Evaluating the Effects of Temperature and Ozone on Particulate Matter Levels in Southeastern Michigan

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Abstract

Understanding particulate matter (PM) levels in the researcher's community is critical for informing public health decisions and raising awareness regarding potential threats to personal lung health. The research was conducted during the Summer and Fall of 2022. Data was collected daily on ground-level ozone, particulate matter (PM2.5), surface temperature, and air temperature. Crestwood's PurpleAir device and the handheld PocketLab Air was used to determine particulate matter levels. Ground-level ozone was also collected using the Pocketlab Air sensor. The surface temperature was obtained with an infrared thermometer, and the air temperature was recorded using Crestwood's WeatherBug weather station. PM data collected with the Pocketlab Air sensor were compared to data with the PurpleAir device. In addition, the researchers recorded real-time data from three different locations in Michigan using PurpleAir levels. These locations included Detroit, Livonia, and Oak Park. Observing the results through different seasons allowed the researchers to conclude that PM2.5 data from PocketLab Air and PurpleAir appear to positively correlate with changes in temperature and ozone. Reducing ground-level ozone and particulate matter levels can decrease potential health risks and permit athletes to continue enjoying their sport without adverse health complications.

Introduction

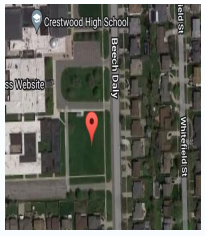
The location of this research was on Crestwood High School's band practice field (Dearborn Heights, MI). As many students do heavy breathing exercises in high temperatures, the potential effects of high PM2.5 and ground-level ozone become increasingly concerning. Examples of these according to the CDC are dust, tobacco smoke, soot, and industrial emissions (National Center for Environmental Health 2023). Previous email discussions with Dr. Margaret Pippen of NASA indicated that the current GLOBE protocol for ozone is not very reliable and she suggested not using it. Current outdoor ozone monitors are expensive and not affordable to use in school research. Ground-level ozone can be created in communities upwind and then brought to the community via variable prevailing Southwesterlies. Ground-level ozone pollution is formed from photochemical reactions in the presence of sunlight and heat. Crestwood's study site is very close to industries such as the Ford Motor Company and Marathon oil refinery. Depending on the wind direction, air emissions from these can move harmful emissions towards the school.

Although both ground-level ozone and particulate matter are criteria air pollutants monitored by the Environmental Protection Agency, levels often reach concerning rates in the community. Those with health issues, such as lung problems or hypertension, can be most at risk (Sinkemani, Li, and Chen). Unlike larger pollution, the tiny PM2.5 can easily make their way into deep parts of the lungs or blood. These issues include, "irregular heartbeat, aggravated asthma, decreased lung function, and irritation of the airways" (Environmental Protection Agency 2022).al effects of high PM2.5 and ground-level ozone become increasingly concerning.

Null Hypothesis

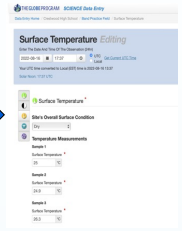
1. There is no significant correlation between PM2.5 with air and surface temperature.
2. There is no significant difference in PM2.5 across a variety of locations in Michigan.
3. There is no significant correlation between ozone and PM2.5 levels.
4. There is no significant difference between PM2.5 taken from the PocketLab Air device and the PurpleAir device.

Methodology

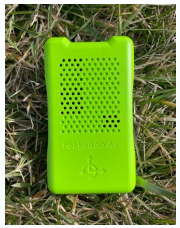


This image is a satellite picture of Crestwood High School's band practice field

A student researcher holds up the infrared thermometer.



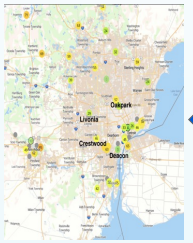
Data being input on the GLOBE website of surface temperature data.



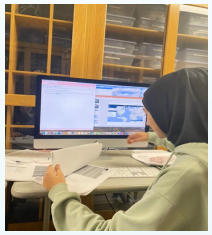
The PocketLab Air device used to take PM2.5 and ground-level ozone measurements.

The student researchers read the PM2.5 and surface temperature data.

A screenshot from the PocketLab Air app displays ozone(to the left) and PM2.5(to the right).



Purple air measurements of PM2.5 at the four southeastern research sites.



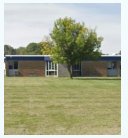
The student researcher inputs data into the GLOBE website.

Discussion

Data from the PurpleAir device and PocketLab were consistent with data obtained through WeatherBug and the Michigan Department of Environmental Quality. On days of high ground-level ozone, the PM levels also rose. The relationship between the two implies that they fluctuate according to similar weather phenomena, such as ambient air and surface temperature. The amount of PM2.5 collected from the PurpleAir device compared to the PocketLab Air data shows positive correlation. However, the PocketLab Air device tends to have lower results. When the researchers analyzed the level of PM2.5 from each site, side-by-side comparisons concluded that the locations had similar results. The positively correlated graph comparing all areas indicates that atmospheric conditions affect PM. One possible source of error in the researcher's investigation was the update on the PocketLab app on the mobile device. In the middle of the study, an update on PocketLab caused some confusion. Another possible source of error is the unknown conditions at each research location. Different circumstances can affect the sensor's ability to provide accurate results. A final possible source of error in this investigation is not allowing the PocketLab Air to acclimate long enough to the outside weather conditions.

Conclusion

The data collected at the research locations revealed that surface and air temperature are positively correlated to ozone and PM2.5 levels. The researchers were able to compare two datasets because they had PocketLab data in addition to PurpleAir. Although our particulate values did vary between the PocketLab PurpleAir devices, the differences were consistent. The researchers believe that PM2.5 counts taken by the PurpleAir are more accurate and precise. When ozone action days were not present, the PocketLab reported high ground-level ozone. While this was not always the case, it led the researchers to conclude that the PocketLab Air device is better suited for PM rather than ozone measurements. It is essential to research PM and ozone as they are two of the six criteria for air pollutants regulated by the Clean Air Act. Because all four study sites are near schools and public parks, students should be aware of the high levels. Workouts and practice times can be adjusted or canceled by informing coaches. According to research on ground-level ozone and particulate matter health impacts, "exposure to elevated concentrations of ozone is associated with increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma," and other respiratory illnesses (Kristie L.Ebi and Glenn McGregor). In the future, the researchers hope to work with multiple cities around Michigan to bring awareness and understand the causes of PM and ground-level ozone.



Acknowledgements/Bibliography

Thank you to Crestwood High School's GLOBE advisor, Mrs. Diana Johns for always being available to answer any questions when needed as well as other resources to help better our investigations. Also, a special thank you to the GLOBE Mission Earth project that provided equipment used in the research. To add, another thank you to Dr. Margaret Pippen of NASA, whose previous emails to the researcher's teacher helped guide the researchers in choosing suitable protocols to follow in the research.

Results

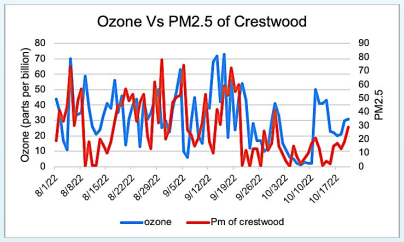


Figure 1: Crestwood High School's particulate matter levels indicate a positive correlation with ozone levels. As ozone increases, so does PM2.5.

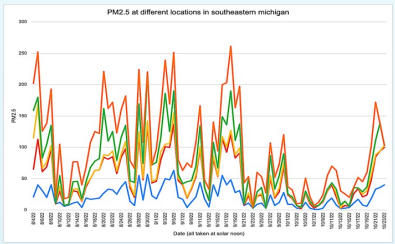


Figure 2. PM2.5 data at the four (4) research sites taken from PurpleAir and Pocketlab Air being compared on the same dates at solar noon.

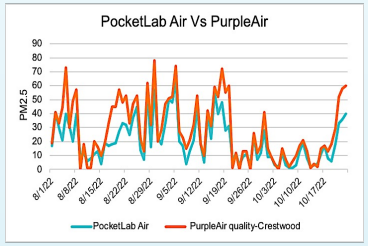


Figure 3. PM2.5 at Crestwood on the PurpleAir device vs. the PocketLab device seem to have a very close relationship.

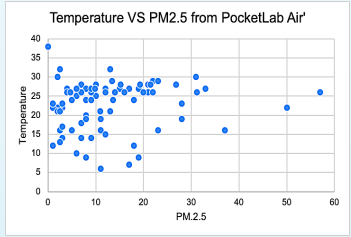


Figure 4. Temperature in comparison to PM2.5 using a PocketLab Air. These characteristics are positively correlated, as the temperature increases so does the PM2.5

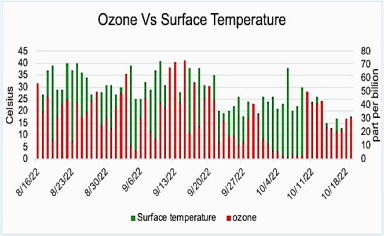


Figure 5. The surface temperature taken from an infrared thermometer in comparison to ozone shows a positive correlation. As the surface temperature increases, so does the ozone levels.