The Relationship Between Cloud Formation and Precipitation pH

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Abstract

Acid rain is a growing problem, as pollution and global warming worsens. Establishing a relationship and some correlation between a more acidic precipitation and cloud formations, we can identify an acidic environment more efficiently and easily. We hypothesized that if clouds are lower in the atmosphere, such as status or cumulus clouds, then they will produce precipitation of a lower pH because a more acidic atmosphere creates less cloud formation. Data was collected over a 68-day period. Data was collected in a container, then a pH strip was placed in the liquid. After leaving the strip for 1 minute, the color was analyzed and collected with its correlating pH. While collecting the precipitation, using the National Aeronautics and Space Administration cloud analyzation chart, we recorded cloud type that day. The results over time, showed the altostratus clouds had, on average, a lower pH in precipitation than other recorded clouds. Other cloud formations recorded were cumulus, cirrocumulus, and no clouds/clear sky; and they had an average pH higher than that of the altostratus. It was concluded that this data was unsupportive of our hypothesis, as altostratus clouds sit in the middle of the atmosphere, relatively. If the data were to support our hypothesis, the recorded pH of the cumulus cloud precipitation would be most acidic.

Research Question

Asking Questions

How does cloud formation effect the pH of the precipitation it produces? This question is important as it can help us identify if precipitation is more acidic, and help us act on it faster.

Introduction

Content Knowledge

How does cloud formation affect the pH of precipitation? If the clouds are lower in the sky, such as stratus or cumulus clouds, then they will produce precipitation of a lower pH, because a more acidic atmosphere creates less cloud formation. The topic was chosen because acid rain is a very interesting topic. Acid rain and air pollution as a whole is a large problem everywhere. By attempting to establish a relationship with cloud formation and precipitation acidity, we are able to identify acid rain more efficiently. A correlation between cloud type and positioning can also help us recognize a dangerous and acidic atmosphere. For background, clouds that are low in the sky are stratus, stratocumulus, and cumulus. Cloud formations that are typically high in the sky include cirrostratus, cirrus, and cirrocumulus clouds. Formations found in between are nimbostratus, altostratus, and altocumulus. Cumulonimbus clouds are so large that one cloud can be found in low, middle, and high regions of the sky. Our hypothesis describes how cloud formations lower to the ground would produce more acidic precipitation because of pollution in the air. The more pollution in the air, the more acidic the clouds can be. As air pollution rises, it disperses because of wind currents and a natural mixing of air. It is known that warm air can carry pollutants. As warm air rises, the pollutants with it begin to disperse (Wylie, 2021). Though, during winter, a layer of warm air can act as a lid to the cold air below it creating a thermal inversion. This makes the cold air and pollution stuck at ground level (UCAR, 2025). How warm air can trap air pollution or disperse it as it goes higher throughout the air leads us to our hypothesis. Precipitation is influenced by the balance of acids and pollutants in the atmosphere (Shaw, Jacob, Moch, Wang, Zahi, 2020). The formation of clouds is greatly attributed to the presence of sulfuric acid, as it gives a site for water droplets to form (Hamilton, 2021). Sometimes, through the application of heat, this sulfuric acid breaks down into sulfur dioxide. Sulfur dioxide is a known source of acid rain, along with nitrogen oxides (EPA, 2024). Thus, the lack of sulfuric acid, the causation of clouds, links with the presence of acid rain, or rain with low pH.

Research Methods

Planning Investigations

The Planning Process

- Used the NASA cloud analysis chart to see type of clouds in the sky, sky shade, and sky visibility.
- Used Natures Brands 5.5-8.0 pH scale 15 foot litmus paper
- To be collected between the dates of November 8th, 2024, and January 18th, 2025.
- 25 ml of precipitation, snow or rain, was to be collected then tested with litmus paper
- Cloud formation and precipitation pH was recorded and analyzed for that date.

Carrying Out Investigations

The Procedures

- Area kept constant, at 41.66959 latitude and -83.63102 longitude
- Data was collected around 10:20 each day of testing
- If snow was the type of precipitation collected, it was melted before being tested
- The color was anylized based on paper on the packaging
- The lighter and more yellow the paper was, the more acidic the substance was
- Substances turned light and dark green, and a bright yellow
- All data gathered was logged into the GLOBE database
- A glass beaker was used to collect the precipitation samples

Site Map and Testing Spot

GLOBE Badges

Be a**Collaborator**

All team members are listed including students from the same school or schools from around the world, along with clearly defined roles, how these roles support one another, and descriptions of each student's contribution. The descriptions clearly indicate the advantages of the collaboration. If the students collaborated with students from another school, describe how working with other schools improved the research.

Be a**Data Scientist**

The report includes in-depth analysis of students' own data as well as other data sources. Students discuss limitations of these data, make inferences about past, present, or future events, or use data to answer questions or solve problems in the represented system. Consider data from other schools or data available from other databases.

Make an Impact

The report clearly describes how a local issue led to the research questions or makes connections between local and global impacts. The students need to clearly describe or show how the research contributed to a positive impact on their community through making recommendations or taking action based on findings.

Results

Analyzing Data

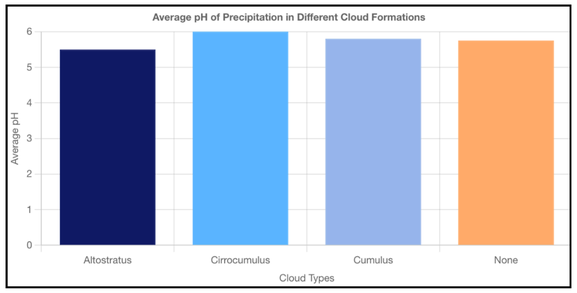
These results suggest that altostratus clouds produce more acidic precipitation, compared to cloud types cumulus, cirrocumulus, or a clear sky. Its average pH sat at 5.5 on the scale, as opposed to no clouds and cumulus clouds at 5.75 in pH, and cirrocumulus at 6. We found averages, as multiple samples were collected of the same cloud type. For example, two days we tested the pH of a clear sky, yet one day had a pH of 6, and the other with a pH of 5.5. This averaged for our displayed pH of 5.75. These findings do not support our hypothesis, as it was displayed that mid-atmospheric clouds had a lower precipitation pH. We hypothesized that the lower the cloud was in the atmosphere, the lower the pH of the precipitation because as pollutants, the cause of acid rain gets higher in the sky, the more it disperses. The higher the warm air carrying it gets, the less concentrated the pollutants get. Information found in other studies would support our hypothesis, stating that as warm air rises, the pollutants disperse. These findings are not supported by our data as well. A factor in obtaining these specific results was our location. Ohio does not have a lot of acid rain, and is not specifically acidic in the environment. This would affect our results because as said before, the presence of sulfur dioxide would result in less cloud formation. A more acidic environment would have more sulfur dioxide, as it is a known cause of acid rain. To improve this experiment, we would replicate procedures but more consistently and over a longer period of time. As well, using a location that has more acid rain or has a more acidic environment would help to show results better. This experiment accurately tested our hypothesis, as it helped to establish a correlation between our two topics.

Figure #1

Cloud type	Precipitation pH	Date
none	6	11/8/24
cumulus	5.8	11/26/24
altostratus	5.5	12/2/24
none	5.5	12/6/24
cirrocumulus	6	1/17/25
altostratus	5.5	1/18/25

Data table representing the cloud type, pH of the precipitation, and the date of data collected over a 68 day period.

Figure #2



Bar graph comparison of different cloud formations, and their average pH on a scale of 1-6, and data collected over a 68-day period.

Discussion

Interpreting Data

The relationships between cloud formation and precipitation pH can help identify the acidity of rain, snow, or sleet more efficiently. As well, a relationship between the two can help one identify, based on clouds, when their environment needs help, or is unbalanced. If this project was repeated, possible improvements could be more data collected, more cloud types collected, and a longer period of collection. There is not much research comparing the two topics, however, findings on air pollution and acid rain support that a lower cloud would relate to a lower pH. For further study, it would be interesting to replicate this experiment in environments where acid rain is more common, such as eastern North America or eastern Europe.

Conclusions

Drawing Conclusions & Next Steps

The data and results collected from the experiment do not support the hypothesis. Based on the data, on average, the precipitation under altostratus clouds produced a more acidic precipitation; at around 5.5 in pH. This contradicts the given hypothesis, that clouds lower in the sky would produce more acidic precipitation, as the cumulus cloud formation is much lower in the sky then altostratus, yet produced precipitation with a higher average pH. The data also illustrates that a sky with no clouds precipitation pH higher than the altostratus. This does not support the hypothesis as well. Expected results were that the less and lower the clouds were, the more acidic in precipitation, however, this was not demonstrated by the data.

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