Movement of Pollution Based on The Mountain Chimney Effect

INTRODUCTION

Pollution continuously flows in the atmosphere. Black carbon and particulate matter make up a good portion of the pollution created and released into the atmosphere. These pollutants negatively impact the air quality, the climate, and our health. Its levels are higher in industrial cities compared to towns and rural areas. There is a hypothesis that states the flow of these pollutants changes direction with the time of day so in order to test that, data was collected from the mountain range, in one of the biggest cities in Bolivia, to track and measure the flow of these pollutants for 24 hours. This hypothesis is called the Mountain Chimney Effect, which is a phenomenon where solar heating on the slopes leading up to a higher elevation creates a region of heated, less dense air that tends to flow uphill. Conversely, overnight colder air can travel downslope. To attempt to measure this
effect, there were 5 locations where low cost atmospheric sensors were located at different elevations collecting data simultaneously. This research was important because it tracked the flow of pollutants and their amount. This research could also help with finding ways to reduce the amount of black carbon and particulate matter released into the atmosphere.

The goal of the project was to use data collected by the Bolivia Campaign to test the Mountain Chimney Effect and track the flow of pollutants as it pertains to the Mountain Chimney Effect. Due to this project's nature, statistical tests cannot be performed. This project could be applied to many aspects of research involving pollutants and its connection to climate change. The goal of this project and the problem identified were similar as they both focused on the movement of pollutants between the earth's surface and atmosphere.

It has been hypothesized that any existing pollutants available will be transported toward the summit following the Mountain Chimney Effect. The assumption for this project was that data collection started before sunrise, and wind speed and direction did not affect the data collection process.

Picture of Mount Chacaltaya is La Paz, Bolivia. This is the location where the data for this project was collected.
https://dnwsite.weebly.com

METHOD

The atmospheric data were collected on July 26, 2023 and were used for this project. To collect the data, many low cost sensors were used. To properly track the Mountain Chimney Effect, five stations along a canyon leading to Mount Chacaltaya collected data simultaneously.

For this project, the data served as a material since the researcher did not collect the data. With the type of data collected, an application called Mathematica was used to analyze the data. The projected collected data that covered the concentration of pollutants, solar radiation, and measured the speed and direction of the wind on one day.

Preparing Data

1. Opened the data file on Microsoft Excel and created a new document was on Mathematica.
2. Uploaded the data file was to the empty document and the document was saved.

Graphing Data

1. Used various functions, such as the Transpose function, Import function, and the DateListPlot function, to create the graphs.
2. Analyzed the graphs to determine whether the data aligns with the Mountain Chimney Effect or not.

ACKNOWLEDGEMENTS

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Kendra Nketsiah

FINDINGS

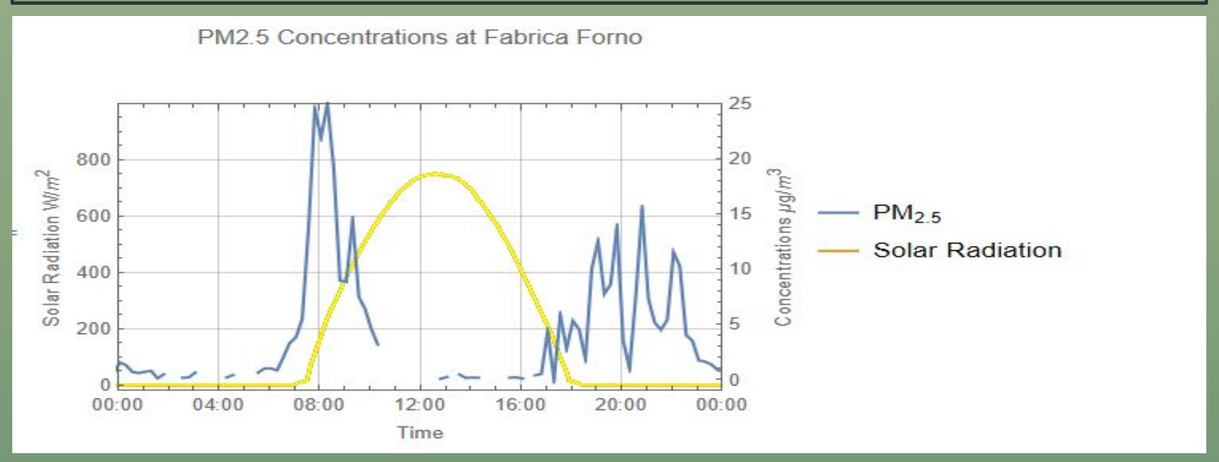
The Campaign data was collected only once, so there were no factors to compare nor to conclude any correlation. If the data was collected multiple times, there would be too many outside factors that could affect the data. Therefore, there was no statistical test used to determine correlation and statistical significance.

The first graph presented the PM2.5 concentrations and solar radiation levels through the day on July 26th, 2023. The measurements were acquired at Fabrica

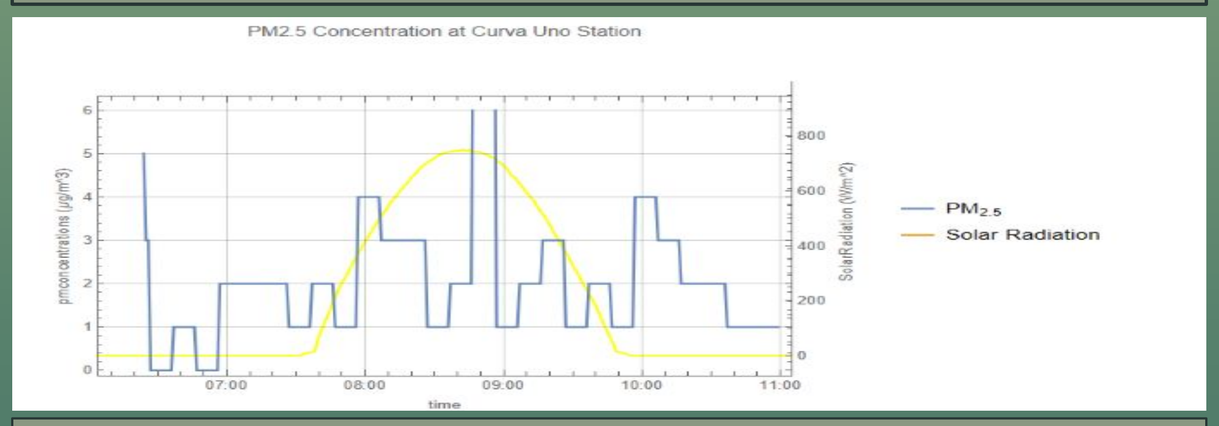
Forno, which is a station near the base of the mountain and closer to the city of La Paz compared to the other 4 stations. It was shown that the peak of the sun's radiation was around the early afternoon hours and the high points of PM2.5 were around the early morning and late in the evening. Based on the graph, PM2.5's lowest points occurred during the sun solar radiation's peak.

The second graph presented the PM2.5 and the solar radiation levels taken from Curva Uno, one of the stations on the mountain. The solar radiation for both graphs were the same, however, the PM2.5 measurements were different. As shown, the PM2.5 levels were higher during the time the PM2.5 in the first graph is lower.

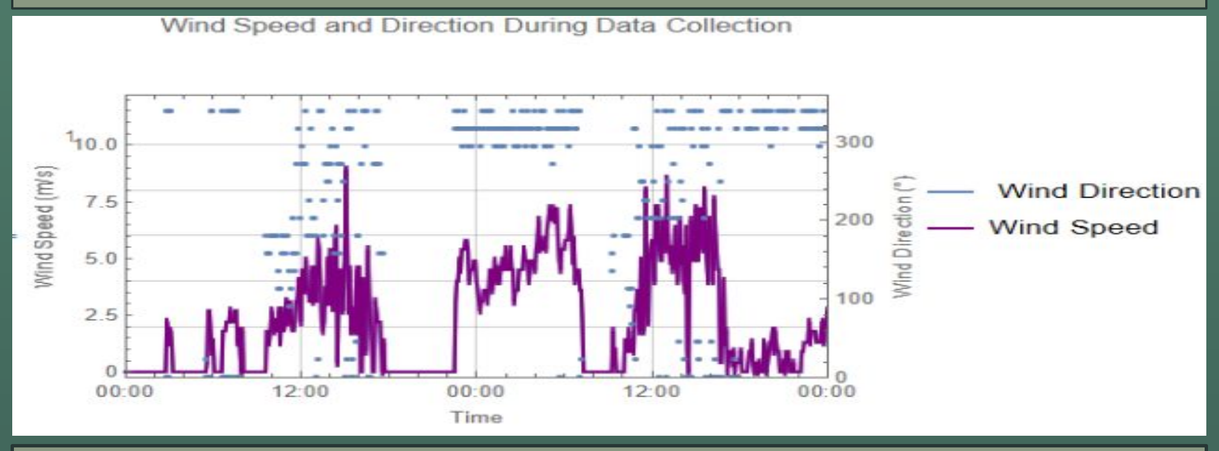
The third graph showed the wind speed and direction on the day the data for this research was collected. This graph represented how wind speed and direction constantly changed throughout the day. The graphs created by the researcher can be seen below.



This graph focused on the flow of the PM2.5 concentration as it relates to solar radiation concentration throughout the day to represent time. The solar radiation line represents the movement of the sun whereas the PM 2.5 line represents the concentration levels of PM 2.5 as a way to show its movement during the day.



This graph focused on how the flow of the PM2.5 concentration in Curva Uno relates to solar radiation concentration throughout the day to represent time. The solar radiation represents the movement of the sun during the day. The PM 2.5 line shows the concentration of PM detected at the Curva Uno station during the day.



The wind speed and direction are graphed based on the time during the day. For this project one day was selected at random. The blue lines represent direction in which the wind moved in in degrees and the wind speed , represented by the purple line is measured in m/s.

CONCLUSION

When the peaks of PM2.5 in graphs 1 and 2 were compared, it was shown that the peaks for graph 1 only occurred during sunrise and sunset, and the peaks for graph 2 mainly occurred at noon. Based on this finding, there was an evident pattern in the rise and fall of PM2.5 following the Mountain Chimney Effect. Therefore, the hypothesis stating that if the time of day in the mountains correlates with the speed of climate change, the pollutants in the atmosphere will flow up and downhill following the Mountain Chimney Effect is correct.

The main limitation identified in the project was the statistical tests. Due to the nature of the project, it was not possible to take the measurements of all the variables that influenced the given atmospheric conditions so, the experiment could not be controlled. As a result, the correlation between variables as it pertains to the Mountain Chimney Effect could not be found.

Future studies could use this to understand how pollutants makes its way to the atmosphere and affect the climate. This research could also make it easier to identify areas that emit large amounts of pollution into the atmosphere and connect it to other factors in society, so solutions can be made.