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.

Introduction

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.

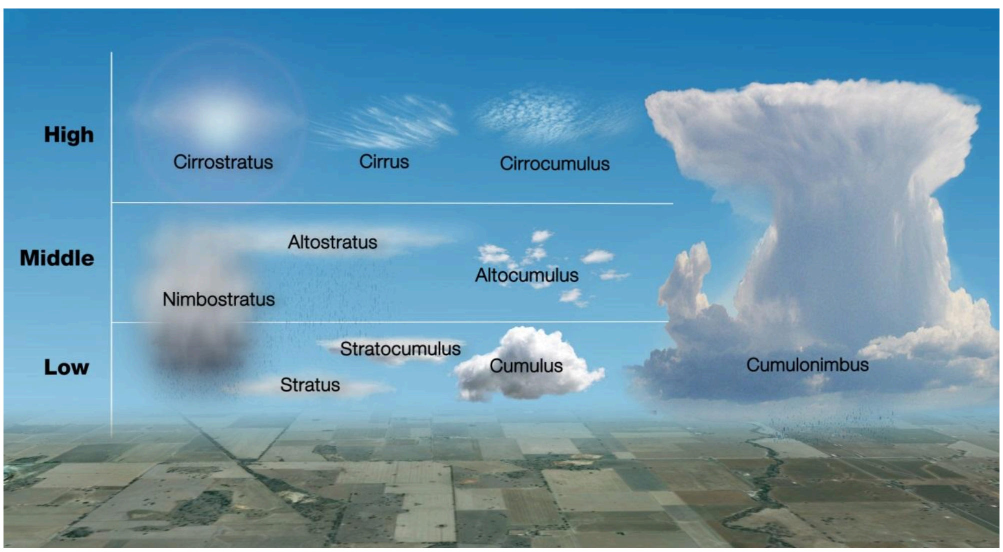

Figure 1. Shwayder, R. (2022). *What's in the Clouds?*.

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 (see fig. 1). 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.

Methods and Materials

Between the dates of November 8th, 2024, and January 18th, 2025, precipitation was collected. Whether it was snow or rain, each test day entailed collecting 25 ml of precipitation in a glass beaker, and analyzing the cloud formations. The area for data collection was kept constant, at 41.66959 latitude and -83.63102 longitude. Bringing the precipitation inside, we sampled pH with the Natures Brands 5.5-8.0 pH scale 15 foot litmus paper. The litmus paper was dipped into the liquid. If snow was collected, it was melted naturally before being tested. The litmus paper was taken out of the liquid, and was left for one minute. The color was then analyzed, guided by the colors on the packaging, to determine the precipitation pH. The lighter and yellow the paper was, the more acidic the substance was. Substances turned light and dark green, and yellow.

While collecting precipitation outside, we used a National Aeronautics and Space Administration chart to dictate the types of clouds in the sky, the deepest shade of blue, and the sky visibility. All of the data gathered was then logged into the GLOBE database, under pH and clouds. We performed six trials. Potential risks were looking up towards the sky, be careful when looking near the sun. When using a glass beaker, be cautious and handle it with care.

Presentation of Data and Results

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

Figure 2. Data table representing the cloud type, pH of the precipitation, and the date of data collected over a 68 day period.

Figure 2 represents the date, cloud type of that day, and the pH of the precipitation. This table was added over a 68 day period to track our data. On November 8, 2024, we went outside to find there were no clouds in the sky, but precipitation on the ground. We collected the precipitation in the form of rain and found the pH to be 6.0. On the 26th of November in 2024, there were cumulus clouds in the sky. Cumulus clouds are classified as low to the ground. When we collected the precipitation in rain form, we found the pH to be 5.8. Later, on December 2, 2024, we classified the clouds as altostratus and the precipitation had a pH of 5.5. Altostratus clouds are typically in a midrange in the atmosphere. A few days later, on the 6th, there were no clouds in the sky. When we collected the precipitation, it was in the form of snow. When melted naturally, the pH was 5.5. The next day that we took data was the 17th of January in 2025. There were cirrocumulus clouds in the sky which are high in the atmosphere normally. The pH was 6.0 and the precipitation was in the form of snow. The next day (January 18, 2025), there were altostratus clouds in the sky. The precipitation was once again in the form of snow and had a pH of 5.5. All this data and more was logged into the GLOBE data website.

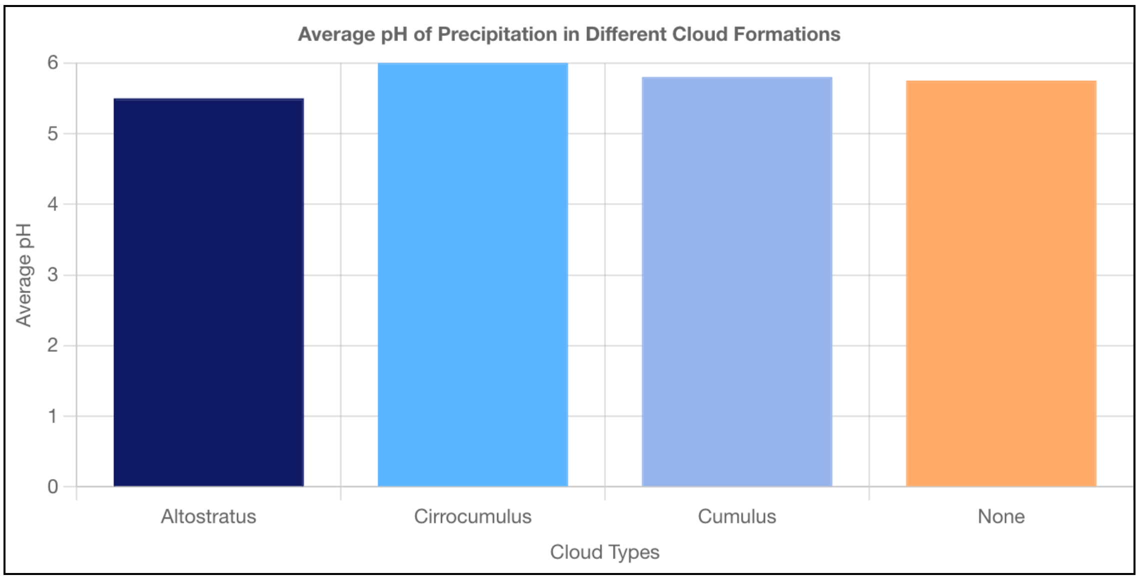

Figure 3. Bar graph comparison of different cloud formations, and their average pH on a scale of 1-6, and data collected over a 68-day period.

Figure 3 is displaying the average pH of the precipitation of each cloud type. Using the pH scale from 0-6, the closer to zero being more acidic, we can use the graph to easily find what cloud type had precipitation with a lower pH. The mean average of each pH was taken, as multiple data was taken with the same cloud formation. Each cloud type has its own bar, with the inclusion of none, meaning there were no clouds in the sky at the time of data collection. By looking at this graph, cirrocumulus clouds have a higher pH, as its bar reaches 6. Bars None and cumulus have an average pH at 5.75. However, altostratus clouds read as the lowest in pH, and higher acidity.

Analysis and Results

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.

Conclusion

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.

Discussion

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.

Acknowledgments

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