An Analysis of the Effects of Precipitation on Soil pH

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Abstract

In this experiment, the goal was to find the correlation between soil pH and precipitation. This is in order to show the importance of preserving the environment because global warming is causing increased precipitation. This increase in precipitation causes soil to acidify, hurting the plants. It was hypothesized that an increase in precipitation would decrease the pH because the precipitation replaces basic ions with hydrogen ions that increase acidity. The findings showed that soil pH does decrease with the increase of precipitation. We used provided materials such as pH test strips, laser thermometer, test tubes, and other lab equipment. In conclusion, the effect of precipitation is apparent in relation to soil pH.

Research Question And Hypothesis

Question: How does precipitation affect the ability for plants to grow with regards to the soil's pH?

Importance: An extreme soil pH of high or low could significantly harm plant growth which are essential to the enviroment. Agricultural plants can also be harmed.

Hypotheisis: If there is an increase in precipitation, then the pH will decrease because the precipitation replaces basic ions with hydrogen ions that increase acidity.

Introduction

The agricultural industry, one of the most important industries on the planet, is expected to be feeding 10 billion people by the year 2050 (Agriculture and Food, n.d.). However, global warming and climate change threaten to damage this vital industry. Specifically, global warming is causing a rise in precipitation above the historical record, which in many ways can damage soil and harm plant growth. The experiment intends to explore the effects of precipitation on soil pH.

Precipitation has increased significantly in the Great Lakes region compared to other regions. Between 1958 and 2016, every northeastern state experienced at least a 40% increase in extreme precipitation events (Great Lakes, 2024). In another study, it was found that the percentage of the country facing extreme single-day precipitation events was increasing at an average rate of 0.5% per decade since 1910 (Climate Change Indicators Heavy Precipitation, 2025). With a general increase in precipitation over time, it is important to learn how this affects our world.

Research Methods

Materials:

- Etekcity Infrared Laser Thermometer
- Test tubes
- Styrofoam cup for each soil sample (3 total containers)
- A pencil (to label the test tubes and styrofoam cup)
- Tape
- Test tube rack
- Clean water (from the sink)
- pH test papers (Hydrion test papers)
- Soil from 3 different places
- A shovel to dig the soil

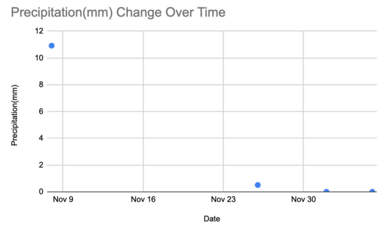
Protocols: Soil pH and Soil Temperature

Procedure:

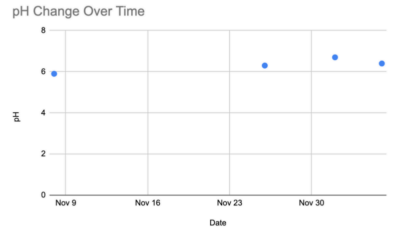
First, label three styrofoam cups with sample numbers. Then, bring the styrofoam cups, a shovel, and the infrared thermometer outside. Find three separate areas with exposed soil for sampling. Using the shovel, remove approximately 5 grams of soil and place in the cup. Next, measure and record the temperature of the soil area using the Etekcity infrared thermometer, holding it approximately 10 centimeters from the ground. Repeat the previous soil sampling and temperature recording steps for the other two test sites. When back inside, mix distilled water with the soil in a 1 to 1 ratio of grams to milliliters. Mix for 3 minutes in periods of 30 seconds mixing and 30 seconds resting. Dip a pH test strip in the soil-water mixture, then place on a paper towel. Label each pH test strip to correspond with the styrofoam cup's number. Compare the color of the test strip with the pH container to determine the pH of the soil-water mixture, then record the value. Repeat this process until you do all 3 samples. Next, using the website wunderground.com, record the amount of precipitation in millimeters for the previous 48 hours. Repeat the previous steps for three more sampling dates. Make sure to keep the three test sites consistent for each sampling date.

This should be done for a total of 4 trials or N = 4. Each trial would have 3 samples for a total of 12 data points for soil temperature and 12 data points for soil pH. The project's trials were conducted on November 8th, November 26th, December 2nd, and December 6th and on those were the dates used for the recording of precipitation. The collection time period was roughly 10:05 am to 10:30 on every single data collection day.

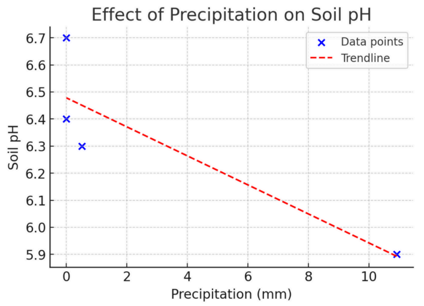
Results



Data points for the trend of precipitation over time.



Data points for the trend of average measured soil pH over time.



This study has suggested that precipitation does have an effect on soil pH, where there is an inverse relationship. To prove this, the trend line was calculated using the basic $y = mx + b$ equation. The slope was found using the equation $m = \Sigma[(x_i - \text{mean}(x)) \cdot (y_i - \text{mean}(y))] / \Sigma[(x_i - \text{mean}(x))^2]$. The mean is calculated plugging in the individual values for x(precipitation value) and y(soil pH value). The slope was calculated and the result was -4.66, showing a downward trend and an inverse relationship. The y-intercept was calculated using the equation $b = \text{mean}(y) - m(\text{slope}) \cdot \text{mean}(x)$ plugging in previous mean values yeilding an intercept of 6.5. Then, the relationship was further proved by finding Pearson's correlation coefficient and the data set's p-value. The equation $r = [n(\Sigma xy) - \Sigma x \Sigma y] / \sqrt{[n(\Sigma x^2) - (\Sigma x)2][n(\Sigma y^2) - (\Sigma y)^2]}$ was used to find Pearson's correlation coefficient. This equation assigns a value of correlation, with 1 being direct relation and -1 being inverse relation. The value was equal to approximately -0.8362, implying an inverse correlation as we already observed from the data. Then, this value was used to calculate a p-value, which can be used to find the significance of the data, using the equation $t = r\sqrt{(n-2)}/\sqrt{(1-r^2)}$. The value for t was approximately -2.15, which, when compared to a t-distribution chart, gave a value of slightly less than 0.10. This means that the overall significance of the data is between 90% and 95% confidence. Overall, this data had an inverse correlation, supporting the hypothesis, as well as published data.

Discussion

This project can be improved by collecting more data. Currently there are a total of 9 data points. 1 data point per location, totaling 3 data points per day for only 3 days. An improvement would be taking more data points per location and having overall more locations to collect samples from. These data points can also be collected over more days, with an emphasis on days with varying precipitation measures, in order to better verify the presence of a trend in the data. These findings are very impactful to the world since plants need a more neutral soil pH in order to grow optimally. However, due to climate change, there is an increase in precipitation, which according to our data is decreasing the soil pH and affecting plant growth. In the end, our data supported our hypothesis and produced similar results as external conclusions.

Conclusion

The experiment aimed to find the relationship between precipitation and soil pH by recording the pH of soil in three locations and the amount of precipitation encountered in the previous 48 hours. This was done over four days between November and December. This resulted in a trend that supported the hypothesis, claiming that soil pH and precipitation would have an inverse relationship. There may be a common misconception that precipitation would neutralize the soil, due to the neutral pH of distilled water. However, rainwater is not perfectly distilled, and contains components like dissolved carbon dioxide, which can acidify the soil. Research performed before the experiment allowed the setting of theoretical values and a hypothesis that was different from this misconception.

Refrences

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