Ottawa Hills High School

The relationship between water temperature, precipitation, and conductivity

Henry Sun

Ottawa Hills, Ohio

Grade 10

Teacher: Dr. KG

3 March 2025

Table of Contents

Title Page —---------- 1

Table of Contents —---------- 2

Abstract —---------- 3

Introduction —---------- 4, 5, 6

Methods and Materials —---------- 7

Presentation of Results —---------- 8, 9

Analysis and Results —---------- 10

Conclusion —----------11

Discussion —---------- 11

Acknowledgements —---------- 11

References —---------- 12,13

Abstract

Conductivity is a major factor in determining and maintaining water quality. Consistently having access to good quality water is essential for life, but it is not readily available in every corner of the globe. Understanding what can influence water quality can lead to quality of life improvements for many, and that's why this report intends to research the factors that affect conductivity in water. This project will provide valuable information regarding these relationships. It was hypothesized that if water temperature is decreased, then conductivity will also decrease, because lower temperature leads to a decrease in ion movement, therefore decreasing conductivity. However, if there are large amounts of precipitation, then conductivity could increase because precipitation adds ions to the water. To gather the data, conductivity meters and thermometers were dipped in the sample of water. The precipitation data was gathered from a well respected online database named Wunderground. It was found that conductivity generally increased as water temperature decreased, and when there was no precipitation. This contradicted the hypothesis and also other studies. This shows just how complex conductivity is, showing that other factors, such as human-related factors can also influence water conductivity. This study has many real-world applications and understanding these relationships can help scientists to create ways to manage water quality, through measuring conductivity.

Introduction

Water quality is an essential part of the global ecosystem impacting all types of life, including ourselves. Poor water quality, a problem in some parts of the world, can lead to detrimental effects to these species and us alike. Crucial aspects like clean drinking water and agriculture can be affected by water quality. One property that influences water quality is conductivity, which can be determined by environmental factors such as temperature and precipitation. Understanding these properties is essential for keeping the ecosystem healthy and safe for all. To explore this relationship, the experiment will test the effect of water temperature and precipitation on the conductivity of water in a freshwater system.

Due to the emerging dangers of climate change, aquatic ecosystems worldwide have been and will continue to be affected. This topic was chosen due to my interest and curiosity about the environment, more specifically, climate change and the hydrosphere. By investigating the relationship between water temperature, precipitation, and conductivity, this research aims to contribute to the understanding of what affects water quality.

Water temperature, for example, is a key factor in determining conductivity/water quality. When water temperature increases, conductivity also tends to increase (Boqu Instrument., 2024). This is due to the fact that increased temperature increases ionic movement. (Fondriest Environmental, Inc., 2014). A recent study conducted in 2023 found a strong positive relationship between temperature and conductivity, citing ionic movement as the main cause (Dewangan et al., 2023). Another study, conducted by scientists in Ireland, also found similar results (see fig. 1.).

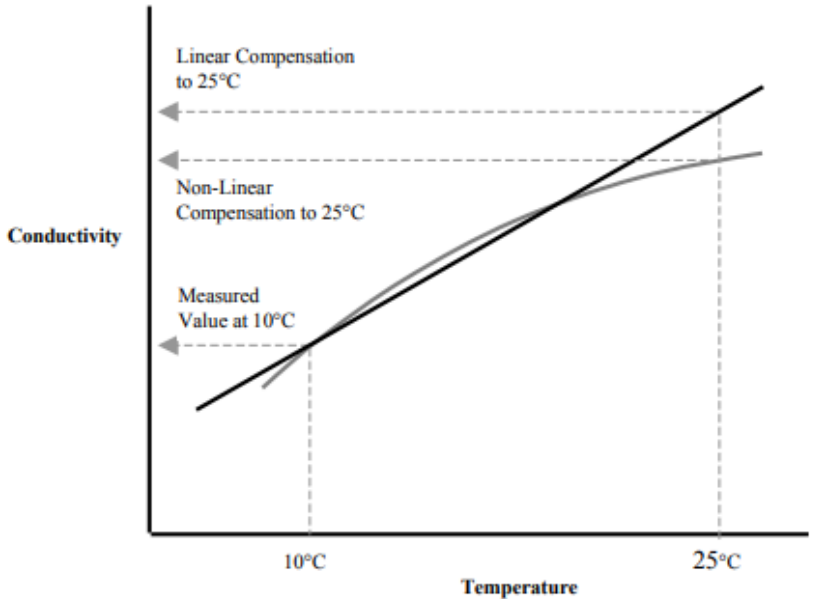


Fig 1. Representation of Linear Compensation & Non-Linear Compensation. Adapted from *The Effect of Temperature on Conductivity Measurement*, by J. Barron & C. Ashton, Reagecon Diagnostics Ltd.

These studies both indicate that temperature has a major part in determining conductivity, both using a conductivity meter. In this experiment, to measure conductivity, a conductivity meter will be placed in the water, which will then output a current that measures how well a current flows through the water; this meter will be used in this experiment.

Along with water temperature, precipitation is also a factor that can influence conductivity and thus water quality. In a paper published by HAL Science, rainfall can create runoffs that can move pollutants into rivers. If conductivity is measured in that body of water, the ionic movement would likely be higher, which could symbolize potential pollution in the water (Roig, Baurès, Jung, Delpla, & Thomas, 2012). Additionally, precipitation could also influence the base water quality of a body of water, meaning that knowing the precipitation data would enable a researcher to

determine the water quality. (Roig et al., 2012). In this experiment, I will use the database Wunderground to find precipitation data on measurement days.

For this research, I hypothesize that if water temperature is decreased, then conductivity will also decrease, because lower temperature leads to a decrease in ion movement, therefore decreasing conductivity. However, if there are large amounts of precipitation, then conductivity could increase because precipitation adds ions to the water. This study will provide valuable insights into how water temperature and precipitation affect water quality, helping to predict possible future changes due to climate change.

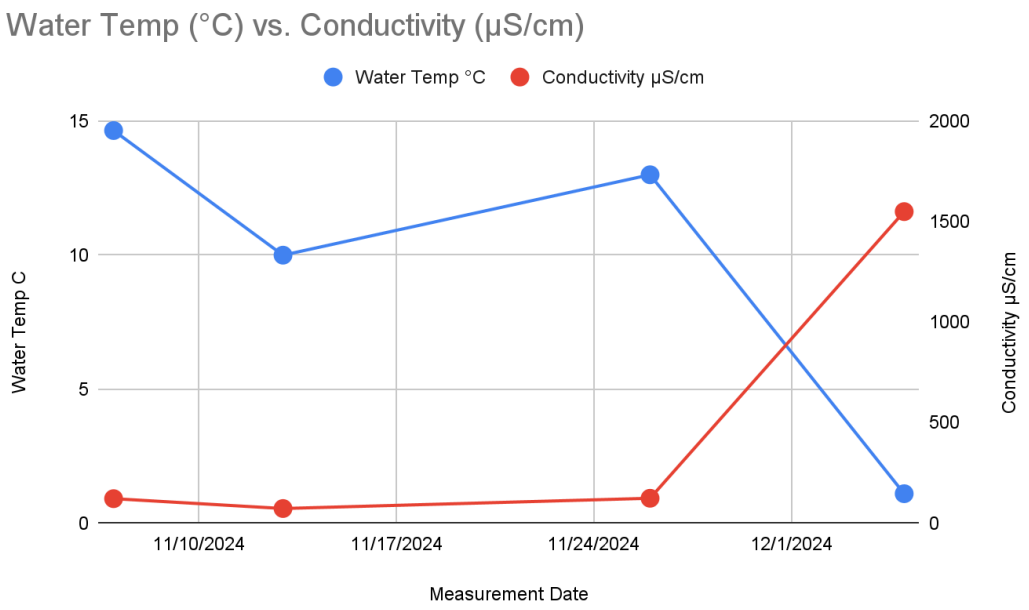
Methods and Materials

The data points of conductivity and water temperature were obtained using GLOBE hydrosphere protocols. For the precipitation data, the Weather underground database was used to find the specific conditions on measurement days. The thermometer used is a digital thermometer by Flinn Scientific. The conductivity meter used is also made by Flinn Scientific.

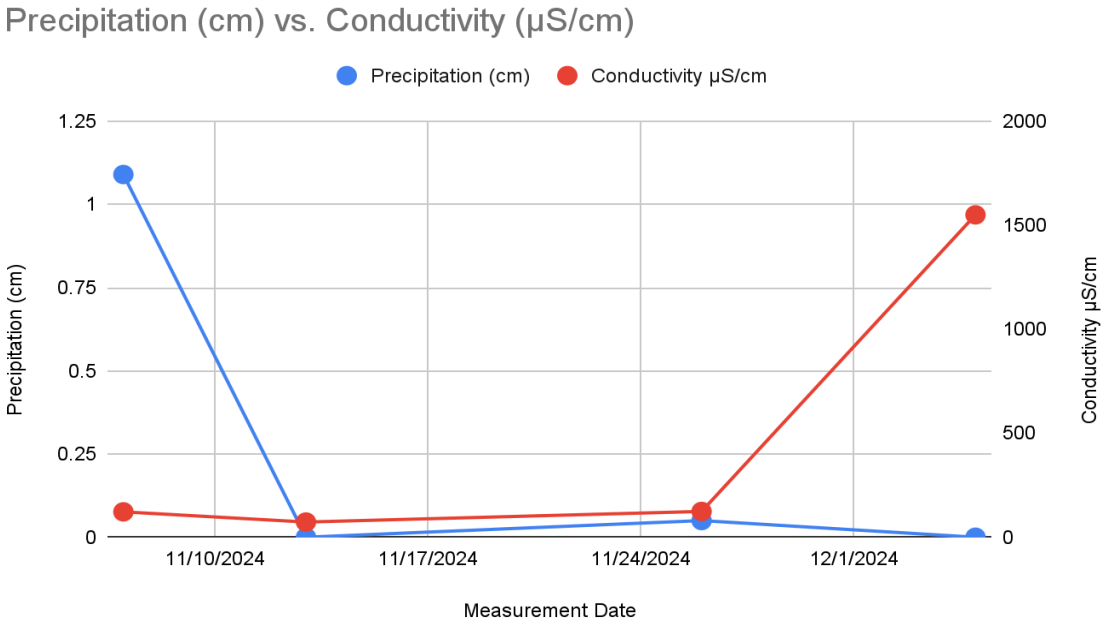
The water obtained from the Ottawa River in Toledo, Ohio served as the sample for this experiment (see Study Site Map) . The area contains a humid continental climate, with all four seasons. Firstly, to find the water temperature, the thermometer was set to Celsius and the tip was then submerged into the sample. Conductivity measurements taken by ensuring the conductivity meter was dry and calibrated to μS/cm. The meter was then dipped into the sample of water. These two protocols both specifically followed GLOBE protocols for their categories. After recording both temperature and conductivity data (three trials each), the Weather Underground database was used to find precipitation data for the given day. Data was measured at around the same time, noon, across all of the days. Since three trials were run on each day, and there were four total measurement days, 12 total trials were run across the experiment.

Initially, only recording one trial of water temperature was planned, as water temperature was believed to not vary much, however, running more trials will always make data more reliable; thus 3 trials were run. To analyze the data, the average of the three trials will be found and will be implemented in the graph. There will be 3 graphs, two of which will be a dual axis chart, allowing the graphs to stay in scale, all with some relation to conductivity. Standard deviation will also be calculated. Standard lab safety protocols were followed, such as proper handling of electrical instruments in water, and accurate calibration before use.

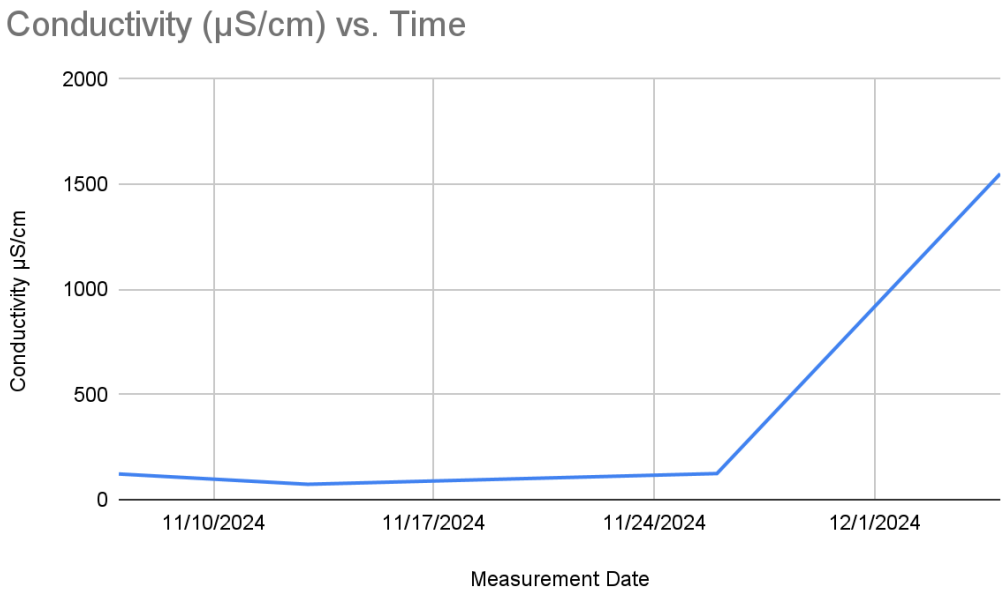
Presentation of Data and Results



How Water Temperature affects Conductivity (Dual Axis Chart).



How Precipitation affects Conductivity (Dual Axis Chart).



Conductivity Graph Alone (relatively stable, then increase)

	11/7/2024	11/13/2024	11/26/2024	12/5/2024
Water Temp °C	0.057	0	0	0
Conductivity µS/cm	1	3.785	1	5.770

(Standard Deviation)

In the graphs, there are numerous trends present. For context, the plotted points are the average of the three trials on each given day. Firstly, the general trend with the conductivity is positive, which occurs when water temperature's trend is negative, and when precipitation is at 0. However, there are also some outliers, for example on 12/5, the temperature was 1.1°C, a drop from the average of around 12°C on the other days. Also on 12/5, conductivity jumps to 1550 µS/cm, which is a significant positive outlier over the previous measurements. Standard deviation of the points was also calculated (not for precipitation, as it was from a database). Standard deviation only varied most on two of the conductivity measurement dates.

Analysis and Results

The results indicate a positive trend of conductivity when water temperature's trend is negative, and when precipitation is 0. For the first three days of data collection, water temperature was relatively stable, and so was conductivity, however on the last day, temperature dropped significantly which led to the increase of conductivity. There is not a very clear trend with precipitation and conductivity, but conductivity was usually highest at points of 0 precipitation. Logarithms could be implemented in the conductivity graph, but it was decided to not be used to better model the point on the last day. The hypothesis, if water temperature is decreased, then conductivity will also decrease, because lower temperature leads to a decrease in ion movement, therefore decreasing conductivity. However, if there are large amounts of precipitation, then conductivity could increase because precipitation adds ions to the water. This hypothesis was not supported based on the results of this experiment. Other studies however, found the opposite, as water temperature increases, conductivity increases too (Dewangan et al., 2023). Additionally other studies also found that high levels of precipitation leads to decreased conductivity, again not supporting the hypothesis, but supporting my data (Fondriest Environmental, Inc., 2014). These results were thought to be measured possibly due to human-related factors that were not researched in the study, such as road salting. If there were experimental errors, they would come in the form of measurement errors, a possibility is that numbers were not measured down correctly, however this is extremely unlikely as three trials were done on each measurement. The results may not support the hypothesis, but they did accurately test it.

Conclusion

This project studied the relationship between water temperature, precipitation, and conductivity. The general trends found may be a bit unexpected, as the conductivity increased when water temperature decreased, and when there was less precipitation. Most previous studies found that conductivity increases with increasing temperature. This shows just how complex conductivity is, showing that other human-related factors can also influence water conductivity.

Discussion

My findings suggest that conductivity increases when water temperature decreases, and when there is less precipitation. Possible improvements could include more trials or just more collection of data in general. More information on possible human activity near the water stream could also help too, as factors like road salting can alter the conductivity measurements. Additionally, gathering salinity or TDS (Total Dissolved Solids) concentration data would also deepen the findings of future studies. The overall findings of the experiment contradict what is traditionally known. However, this study has many real-world applications, understanding these relationships can help scientists to create ways to manage water quality, through measuring conductivity.

Acknowledgments

I would like to thank Dr. KG for her support and for allowing me to use the measurement devices. Also Dr. Mierzwiak from UToledo, who helped to propose additional ideas.

References

Barron, J. J., & Ashton, C. (n.d.). The Effect of Temperature on Conductivity Measurement. *Reagecon Diagnostics Ltd*. https://knowledge.reagecon.com/wp-content/uploads/2021/09/Technical-Paper_The-Effect-of-Temperature-on-Conductivity-Measurement.pdf

Boqu Instrument. (2024, December 12). *The Impact of Temperature on Water Conductivity Readings*. Boqu. Retrieved January 30, 2025, from https://www.boquinstrument.com/a-the-impact-of-temperature-on-water-conductivity-readings.html

Dewangan, S. K., Shrivastava, S. K., Kadri, M. A., & Saruta, S. (n.d.). TEMPERATURE EFFECT ON ELECTRICAL CONDUCTIVITY(EC) & TOTAL DISSOLVED SOLIDS (TDS) OF WATER: A REVIEW. *ResearchGate*. https://www.researchgate.net/publication/371539432_TEMPERATURE_EFFECT_ON_ELECTRICAL_CONDUCTIVITYEC_TOTAL_DISSOLVED_SOLIDS_TDS_OF_WATER_A_REVIEW

Fondriest Environmental, Inc. (2014, February 7). *Water Temperature*. Fondriest Environmental Learning Center. Retrieved January 30, 2025, from https://www.fondriest.com/environmental-measurements/parameters/water-quality/water-temperature/

Roig, B., Baurès, E., Jung, A. V., Delpla, I., & Thomas, O. (n.d.). Rainfall and Water Quality. *Hal Science*. https://hal.science/hal-01664965/document

Weather Underground. (n.d.). *Swanton, OH Weather History*. Weather Underground. Retrieved January 30, 2025, from https://www.wunderground.com/history/monthly/us/oh/swanton/KTOL/date/2024-12