Atmospheric Temperature's Effect on Dissolved Oxygen

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Abstract

The purpose of this experiment was to find how atmospheric temperature affects the dissolved oxygen rate in the Ottawa River. Prior to the experiment, there was much research done and effort put into designing the most effective test. This experiment was conducted using measured dissolved oxygen compared to the atmosphere's temperature, over the span of 28 days. The dissolved oxygen rate fluctuations ranged from 5 to 8 ppm mg/L, with atmosphere temperature also variating. The hypothesis was that if the air temperature decreases, then the dissolved oxygen level will increase, because as air molecules slow down, there are less oxygen molecules from water being released into the atmosphere. During the experiment, there were some obstacles and setbacks, but in the end there were intriguing results that can be used by future scientists to learn more about dissolved oxygen and its relationship with atmospheric temperature.

Introduction

How is the dissolved oxygen level of an ecosystem affected by the surrounding air temperature? In our experiment, we wanted to further explore this question and the repercussions it had on the world around us. We hypothesized that if the air temperature decreases, then the dissolved oxygen level will increase, because as air molecules slow down, there are less oxygen molecules from water being released into the atmosphere. Our background research from USGS (2018) made us conclude that air temperature and dissolved oxygen will have an inverse relationship because as temperature increases, molecules will move faster. The air molecules and the water molecules will both increase in speed as the temperature increases. The hydrogen bonds between water molecules will be broken and the oxygen molecules will be released to the atmosphere. This will cause the dissolved oxygen of the water to decrease. Water molecules are made up of two hydrogen atoms and one oxygen atom, so this is where the oxygen molecules are coming from.

In early spring and winter, dissolved oxygen concentration tends to be high, while summer and fall typically have lower dissolved oxygen concentrations. Orange County Water Atlas (2016) found in a general study on dissolved oxygen that D.O. levels change with the seasons, as temperature change is natural, however, human influence can change the surrounding temperature with runoff from factories. Evidence further supporting this statement from Natural Resources Wales (2018) quotes that, "as the bacteria feed on the pollution that has entered a watercourse, their numbers increase and the demand on the dissolved oxygen in the water increases, resulting in a dramatic decline in the amount of dissolved oxygen available for fish and other aquatic animals, which can lead to their suffocation" (pg 2). These sources show that dissolved oxygen can be influenced by both manmade and natural factors, both which can have negative impacts on the environment around us.

This experiment was prompted by the increase in global temperature that we have noticed throughout the years. We wanted to see how global warming may affect the dissolved oxygen of an ecosystem, since the dissolved oxygen is important for aquatic life. To perform cellular respiration, which all living organisms must do to survive, oxygen is needed. Therefore, animals and plants need oxygen to survive, and if climate change leads to an increase in average temperatures year-round, then animals may struggle to survive. One supporting source, Watershed Academy Web (2009) studied the water-related effects of climate change in the United States and found that one of the worst effects of rising water temperatures will be decreased dissolved oxygen levels because there is an inverse relationship that exists between dissolved oxygen and temperature. This further shows the temperature of the water increases, dissolved oxygen levels decrease, which supports the need for this experiment in the first place.

The effect of air temperature on dissolved oxygen is very relevant today due to environmental problems that impact our everyday lives, such as increasing global temperatures caused by the greenhouse effect. We can connect this elevated output of carbon emissions as responsible for many factors of climate change, such as raised temperatures worldwide. In an analysis of global environmental patterns, Buha (2011) found that many plant and animal species will not be able to cope with our changing environment and would likely die (p.4). This shows that researching how factors of the environment, like dissolved oxygen, are affected is crucial to finding how organisms react and what we can do to stop this.

In a greater context, researching dissolved oxygen can help the world in many aspects and prompt action through more experiments on how these changing numbers and rates contribute to other environmental changes. We hope to answer how dissolved oxygen levels of an ecosystem are affected by the surrounding air temperature in order to contribute to the other scientific observations on dissolved oxygen and take a step towards making a difference.

Methods and Materials

Several GLOBE protocols and data sets were used to collect our information. We used the Dissolved Oxygen protocol, along with the Water Temperature protocol. We tested pH, temperature, and dissolved oxygen using various kits. For pH, we used the Hydrion 5.5-8 Scale paper strips, for water temperature we used a standard glass thermometer, and for Dissolved Oxygen we used the CHEMETS Kit Dissolved Oxygen K-7512. We also recorded the atmospheric temperature at the time the water sample was recorded. These materials were all provided by our teacher and are qualified to take the measurements we needed.

For our actual protocol, we had 3 separate methods for collecting data. Firstly, to record atmospheric temperature, we used the readings provided by our teacher at the time that the river water sample was taken that day and recorded it in degrees Celsius. To record water temperature, we first collected a sample of water from the river. We then collected 25 mL of the water in a 30 mL beaker by carefully dipping the beaker into the glass. We then used a glass thermometer to take the water temperature and recorded the data in degrees Celsius. Next, we took a strip of the Hydrion 5.5-5.8 Scale pH paper and dipped it halfway into the water sample. We laid this strip on a paper towel and let it sit for 1 minute before comparing what color it turned to the provided color guide on the label. We then recorded this data.

To record dissolved oxygen, we took the 25 mL sample of water and the CHEMETS Kit Dissolved Oxygen K-7512. We poured the sample into a special provided graduated cylinder with places to break the glass of vials. We then took a vial from the kit and placed it in the water sample and quickly pressed down, which caused the vial to break and the solution inside it to enter the water and test its dissolved oxygen levels. The liquid from the vial will flow into the graduated cylinder, and after about 30 seconds we remove the vial and place it on a paper towel. After that, we waited about 1 minute and compared the final color of the vial to the provided range of vials at different ppm mg/L of oxygen. We then recorded this data. One potential danger was the broken glass of the probe after it was snapped. We did not have any shattered probes, but we disposed of the small shard of glass in the glass disposal container. We wore gloves to avoid any chemicals in the water that could be potentially harmful.

Presentation of Data and Results

Date:	pH:	Atmosphere Temperature: (Average)	Water Temperature:	Dissolved Oxygen:	Sample Size:
11/8/24	6.6	10.1 C	12.1 C	5 ppm mg/L	25 mL
11/26/24	6.5	4.4 C	6 C	8 ppm mg/L	25 mL
12/2/24	6.5	-7.9 C	1 C	8 ppm mg/L	25 mL
12/6/24	6.5	-3.7 C	1 C	8 ppm mg/L	25 mL

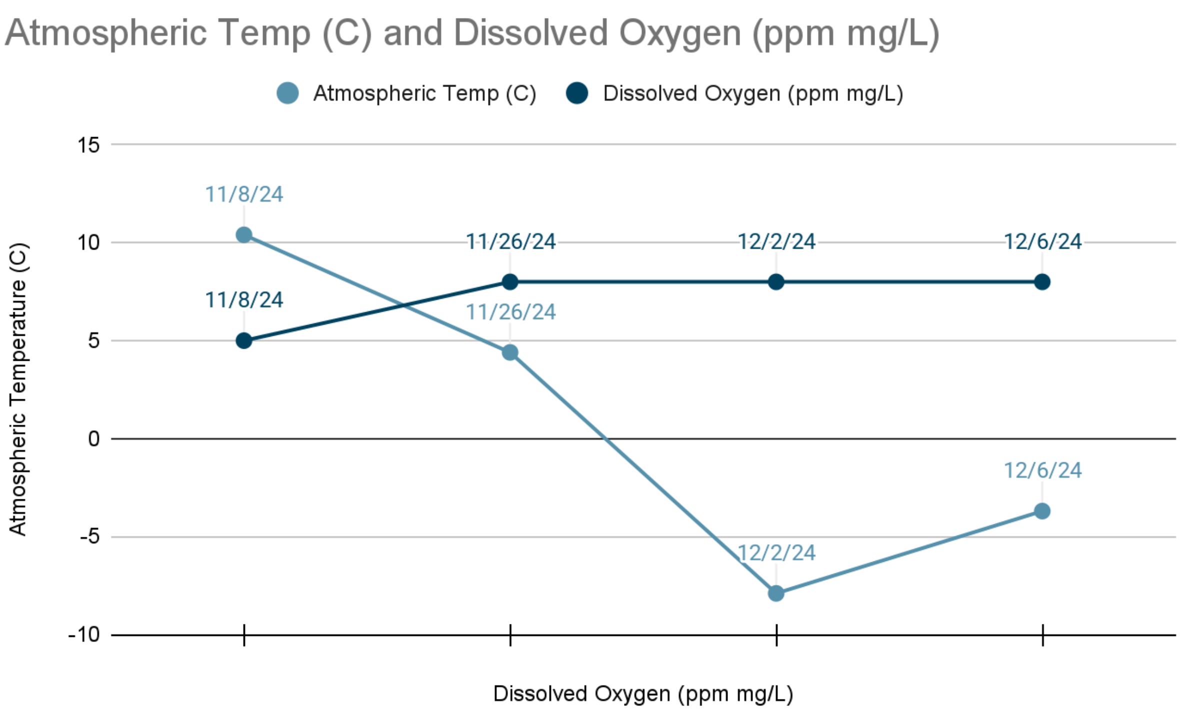

Figure 1. Comparative graph of atmospheric temperature and rate of dissolved oxygen over a 28-day period, measured in degrees Celsius and parts per million / milligrams per liter.

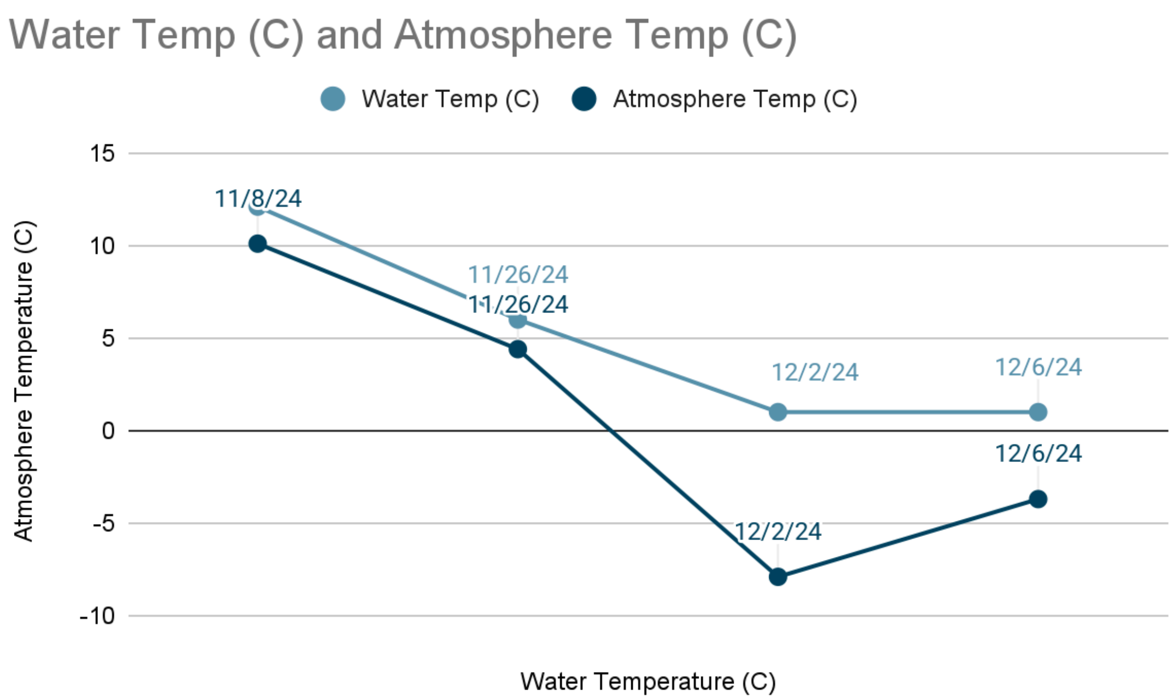

Figure 2. Relationship between water and atmosphere temperature over an approximately month-long period, measured in degrees Celsius.

Our results show a correlation between the air temperature and water temperature. We found a negative correlation between the dissolved oxygen and the atmospheric temperature. Dissolved oxygen was at its lowest point of 5 ppm mg/L when the temperature reached its highest point, at 10.4°C. Beyond a temperature of 4.4°C, dissolved oxygen stopped increasing and remained stagnant (see fig 1.) The dissolved oxygen remained at 8 ppm mg/L when the temperature increased from -7.9°C to -3.7° C, which could be interpreted as an outlier since it could've decreased. One slight outlier in our data is the air temperature had a rapid decline, dropping 12.3°C, the water temperature only dropped by 5° C (see fig. 1 and 2).

Analysis and Results

These results suggest that atmosphere temperature and dissolved oxygen have an inverse relationship. When the temperature reached its highest point of 10.4°C, dissolved oxygen levels were at their lowest point of 5 ppm mg/L. When temperature was at its lowest point of -3.7°C, the dissolved oxygen was at its highest point of 8 ppm mg/L. The dissolved oxygen increased as the temperature dropped throughout winter, showing a negative correlation. The dissolved oxygen levels, however, stopped increasing past a temperature of 4.4°C.

These results supported our hypothesis that if the air temperature decreases, then the dissolved oxygen level will increase. Our results compare similarly to other studies, like Orange County's, that found a negative correlation between D.O. and temperature in sea water. Because our experiment showed a positive correlation between atmospheric temperature and water temperature, we can compare our results with other experiments testing water temperature and D.O. levels. When we graph our results with the x coordinate as atmospheric temperature, and the y coordinate as dissolved oxygen in ppm mg/L, the slope of our line goes from stagnant to downwards. The other experiments show the line as steadily decreasing as D.O. levels increase.

This could be due to our lack of data points, as we only recorded D.O. levels from a temperature range of -3.7°C to 10.4°C, while the graph in the other experiment ranges from 0°C to 35°C. When we found the dissolved oxygen, our procedure used a D.O. kit, which called for a color comparison of the water to a paper, and was a potential experimental error. Overall, our experiment tested our hypothesis well, as we measured the independent variable (atmospheric temperature) and the dependent (dissolved oxygen), keeping our controlled variables the same.

Conclusion

How is the dissolved oxygen level of an ecosystem affected by the surrounding air temperature? From our research, experiments, and results, we have explored this question thoroughly. Based on our initial hypothesis that if the air temperature decreases, then the dissolved oxygen level will increase, because as air molecules slow down, there are less oxygen molecules from water being released into the atmosphere, we were correct. We tested this hypothesis using the Dissolved Oxygen protocol (GLOBE), Water Temperature Protocol, and several tools. These included the Hydrion 5.5-8 Scale paper strips for pH, a standard glass thermometer for water temperature, the CHEMETS Kit Dissolved Oxygen K-7512 for Dissolved Oxygen, along with the Wunderground database for air temperature. These methods and tools allowed us to collect accurate results, which further support our belief that our hypothesis is correct .

The results we drew from the samples showed a clear trend in favor of our hypothesis. Firstly, our DO levels and atmospheric temperature aligned. The dissolved oxygen rates reached their lowest point (5 ppm mg/L) when the temperature reached its highest point (10.4°C). This supports our belief that air molecules will slow down because there are less oxygen molecules being released from the atmosphere, because DO and temperature showed an inverse relationship. Furthermore, beyond a temperature of 4.4°C, dissolved oxygen stopped increasing and remained stagnant. The dissolved oxygen remained at 8 ppm mg/L when the temperature increased from -7.9°C to -3.7° C. This could be interpreted as an outlier since it could've decreased, or could show that dissolved oxygen is only affected by temperature change when it is over a certain amount. This topic could be used as a future research topic for us, and has been researched by several other scientists. In conclusion, our experiment found that the dissolved oxygen level of an ecosystem is indeed affected by the surrounding air temperature.

Discussion

Looking back, our experiment had a few flaws that could be straightened out if a redo of the project was attempted. There are two main questionable areas of our experiment that could be improved upon. Firstly, our amount of data points was not very large. Although the results did not appear to be affected by the number of points we had, if we were to measure the temperature and amount of dissolved oxygen once every day opposed to once every week, the results could have shown greater fluctuation and possibly affected our end results. However, too many data points could have also made us focus too much on the variations in data, which distracts from the general data trend of an inverse relationship between dissolved oxygen and atmospheric temperature. The second possible error that could be revised is the body of water we tested. Although the Ottawa River is not a bad candidate, larger and more populated bodies of water like the Ohio River could have been better candidates due to the larger amount of organisms found in the river, which produce more dissolved oxygen when breathing according to Watershed Academy Web (2009) (pg 4). However, we agree with our decision for using the Ottawa River for this particular experiment, because as we researched negative effects of dissolved oxygen on the environment, we decided that we want to research the body of water that most directly impacts us if it were to become polluted.

Looking forwards, our research could go on to be used in a variety of ways. According to Watershed Academy Web (2009), research on dissolved oxygen is most often used to explore issues like pollution in bodies of water caused by algal blooms that go on to kill organisms due to lack of oxygen (pg 4). However, because of our unique method of incorporating atmospheric temperature with dissolved oxygen, not many studies exist with the same independent and dependent variable, which imposes some problems when looking for other experiments to compare results with. This therefore shows that the relationship of dissolved oxygen and atmospheric temperature should be extended for further study by other scientists in the future. Considering this, there are a handful of other experiments that tested this, such as Watershed Academy Web (2009), which share extremely similar results to us. This alignment shows potential for future experiments on our topic to come to the same conclusions as us.

Acknowledgments

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References

Buha, A. (2011). *The Greenhouse Effect*. Toxipedia. Retrieved January 30, 2025, from https://www.healthandenvironment.org/docs/ToxipediaGreenhouseEffectArchive.pdf

Dissolved Oxygen and Water. (2018, June 5). USGS.gov. https://www.usgs.gov/special-topics/water-science-school/science/dissolved-oxygen-and-water

Dissolved Oxygen in Water. (n.d.). Cyfoeth Naturiol. https://cdn.cyfoethnaturiol.cymru/media/692076/new-information-note-dissolved-oxygen.pdf

The Effect of Climate Change on Water Resources and Programs. (n.d.). Watershed Academy Web. https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=2456

Learn More: Dissolved Oxygen. (n.d.). WaterAtlas.org. https://orange.wateratlas.usf.edu/library/learn-more/learnmore.aspx?toolsection=lm_dissolvedox