THE IMPACT OF RISING ATMOSPHERIC TEMPERATURES ON RIVER PH

to

The Ohio Academy of Science

by

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ABSTRACT

The objective of this experiment was to determine how air temperature affects water pH, which is important to see the effects of global warming to aquatic environments. Monitoring water pH provides context as to how ecosystems are affected. We proposed that if air temperature increased, the pH of river water would have decreased because increasing the temperature will cause more water to evaporate, and increased concentration of H^+ ions in the water will decrease the pH. Water samples were collected from the same site over the course of 10 days, with three 60 mL samples per day. The appropriately ranged pH paper was used to measure water pH, and air temperature was recorded with a thermometer. Upon conclusion of its collection, all of the documented data was uploaded to Globe. We then analyzed it, determining whether there was statistical significance. Since there was, from this experiment, we concluded that water pH significantly changes based on the outside air temperature, supporting our hypothesis. These findings highlight potential risks to aquatic ecosystems as global temperatures rise.

INTRODUCTION

Areas like rivers, and their offshoots, such as streams, are crucial parts of our environment, providing water and homes for different species like plants, animals, and people. Water pH, a crucial factor of river and all water, shows how acidic or basic water is, and affects the health of all living organisms that depend on the water source. However, the pH of water is not a standalone factor, independent of everything around it. Rather, it can be affected by many other conditions, one of which is air temperature. Due to temperature fluctuations throughout the year, and the steady increase globally due to climate change, river conditions, and therefore the interdependent species, could be affected severely. Therefore, the question was posed: how does the air temperature around us actually have an effect on the pH of local waters?

Due to its importance and significance in a warming world, studies have already been conducted on this relationship. For example, a study conducted by various researchers on the Nairobi River explored the relationship between meteorological activities and surface water quality on environmental health. They explored many parameters, including rainfall, temperature, water pH, and others. Within their research they discovered, “The regression analysis for pH yielded a remarkably high multiple R2 value of 1.00, indicating a very strong relationship with Rain and Temperature.” As the paper progressed, the researchers also observed a statistically significant, moderate positive correlation between pH and Temperature, with an R2 value of 0.49.

In addition, another study conducted by researchers in the Jiaozhou Bay from spring to summer indicated similar results. Their study set out to find the impact of environmental factors on both sea surface pH and aragonite saturation state. While doing this, they observed the

relationship between temperature and both aforementioned factors. They found that an increase in temperature leads a body of water to release more carbon dioxide in order to maintain equilibrium with the environment. This in turn increased the surface pH of the tested waters, showing an indirect, but positive, relationship between air temperature and water pH.

METHODS AND MATERIALS

Question: What is the relationship between air temperature and river water pH?

Hypothesis: If air temperature increases, the pH of river water will decrease because increasing the temperature will cause more water to evaporate, and increased concentration of H^+ ions in the water will decrease the pH.

Materials:

- Graduated cylinder (100mL) - to measure water samples
- Cup or container - to pour water samples into for more convenient testing
- pH paper - within the range of 5.5 to 8.0 in order to best test the water
- Thermometer - to measure outside air temperature
- Air Temperature Data Sheet
- Water pH Data Sheet

Procedure:

1. Go to the desired site: must have a water source
2. Measure the temperature at the site using the thermometer
3. Record the temperature on the Air Temperature Data Sheet
4. Measure a 60ml sample of the water
5. Use pH paper to test the pH of the sample
6. Record the Data on the Water pH Data Sheet
7. Repeat steps 3-6 two more times for your first testing day
8. Repeat steps 1-7 for nine additional testing days

Independent Variable: Air Temperature

Dependent Variable: Water pH

Constants:

- Thermometer used
- Time of the day
- Testing site
- Type of pH paper used

Data Collection and Analysis:

- We collected temperature data by using the thermometer to record the outside air temperature.
- We collected water pH data by using pH paper in the desired range and observing the change in color of the paper
- We conducted 3 trials per day when data was collected, so N = 3

DATA

Organized by Date

Date	11/14	11/15	11/16	11/17	11/18	1/22	1/23	1/24	1/27	1/28
Outside air temp	14°C	17°C	6.5°C	7°C	4.5°C	-6.5°C	-13°C	-17°C	-8.5°C	-11.5°C
pH test sample #1	5.8	5.8	5.9	5.8	5.8	6	6.1	6.1	6	6
pH test sample #2	5.8	5.7	5.8	5.8	5.9	6	6	6.1	6	6.1
pH test sample #3	5.8	5.8	5.8	5.8	5.9	6	6.1	6.1	6	6
Average pH	5.8	5.77	5.83	5.8	5.87	6	6.07	6.1	6	6.03
STD	0	0.06	0.06	0	0.06	0	0.06	0	0	0.06
SEMS	0	0.03	0.03	0	0.03	0	0.03	0	0	0.03
2 SEMS	0	0.06	0.06	0	0.06	0	0.06	0	0	0.06

Organized by Temperature

Date	1/24	1/23	1/28	1/27	1/22	11/18	11/16	11/17	11/14	11/15
Outside air temp	-17°C	-13°C	-11.5°C	-8.5°C	-6.5°C	4.5°C	6.5°C	7°C	14°C	17°C
pH test sample #1	6.1	6.1	6	6	6	5.8	5.9	5.8	5.8	5.8
pH test sample #2	6.1	6	6.1	6	6	5.9	5.8	5.8	5.8	5.7
pH test sample #3	6.1	6.1	6	6	6	5.9	5.8	5.8	5.8	5.8
Average pH	6.1	6.07	6.03	6	6	5.87	5.83	5.8	5.8	5.77
STD	0	0.06	0.06	0	0	0.06	0.06	0	0	0.06
SEMS	0	0.03	0.03	0	0	0.03	0.03	0	0	0.03
2 SEMS	0	0.06	0.06	0	0	0.06	0.06	0	0	0.06

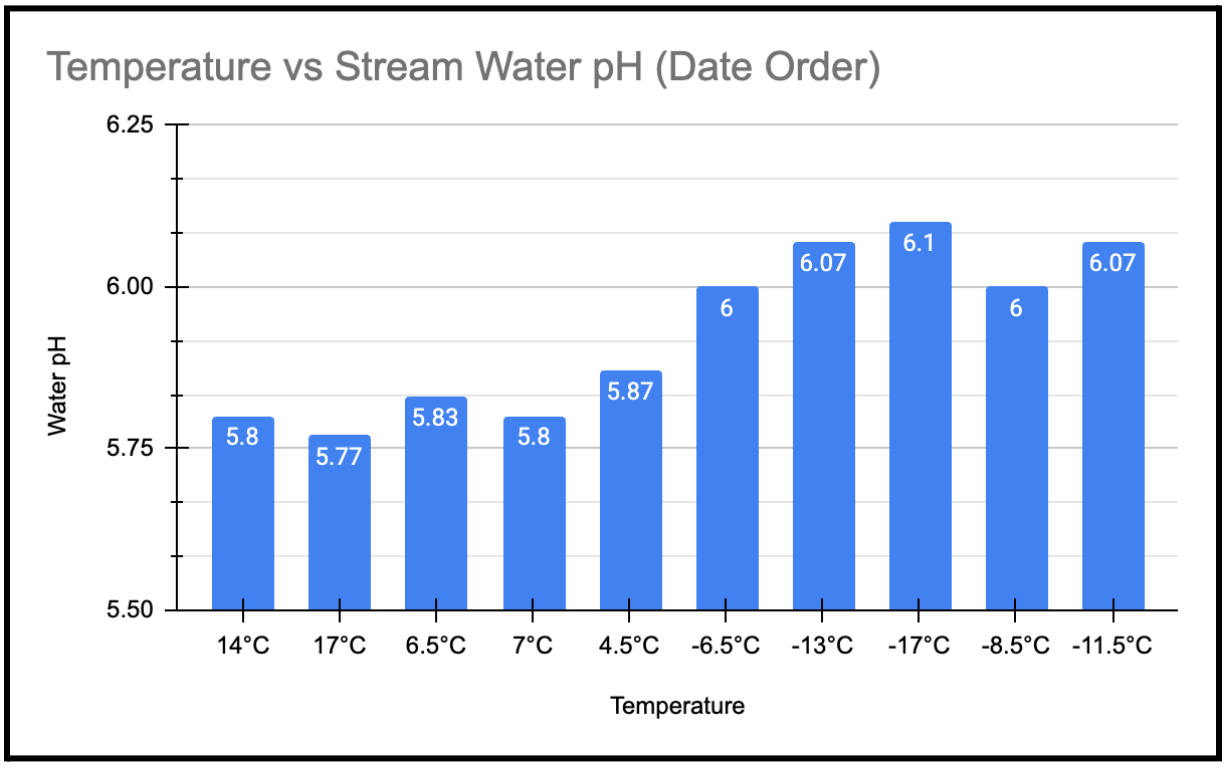
Temperature vs Stream Water pH (Date Order)
6.25
6.00
5.75
5.50
Water pH
5.8
5.77
5.83
5.8
5.87
6
6.07
6.1
6
6.07
14°C
17°C
6.5°C
7°C
4.5°C
-6.5°C
-13°C
-17°C
-8.5°C
-11.5°C
Temperature

fig. 1

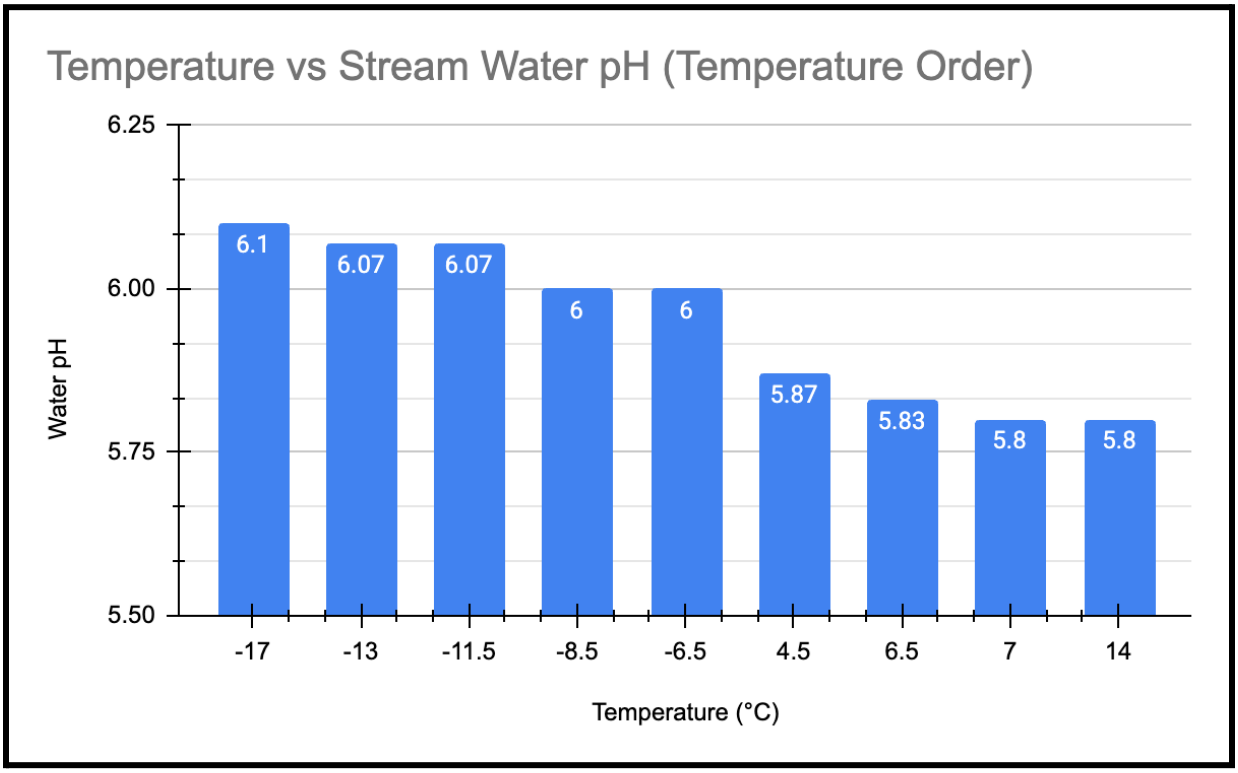
Temperature vs Stream Water pH (Temperature Order)
6.25
6.00
5.75
5.50
Water pH
6.1
6.07
6.07
6
6
5.87
5.83
5.8
5.8
-17
-13
-11.5
-8.5
-6.5
4.5
6.5
7
14
Temperature (°C)

fig. 2

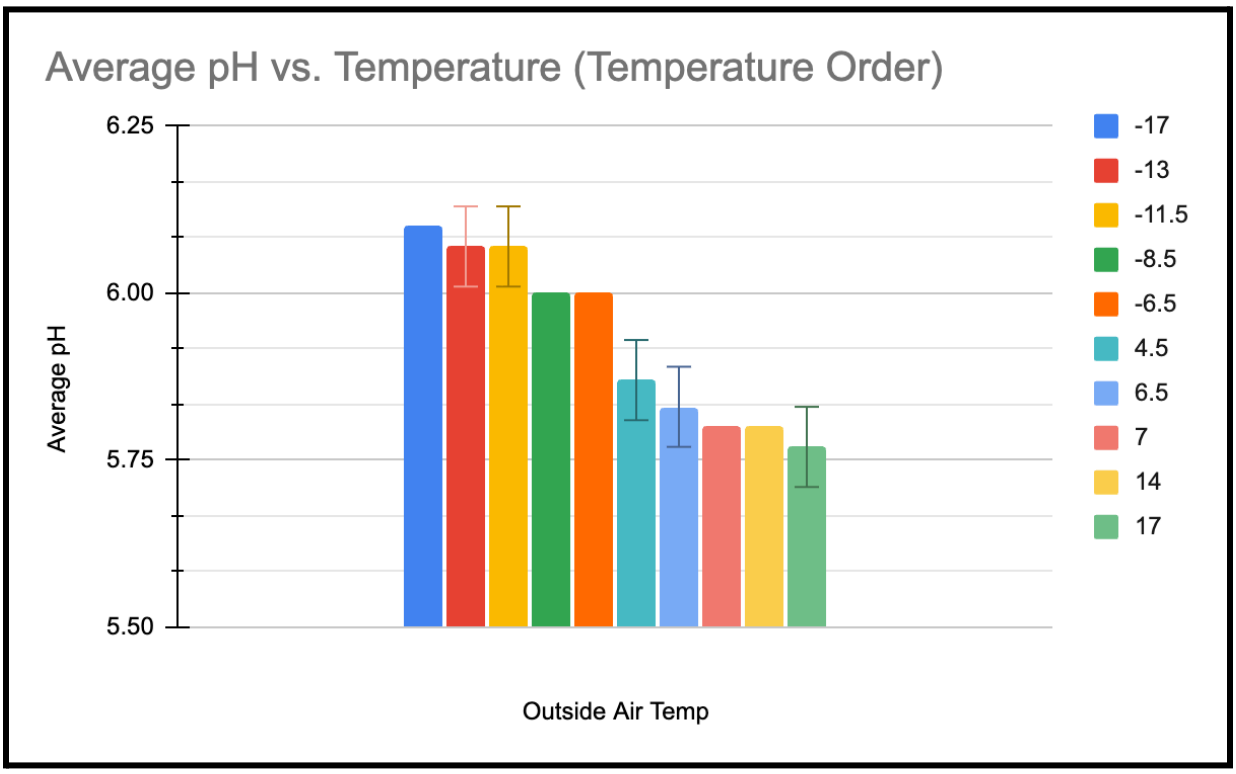
Average pH vs. Temperature (Temperature Order)
6.25
6.00
5.75
5.50
Average pH
Outside Air Temp
-17
-13
-11.5
-8.5
-6.5
4.5
6.5
7
14
17

fig. 3

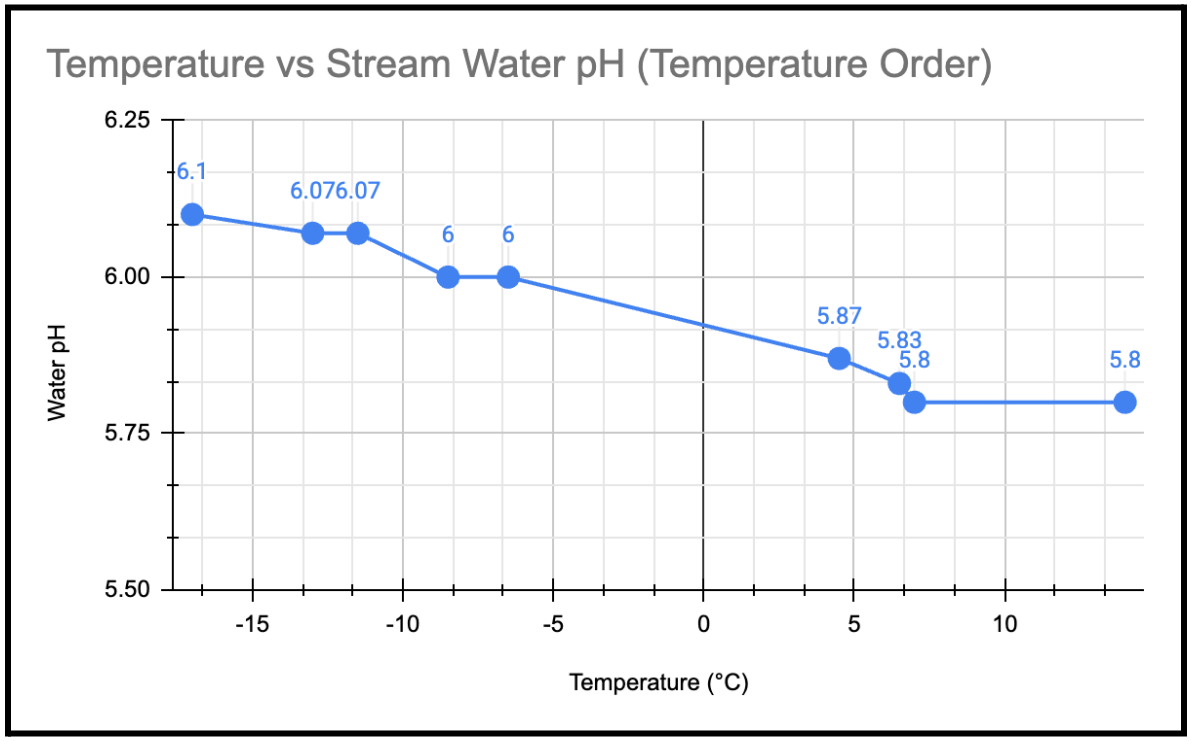
Temperature vs Stream Water pH (Temperature Order)
6.25
6.00
5.75
5.50
Water pH
6.1
6.076.07
6
6
5.87
5.83
5.8
5.8
-15
-10
-5
0
5
10
Temperature (°C)

fig. 4

DATA ANALYSIS

From our data, we can see that overall, as the temperature of the air increases, the water pH decreases. This data trend supports the research that was previously discussed in our background research paper. In figure two, we can see that at the warmer temperatures (4.5-17 degrees celsius) there is no statistical difference. In addition, we can see the colder temperatures (-17 - -6.5) have a statistical difference in the data between -17 & -11.5 and the data between -8.5 & -6.5, but are overall very similar. However, there is a significant difference between the pHs of the warmer temperature set and colder temperature set.

DISCUSSIONS

The results from our experiment shows that air temperature has a significant effect on river water pH. A statistically significant difference was found between the pH values measured at warmer temperatures compared to colder temperatures, with warmer outdoor temperatures resulting in higher pH values, and vice versa for colder outdoor temperatures. Similarly, this can be seen in previous research around the world. Studies conducted at the Nairobi River showed a strong relationship between higher temperatures and higher pH. A scientific analysis for this relationship is that water, during an increase in temperature, separates into components, one of which is H+. The increase in H+ concentration decreases the pH of the water.

Although the experiment aligns with previous studies and our hypothesis was supported, to improve the validity and reliability of this experiment, there are still improvements that could be made. The use of pH paper has limited accuracy as it relies on visual color comparison, which can be subjective. Environmental factors such as rainfall or biological activity may have influenced water pH independently of air temperature. To improve the experiment, a digital probe to collect pH or collecting data for a longer period of time would help reduce uncertainty.

Generally, the experiment effectively tested our hypothesis that air temperature affects river water pH. The observed trend supported the hypothesis, and the results were consistent with expectations.

CONCLUSIONS

Our hypothesis was accepted, as there was a significant statistical difference between the pH of water at the warmer temperature set and colder temperature set. Within this experiment, we had many successes. We kept variables constant by going to the site at approximately the same time each day, and using the same type of pH paper to measure and record our data. We also made sure to assess our data for statistical significance through the calculation of standard deviations and standard error of the mean. If we were to investigate further, it would be beneficial to include more temperature ranges. However, this would require a longer data collection period, such as over the course of the year. In addition, if we were to improve upon this experiment, we would test multiple sites in order to determine if the observed phenomenon was site-specific, or a generalized conclusion.

This research is significant, especially in today's world. With global temperatures consistently on the rise, it's important to study the impacts this will have on our planet. Many organisms rely on aquatic habitats to maintain their lives. However, the changing pH in response to the global temperature rise may limit the aquatic life sustainable by rivers, lakes, and even oceans. Therefore, we must prematurely assess the consequences in order to better prepare for this eventuality.

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