# Precipitation Chemistry : The effects of the COVID-19 Pandemic

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## Introduction

This research focuses on precipitation chemistry and the effects the COVID-19 pandemic has had on the environment. It consists of determining the concentration of anions and cations present in precipitation samples collected around the country as well as at Susquehanna University. The concentrations are being used to determine if there was a change in the concentrations due to the pandemic. It is hypothesized that there will be a difference in specific concentrations due to less transportation and industrial operations due to the lockdowns during the pandemic. The ions being studied are nitrate and sulfate, as they are primarily released into the atmosphere from the combustion of fuels, and ammonium from agricultural operations. Calcium is being studied because its source is generally wind-blown dust and is expected not to have any variation related to the pandemic.

The sites being studied are located at:

- Penn State
- The Bronx, NY
- Charleston, SC
- Dade, FL
- Susquehanna University

## Methods

Databases:
National Atmospheric Deposition Program – NADP

- Precipitation
- 263 sites across the United States
- Precipitation is collected weekly
- Analyzed in a lab using ion chromatography
- Downloadable data for the sites to be used in statistical analysis
- Data was downloaded for the years 2010-2020

Sample collection and analysis at Susquehanna University:

- Samples were collected weekly using an atmospheric deposition sampler (Figure 2)
- Ion chromatography was used to calculate concentrations of the ions in the sample (Figure 1)

Statistical analysis:

- Data was separated into two time periods
- Pre-Pandemic: January 1st – March 13th
- Initial Pandemic: March 13th – June 1st
- Two sample T-test to determine statistical significance
  - 2020 data compared to historical data for each time period
  -Significance level is set at 0.05
  -If the P-value is less than 0.05 the data is statistically significant
- Percent change was calculated from mean values

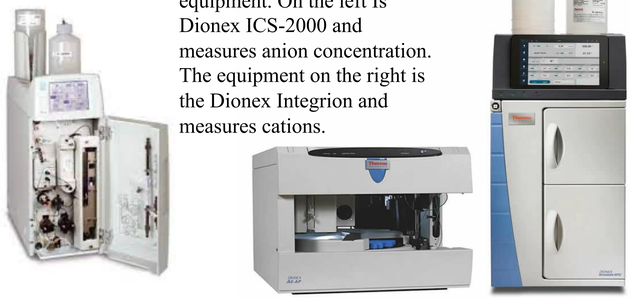

Figure 1. Ion chromatography equipment. On the left Is Dionex ICS-2000 and measures anion concentration. The equipment on the right is the Dionex Integrion and measures cations.

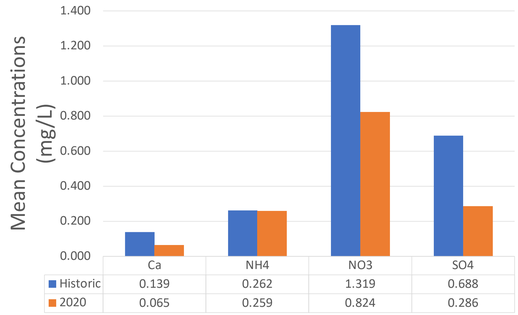


Figure 3. Graph of Penn State pre-pandemic 2020 vs. historical data from the last 10 years.

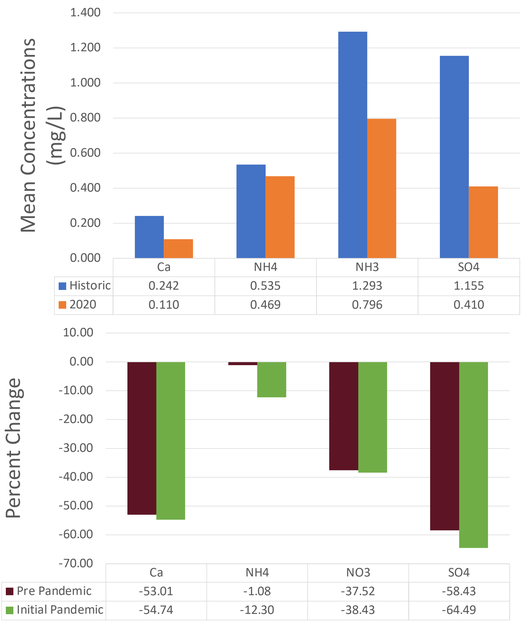


Figure 4. Graph of Penn State initial pandemic 2020 vs. historical data from the last 10 years.

Figure 5. Graph of Penn State pre-pandemic vs initial pandemic percent change.

Figure 2. Atmospheric deposition sampler used for collection of weekly precipitation samples on the campus of Susquehanna University.

## Results and Discussion

NADP / Statistical data

Figures 3,4,and 5 show results from the NADP's data from Penn State. The pre-pandemic period from January 1st – March 13th had a statistically significant decrease for Ca, $NO_3$, and $SO_4$. $NO_4$ was not statistically different. Figure 4 shows a graph of the initial pandemic period for Penn State, where a statistically significant difference was seen in Ca, $NO_3$, and $SO_4$ as well. There is no statistically significant decrease between the pre-pandemic period to the initial pandemic period; rather they were nearly the same. Figure 5 shows the percent decrease between the pre-pandemic and initial pandemic period compared to the previous 10 years.

The pre-pandemic phase for the other three sites had fewer statistically significant differences than Penn State. The Bronx had a statistically significant decreases in Ca and $SO_4$, while Dade, FL, and Charleston, SC had statistically significant decreases in just $NO_3$ during the pre-pandemic period. The initial pandemic period for the Bronx, Dade, and Charleston had no statistically significant differences for any of the ions.

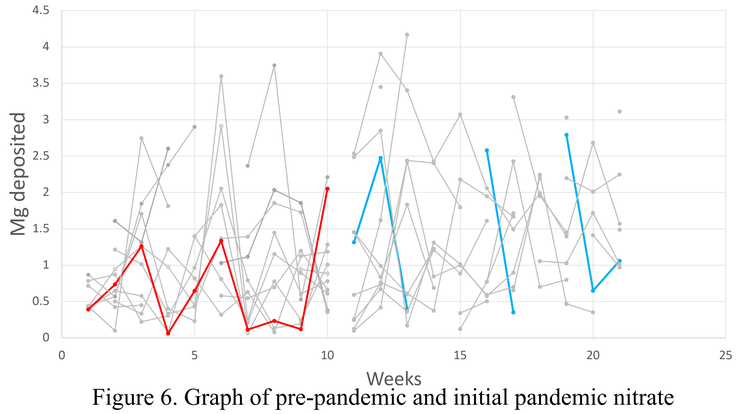


Figure 6. Graph of pre-pandemic and initial pandemic nitrate deposition. Red is pre pandemic 2020 and blue is initial pandemic 2020. The grey represents the last 10 years.

Susquehanna University Results

The precipitation collection at Susquehanna University is unique because there are no previous years of collection to compare to. The research done at Susquehanna was intended to gain a hands-on experience to how the NADP collected and analyzed their samples. The results from the sample collection could be used to compare to NADP sites; however, the lack of significant changes in the statistical analysis shows that it is unlikely a difference will be seen. The SU data from September 31st - December 4th can be used in future analysis.

## Conclusion

In conclusion, the statistical analysis for precipitation across the four NADP sites does not confirm that the COVID-19 pandemic had a significant influence on precipitation chemistry. Figure 6 provides a graph of the variation of nitrate for Penn State over the last 10 years. While some samples showed a statistically significant change, it may not be from the pandemic due to the variation that has been seen in the samples before the pandemic.

Future Work

To continue this research, the NADP will have to release the rest of the 2020 data since their data has not been updated since the end of the initial pandemic period. Another data set that can be used is the IMPROVE data set. This data is on particle chemistry and is recorded every 3 days versus the NADP's 7 day. It could show more accurate data on the emissions in the atmosphere.