor and fair ventilation where the home was impacted or damaged by the fire. Overall, this could have increased the likelihood of these houses experiencing any concentrations of toxic residue left over from the wildfire.

Suggestions for further research include:

- Consider working on this study over a longer period and ask participants to track their daily activities, such as cooking or burning wood furnaces (this could have been recorded and reflected in the data).
- Conducted further statistical analysis to understand the statistical significance of the study.
- Focus on doing a pilot study when wildfire season is much more prominent and the Phoenix-Talent area is experiencing more poor air quality days.
- Compare air quality to EPA-grade monitors to see any patterns or smoke events or air inversions which can help rule out smokey air days.
- Conduct the soot testing within one month after a wildfire has occurred to get more conclusive results that may correlate.

Key Takeaways & Potential Outcomes

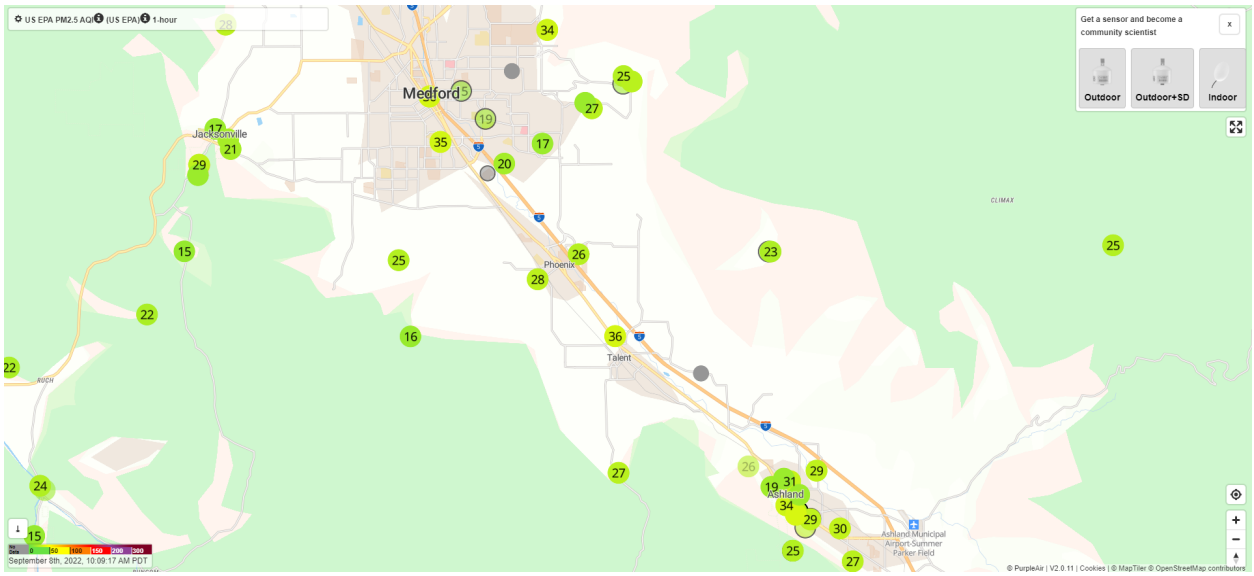
Although, there was not enough conclusive evidence to correlate worse indoor air quality in older homes with poor ventilation versus newer homes with good ventilation having better indoor air quality readings. This pilot project provided evidence to conduct more studies on the impact indoor air quality may have on people's health, especially as wildfires are becoming more frequent.

This study can be used in local efforts for Jackson County to advocate for better air ventilation or portable air filters for low-income and communities of color to minimize the risk of prolonged exposure to high PM 2.5 levels. The County should also consider building looking at how the building quality of homes could make them more resilient to climate change as wildfires are being more frequent.

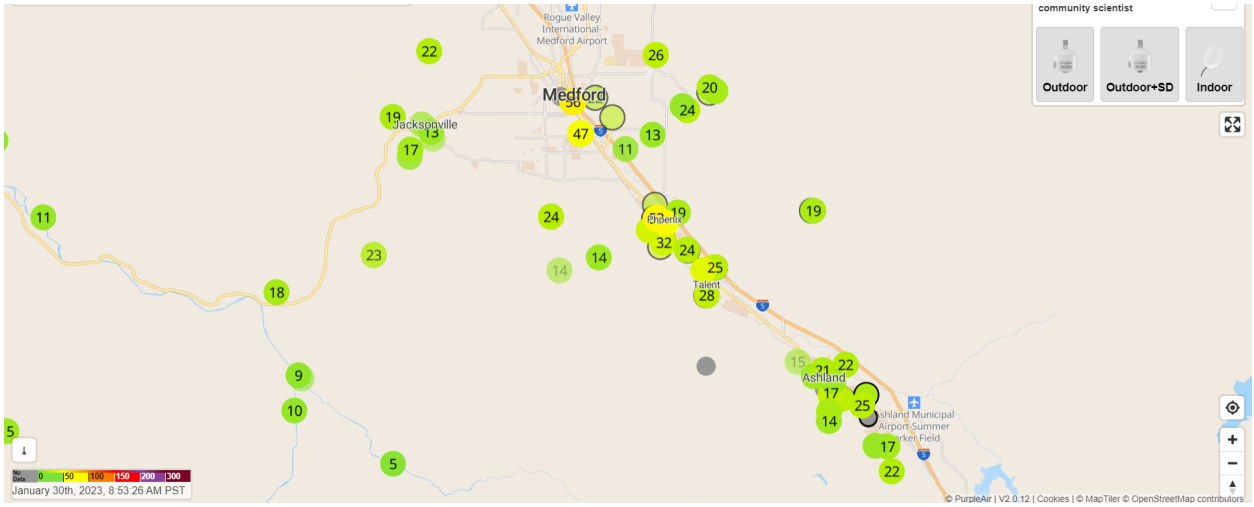
The purpose of this report is to give community members the knowledge of how to modify their behaviors to be more health-preventative during elevated events of harmful particulate

matter and toxic residuals in the home. There is an increased need for wildfire preparedness to protect public health and guide community members on preventative measures before, during, and after a wildfire.

Appendix A



Phoenix and Talent had a low concentration of Purple Air Monitors before the study.



Phoenix and Talent have a higher concentration of Purple Air Monitors than before the study.

Appendix B

Date	Address	ID Number	# of Samples	Description of the sample site.	Sample Method used	Variable	Other notes (History)
11/11/22	Colver Rd, Phoenix, OR 97535	BT_PHX_01	2 samples	On the inside corner window that is to the right of the glass sliding door at the learning center	1 tape lift 1 wipe	Impacted home	
11/11/22	Lithia Way, Talent OR 97540	BT_TAL_02	2 samples	Behind the Piano.	1 tape lift 1 wipe	Control Home	No central Air conditioning. Use Window AC. Uses Air purifiers in the house.
12/17/22	S Pacific hwy, TAL Or. 97501	BT_TAL_04	2 samples	Corner Window Sill, close to the wildfire damaged	1 tape lift 1 wipe	Impacted home	Owner had damaged window
12/17/22	Schoolhouse Rd. Talent,	BT_PHX_06	2	Underside of the	1 tape lift	Control	Visible black residue on the

	OR		samples	fan.	1 wipe	Home	underside of the fan. No central air conditioning.
12/17/22	Willow Springs, Phoenix, OR	BT_PHX_08	2 samples	Inner door frame near hinges	1 tape lift 1 wipe	Impacted home	Visible black residue was identified by the owner.
12/17/22	S Main St, Phoenix, OR 97535	BT_MED_03	2 samples	Inner door frame near hinges	1 tape lift 1 wipe	Impacted home	Visible black residue was identified by the owner.
12/17/22	S Pacific Hwy #13, Talent OR 97540	BT_TAL_05	2 samples	Inner door frame near hinges	1 tape lift 1 wipe	Impacted home	
12/17/22	N Rose St. Phoenix OR	BT_TAL_07	2 samples	Top of the door	1 tape lift 1 wipe	Control Home	Best place identified by the homeowner. The fire was close to their home
12/17/22	W 2nd Street, Phoenix, OR	BT_PHX_09	2 samples	Above water heater	1 tape lift 1 wipe	Impacted home	Visible black particles. The owner did use occasional candles. The sample was collected in a separate room
12/17/22	S Main St, Phoenix, OR 97535	BT_PHX_10	2 samples	Inner door frame near hinges	1 tape lift 1 wipe	Impacted home	Visible black residue.

Appendix C

- Laboratory Report -
Combustion By-Products
(Char, Ash, Black Carbon/Soot)

Procurement of Samples and Analytical Overview:

The samples for analysis (ten total) arrived at EMSL Analytical (Cinnaminson, NJ) on December 28, 2022. The package arrived in satisfactory condition with no evidence of damage to the contents. The purpose of the analysis is to determine the presence of combustion-by-products associated with fire residues. The data reported herein has been obtained using the following equipment and methodologies.

Methods & Equipment:	ASTM D6602-13 (Mod) AIHA Technical Guide for Wildfire Impact Investigations for the OEHS Professional Stereomicroscopy Polarized Light Microscopy (PLM) epi-Reflected Light Microscopy (RLM) Transmission Electron Microscopy (TEM)

Analyzed by: Christen Helou — January 12, 2023

Christen Helou
Assistant Laboratory Manager

Date

Reviewed/Approved by : — January 12, 2023

Eugenia Mirica, Ph.D.
Laboratory Director

Date

ACCREDITED
EMSL Cert #: 2845.01

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Customer ID:	MISC-MATS
Customer PO:	-

Attn:	***Meet Panchal***	Phone:	**(541) 543-2448**
	Beyond Toxics	Email:	**mpanchal@beyondtoxics.org**
	120 Shelton McMurphy Blvd. Suite 280		
	Eugene, OR 97401	Collected:	**11/11/2022-12/17/2022**
		Received:	**12/28/2022**
Project:	**Southern Oregon Soot Testing**	Analyzed:	**1/12/2023**

- Laboratory Report -
Combustion By-Products
(Char, Ash, Black Carbon/Soot)

Sample Description:

Ten composite samples each composed of one alcohol prep wipe and one adhesive tape lift were submitted for analysis. The purpose of the analysis was to identify the components associated with fire debris (char, ash, and black carbon/soot).

Figure 1. Image of the as-received samples

Sample Preparation Procedures:

The samples were initially observed in the as-received condition to determine the general constituency and homogeneity.

Each wipe sample was sonicated for 10 minutes in a sealable plastic vial with 10 ml iso-propanol (enough amount to cover the sample) to extract the particles in suspension. The resulting suspension was filtered onto PC filter using vacuum filtration. The particles on the filter are subjected to the light microscopy analysis. Aliquot of the suspension was drop mounted on Formvar-coated copper grid for TEM analysis.

A representative piece from each tape was cut to size for appropriate mounting for analysis by light microscopy.

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- Laboratory Report -
Combustion By-Products
(Char, Ash, Black Carbon/Soot)

Results and Discussions:

Table 1. Summary of results from wipe samples

EMSL Sample ID	*Sample ID*	*Description*	*Analyte*	*Concentration (%)*	*Comments (sample specific)*
362304275-0001	1	Window Sil - BT_Soot_PHX_01	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 2 ND 20	The opaque particles in the sample are composed of non-specific organic dust, rust, rubber dust, and mold-see Note 1.
362304275-0002	2	Behind Piano - BT_Soot_PHX_01	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 2 ND 25	The opaque particles in the sample are composed of non-specific organic dust, rubber dust, mold, and rust-see Note 1.
362304275-0003	3	Window Sil – close to wildfire	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 5 ND 30	The opaque particles in the sample are composed of rubber dust, non-specific organic dust, rust, mold, and paint-see Note 1.
362304275-0004	4	Underside of Fan	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 5 ND 25	The opaque particles in the sample are composed of non-specific organic dust, rust, mold, rubber dust, and paint-see Note 1.
362304275-0005	5**	Inner Door Frame - Visible Residue	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 <1 ND 85	The opaque particles in the sample are composed of rust/metal dust and non-specific organic dust-see Note 1.

LOQ: 1% (VAE Method)

Note 1: The opaque/dark particles do not have characteristics typically associated with combustion-by-products.

** The wipe sample has a much lower particle loading than the corresponding tape lift (see table 2 page 5).

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- Laboratory Report -
Combustion By-Products
(Char, Ash, Black Carbon/Soot)

Table 1(cont.). Summary of results from wipe samples

EMSL Sample ID	*Sample ID*	*Description*	*Analyte*	*Concentration (%)*	*Comments (sample specific)*
362304275-0006	6	Inner Door Frame - Visible Residue	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 <1 ND 90	The opaque particles in the sample are composed of rust/metal dust and non-specific organic dust-see Note 1.
362304275-0007	7	Inner Door Frame - Visible Residue	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 1 ND 20	The opaque particles in the sample are composed of rust, non-specific organic dust, rubber dust, mold, and paint-see Note 1.
362304275-0008	8	Top of Door – dust Residue	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 2 ND 35	The opaque particles in the sample are composed of aerosolized paint, non-specific organic dust, rust, mold, and rubber dust-see Note 1.
362304275-0009	9	Top of the heater – Visible black residue	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 2 ND 20	The opaque particles in the sample are composed of non-specific organic dust, paint, rust, and mold-see Note 1.
362304275-0010	10	Inner Door Frame – Visible Residue	Black Carbon (Soot) Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	<1 <1 ND 90	The opaque particles in the sample are composed of rust/metal dust-see Note 1.

LOQ: 1% (VAE Method)

Note 1: The opaque/dark particles do not have characteristics typically associated with combustion-by-products.

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- Laboratory Report -
Combustion By-Products
(Char, Ash, Black Carbon/Soot)

Table 2. Summary of results from adhesive tape lift samples

EMSL Sample ID	*Sample ID*	*Description*	*Analyte*	*Concentration (particles/mm²)*	*Concentration (%)*	*Comments (sample specific)*
362304275-0001	1	Window Sil - BT_Soot_PHX_01	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	ND 3.0 0.8 45.9	ND 2 <1 30	The opaque particles in the sample are composed of rust, non-specific organic dust, rubber dust, aerosolized paint, mold, and coal tar-see Note 1.
362304275-0002	2	Behind Piano - BT_Soot_PHX_01	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	0.3 4.9 ND 68.4	<1 5 ND 25	The opaque particles in the sample are composed of non-specific organic dust, mold, rust, rubber dust, and paint-see Note 1.
362304275-0003	3	Window Sil – close to wildfire	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	0.3 2.7 0.5 13.2	<1 2 <1 10	The opaque particles in the sample are composed of rust, non-specific organic dust, mold, and paint-see Note 1.
362304275-0004	4	Underside of Fan	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	0.5 6.3 ND 147.0	<1 5 ND 35	The opaque particles in the sample are composed of rust, non-specific organic dust, rubber dust, mold, and paint-see Note 1.
362304275-0005	5**	Inner Door Frame -Visible Residue	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	- - - TNTC	<1 <1 ND 95	The opaque particles in the sample are composed of rust/metal dust and aerosolized paint-see Note 1. The elemental composition of the dark particles in the sample was verified by SEM/EDX.

LOQ: 0.3 particles/mm² (counting method); 1% (VAE Method)

* Black Carbon/Soot analysis is limited to presumptive analysis only. In order to resolve the submicron size and the aciniform morphology of the particles confirmatory analysis by Transmission Electron Microscopy (TEM) is needed, which cannot be applied to this media.

TNTC = Too Numerous to Count (the concentration by count method could not be applied due to particle overload and overlapping).

Note 1: The opaque/dark particles do not have characteristics typically associated with combustion-by-products.

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- Laboratory Report -
Combustion By-Products
(Char, Ash, Black Carbon/Soot)

Table 2(cont.). Summary of results from adhesive tape lift samples

EMSL Sample ID	*Sample ID*	*Description*	*Analyte*	*Concentration (particles/mm²)*	*Concentration (%)*	*Comments (sample specific)*
362304275-0006	6	Inner Door Frame -Visible Residue	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	- - - TNTC	<1 <1 ND 95	The opaque particles in the sample are composed of rust/metal dust, paint, and non-specific organic dust-see Note 1.
362304275-0007	7	Inner Door Frame -Visible Residue	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	0.3 2.5 ND 69.0	<1 2 ND 35	The opaque particles in the sample are composed of rust/metal dust, non-specific organic dust, rubber dust, mold, and paint-see Note 1.
362304275-0008	8	Top of Door – dust Residue	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	0.5 4.7 ND 112.4	<1 5 ND 35	The opaque particles in the sample are composed of aerosolized paint, rust, non-specific organic dust, and mold-see Note 1.
362304275-0009	9	Top of the heater – Visible black residue	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	0.3 2.5 ND 47.5	<1 2 ND 25	The opaque particles in the sample are composed of rust/metal dust, paint/aerosolized paint, non-specific organic dust, and mold-see Note 1.
362304275-0010	10	Inner Door Frame – Visible Residue	Black Carbon (Soot)* Carbonized Material (Char) Carbonized Material (Ash) Opaque/Dark Particles	- - - TNTC	<1 <1 ND 95	The opaque particles in the sample are composed of rust/metal dust-see Note 1.

LOQ: 0.3 particles/mm² (counting method); 1% (VAE Method)

* Black Carbon/Soot analysis is limited to presumptive analysis only. In order to resolve the submicron size and the aciniform morphology of the particles confirmatory analysis by Transmission Electron Microscopy (TEM) is needed, which cannot be applied to this media.

TNTC = Too Numerous to Count (the concentration by count method could not be applied due to particle overload and overlapping).

Note 1: The opaque/dark particles do not have characteristics typically associated with combustion-by-products.

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- Laboratory Report -
Combustion By-Products
(Char, Ash, Black Carbon/Soot)

Terms and Definitions:

None Detected (ND): absence of an analyte in the subsample analyzed. Trace levels of the analyte may be present in the sample below the limit of quantitation (LOQ).

Limit of Detection (LOD): minimum concentration that can be theoretically achieved for a given analytical procedure in the absence of matrix or sample processing effects. Particle analysis is limited to a single occurrence of an analyte particle in the sub-sample analyzed.

Limit of Quantitation (LOQ): minimum concentration of an analyte that can be measured within specified limits of precision and accuracy during routine laboratory operating conditions

Trace concentration: denotes the presence of an analyte above LOD but below LOQ. When results are reported as Trace Concentration, at least one particle was detected in the collection of particles that represents the sample.

Concentrations for bulk samples are derived by Visual Area Estimation (VAE) unless otherwise noted. Air sample concentrations are calculated to particles per unit volume. VAE technique estimates the relative projected area of a certain type of particulate from a mixture of particulate by comparison to data derived from analysis of calibration materials having similar texture and particulate content. Due to bi-dimensional nature of the measurements, in some cases the particle thickness could affect the results.

Black Carbon (Soot): submicron black powder generally produced as *an unwanted by-product of combustion or pyrolysis*. It consists of various quantities of carbonaceous and inorganic solids in conjunction with adsorbed and occluded organic tars and resins; it commonly has a spherical to pseudo-spherical (aciniform) morphology. Examples of soot are carbon residues from diesel and gasoline engines, industrial flares, sludge pits, candles, and plastics.

Carbon Black: *an engineered material*, primarily composed of elemental carbon, obtained from the partial combustion or thermal decomposition of hydrocarbons, existing in the form of aggregates of aciniform morphology which are composed of spheroidal primary particles characterized by uniformity of primary particle sizes within a given aggregate and turbostratic layering within the primary particles.

Char: particulate larger than 1 µm made by incomplete combustion which may not de-agglomerate or disperse by ordinary techniques, may contain material which is not black, and may contain some of the original material's cell structure, minerals, ash, cinders, and so forth

Ash: residue left after complete carbonization of the material. It does not maintain its original form. Wood ash contains calcium carbonate as its major component. It also contains potash, phosphate; there are trace elements of iron, manganese, zinc, copper and some heavy metals. The concentrations vary depending on the combustion temperature and wood type.

Carbonized material (char and ash) are analyzed using optical microscopy (epi-reflected and polarized light microcopy). The samples are analyzed for traits such as color, size, morphology, evidence of cellular morphology.

Typically, all the particles that are extracted from the as-received sampling media are considered as part of the sample when deriving the concentrations. Therefore, due to regular environmental dust accumulation, the concentrations of the combustion by-products present in a certain area will diminish in time even if no remediation/cleaning were involved.

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Annex: Micrographs of the analytes of interest in samples:

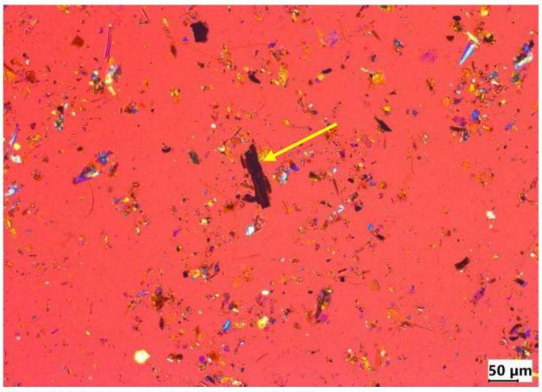

Figure 2: PLM image of char in sample "1"

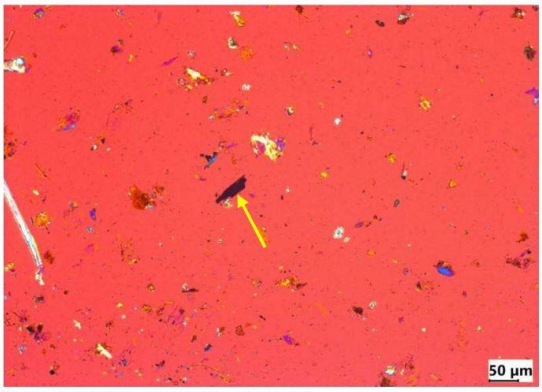

Figure 3: PLM image of char in sample "2"

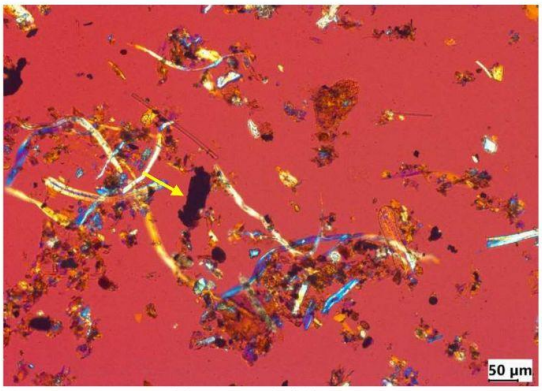

Figure 4: PLM image of char in sample "3"

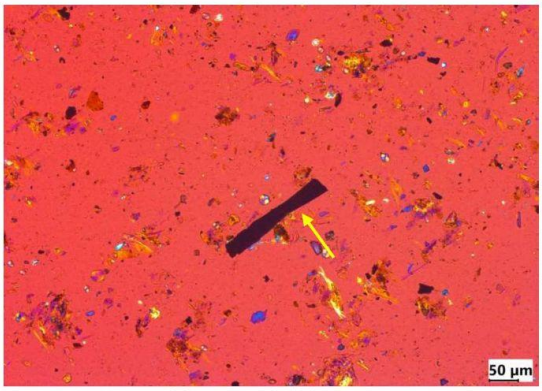

Figure 5: PLM image of char in sample "4"

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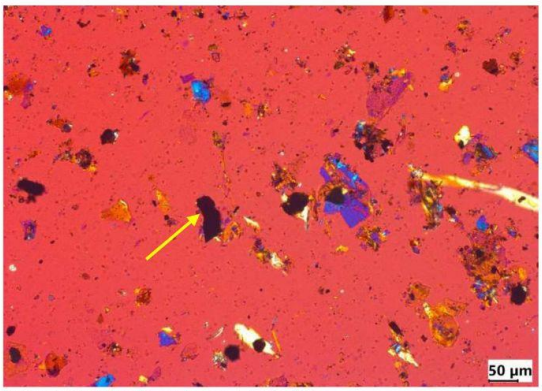

Figure 6: PLM image of char in sample "7"

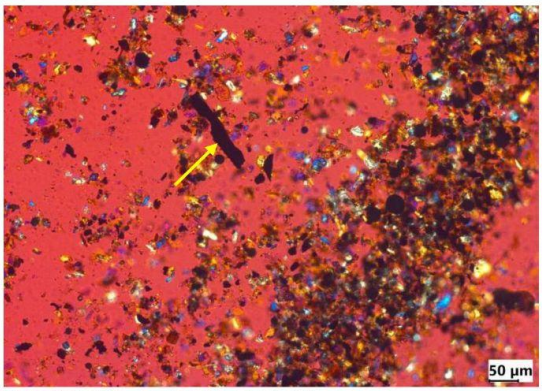

Figure 7: PLM image of char in sample "8"

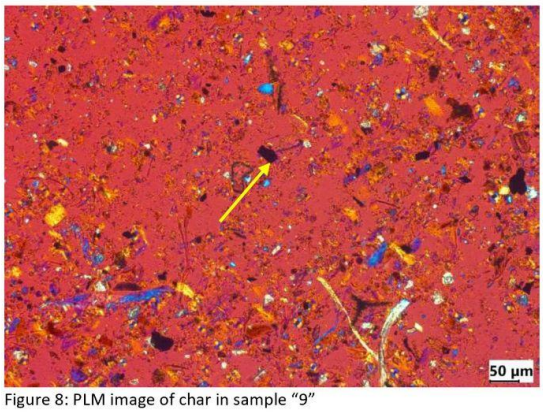

Figure 8: PLM image of char in sample "9"

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Annex.
Typical micrographs of the analyses of interest in Combustion-by-Products analysis and the most common interferences (stock pictures, not project specific)

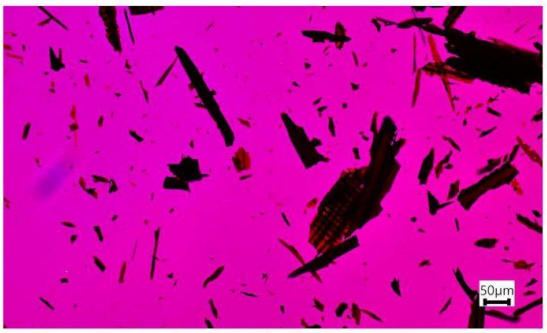

Figure A. PLM image of vegetative char

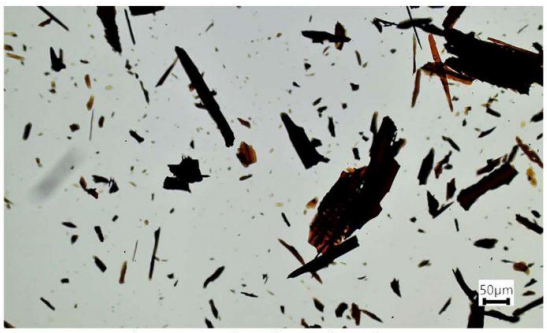

Figure B. Image of vegetative char, plane polarized

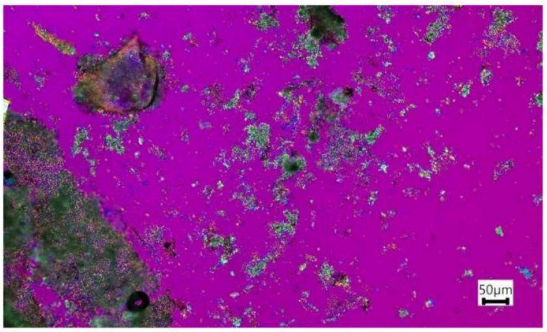

Figure C. PLM image of vegetative ash

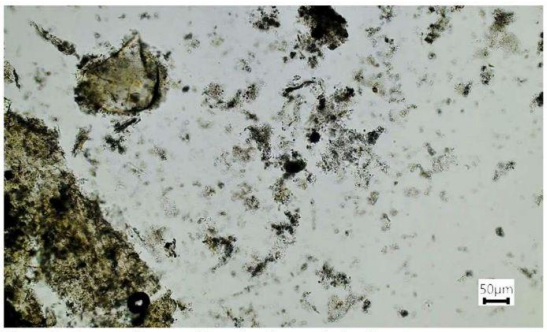

Figure D. Image of vegetative ash, plane polarized

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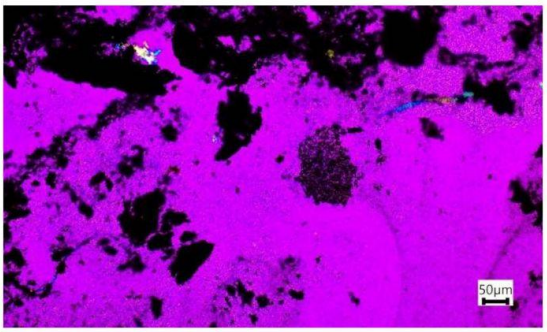

Figure E. PLM image of soot/black carbon

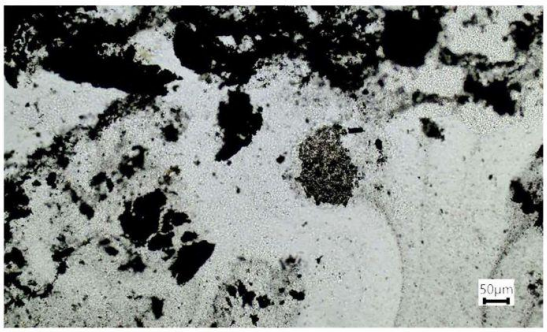

Figure F. Image of soot/black carbon, plane polarized

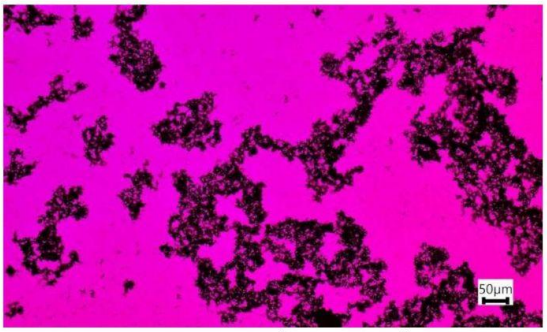

Figure G. PLM image of carbon black (CAS 1333-86-20); differentiation from soot/black carbon is done by TEM analysis only

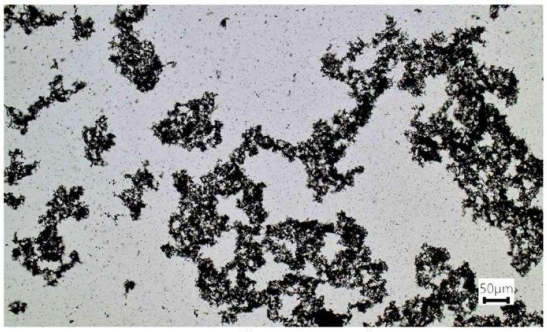

Figure H. Image of carbon black (CAS 1333-86-20), plane polarized

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Figure I. PLM image of soot/black carbon deposits on paper fibers

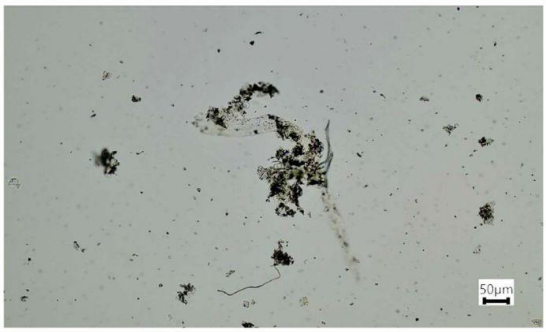

Figure J. Image of soot/black carbon deposits on paper fibers, plane polarized

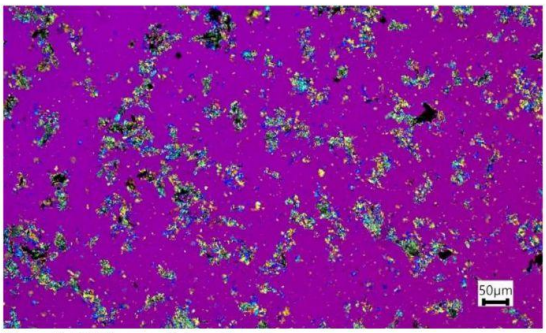

Figure K. PLM image of cigarette ash

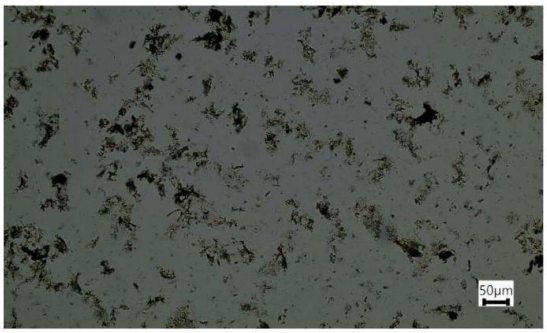

Figure L. Image of cigarette ash, plane polarized

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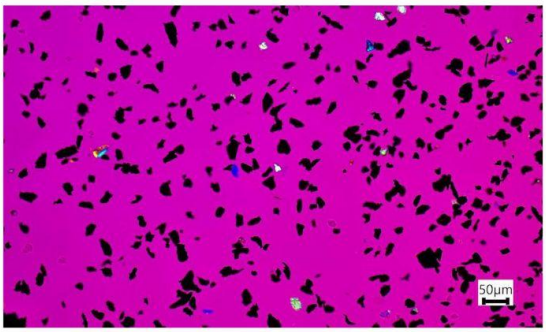

Figure M. PLM image of crumb rubber (the dark particulate)

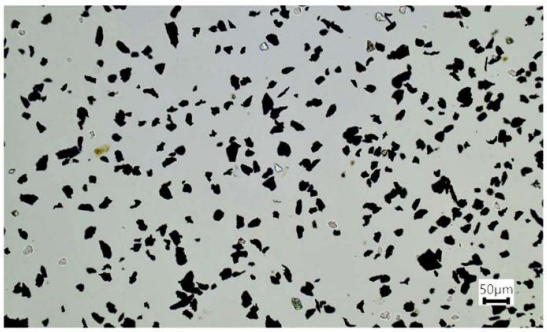

Figure N. Image of crumb rubber, plane polarized

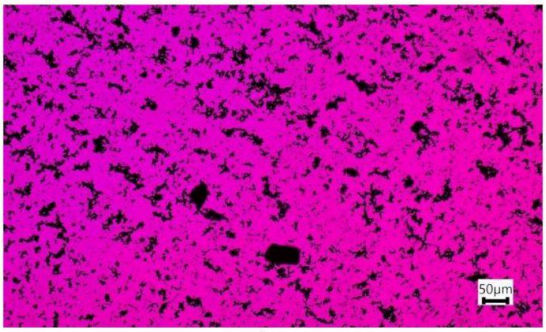

Figure O. PLM image of iron oxide/magnetite, associated with corrosion of metals (rust); note the morphological similarity to soot/black carbon and carbon black when analyzed by light microscopy alone

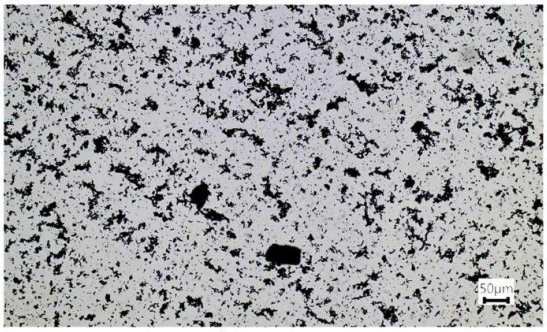

Figure P. Image of iron oxide/magnetite, associated with corrosion of metals (rust), plane polarized

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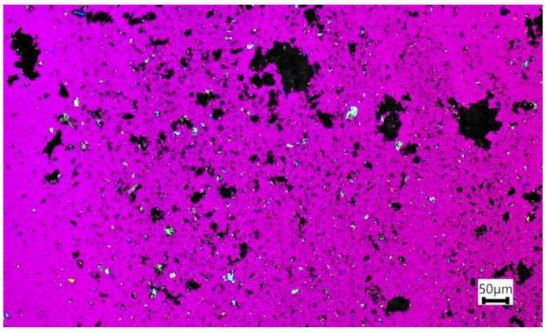

Figure R. PLM image of paint dust (the dark particulate); no soot/black carbon black is present

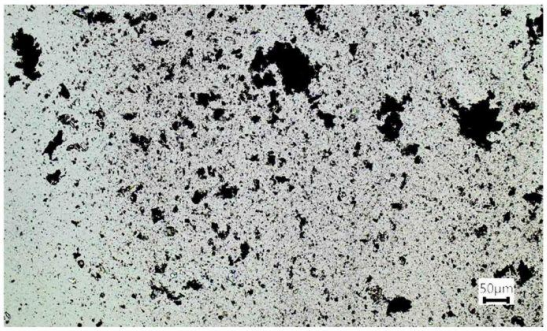

Figure S. PLM image of paint dust (the dark particulate); no soot/black carbon black is present, plane polarized

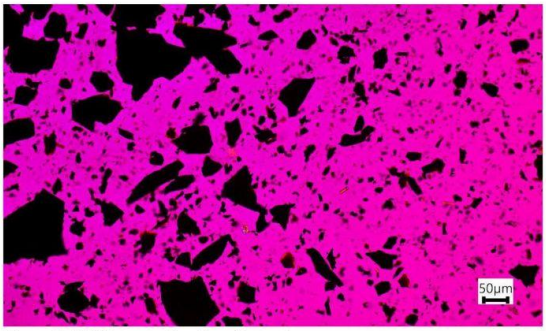

Figure T. PLM image of anthracite coal

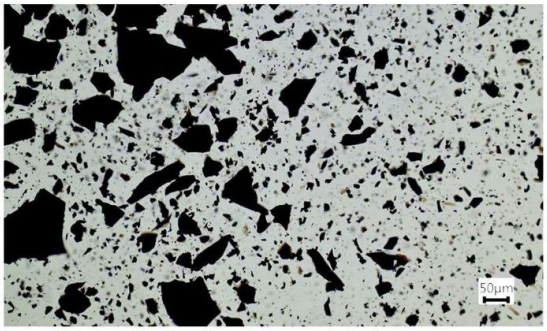

Figure U. Image of anthracite coal, plane polarized

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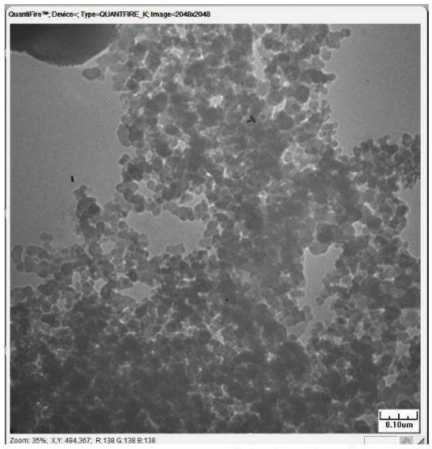

Figure V. TEM image of black carbon/soot