How will warming river temperatures affect aquatic ecosystems?

Alexa Potts and Aurora Puskala
Ottawa Hills High School

Abstract

To grasp a better understanding of climate change, we conducted an experiment that compares river temperatures to dissolved oxygen levels. We hypothesised that if river temperatures rise then dissolved oxygen (mg/L) levels will decrease, because as water heats up, its molecules move faster, which weakens the bonds between the molecules and dissolved oxygen, allowing oxygen to return to the atmosphere. To test this hypothesis, collect water from a local freshwater source and obtain a dissolved oxygen kit and a thermometer. Record the dissolved oxygen level and temperature in a data table on the laptop. Repeat this procedure for four trials, each spaced about one week apart, which ensures trials from differing conditions, and more accurate results. To conclude, as river temperatures rose, the dissolved oxygen levels went down. To put our results into context, we assessed how these trends could impact local aquatic ecosystems; as when an ecosystem faces low dissolved oxygen levels it may lead to stress, decreased growth rates, alterations of food webs/balance, migration changes, and even death.

Research Question

How will warming river temperatures affect aquatic ecosystems? This question is important because worldwide ecosystems are being put in jeopardy by rising temperatures. These are interrupting the balance of habitats necessary to our planet, earth. Climate change also endangers many species and alters their metabolism, growth rates, reproduction, migration, and can even lead to mass death. These shifts in ecosystem balance are concerning due to the way they impact human communities in the way they rely on ecosystems for natural resources like; water, food ect. Previously, studies have focused on ocean and global warming, but not the specific impacts of climate change on local aquatic ecosystems, and the societal effects.

Introduction

- Global warming is the ultimate cause that is endangering our ecosystems, and if climates continue to worsen, dissolved oxygen levels will decrease progressively, affecting many aquatic organisms and eventually will pose the threat of extinction or endangerment of many species.
-National Geographic (2019) states, "Current levels of the greenhouse gases carbon dioxide, methane, and nitrous oxide in our atmosphere are higher than at any point over the past 800,000 years, and their ability to trap heat is changing our climate in multiple ways."
-The majority of these greenhouse gases come from fossil fuels; which is the burning of resources like coal, oil and natural gas for electricity, and heat and transportation; like cars, factories, and power plants.
-Another way pollutants are emitted is when the ocean absorbs carbon dioxide from the atmosphere and changes the pH of the water, making it more acidic. Acidic oceans make it difficult for corals, oysters, and other shellfish to build and maintain their calcium carbonate shells and skeletons, which can potentially lead to their decline.
-The reason for preserving nature and limiting pollutants is because all of these gases being released are limiting oxygen levels, and not only affecting all organisms, but even faster impacting the aquatic ecosystems-since warm water cannot hold as much oxygen as cold water.
-The warmer temperatures are killing off important producers like microscopic algae, which are an essential food source for thousands of species. Marine food webs are actively being changed, causing many species to respond to food web alterations such as: shifts in range, distribution, migration routes, and diet.
-To conclude, rising temperatures from global warming are decreasing dissolved oxygen levels in aquatic ecosystems, threatening species and disrupting food webs. Reducing fossil fuel use and pollutants is essential to protect ecosystems and ensure a sustainable future.

Research Methods

Planning Investigations

The samples were taken from the Ottawa River in Ottawa Hills, OH. During the time of the samples, the air temperature ranged from 30 degrees fahrenheit to 60 degrees fahrenheit. The river conditions included, a riverbank made up of soil, rock, and vegetation, a bedrock level made up of unknown sediments, a muddy substrate, submerged vegetation, as well as logs. The water body state was normal at the time the samples were collected.

To conduct this experiment, materials that were used include, a dissolved oxygen kit and probe from CHEMetrics model R-7512, a laboratory style thermometer, a water bucket, a local freshwater source, a beaker, a pipette, and a computer. We used the dissolved oxygen protocol and the water temperature protocol from GLOBE.gov. To make this as concise of an experiment as possible we recorded data in four trials, each spaced about one week apart, which ensured trials from differing conditions, and more accurate results.

Carrying Out Investigations

The procedures carried out were; to measure dissolved oxygen levels, start by collecting water from a local freshwater source in a bucket, filling it about halfway. Next, grab a dissolved oxygen kit and a thermometer. Begin the dissolved oxygen measurement by taking a clean beaker and filling it with 25 mL of the water sample. Insert the clear reactant-filled probe into the beaker, ensuring the small tip is placed at the bottom. Once the tip breaks, allow the fluid in the probe to change color for approximately five seconds. Then, remove the probe from the water, gently tip it up and down about 5 to 10 times to ensure a consistent color. Compare the color's saturation to the provided testers. Then, record the dissolved oxygen level in a data table on the laptop. To measure the temperature, place the thermometer into the bucket of water and wait for the temperature to be consistent. Once it does, record the temperature on the thermometer in the data table on the laptop. Repeat this procedure for four trials, each spaced about one week apart, which ensures trials from differing conditions, and more accurate results.

Before collecting water from a site, make sure the site doesn't have polluted waters that could possibly harm or poison you. When collecting the water, make sure to do it carefully as it poses the risk of you falling in or getting wet. Be sure to break the tip of the dissolved oxygen probe in the water and when you dispose of it, make sure there are no tiny pieces of glass left behind that could cut someone.

GLOBE Badges

Through this experiment, we were **Data Scientists,** as our report includes analysis of our own data as well as from other data sources, including USGS, EPA, NOAA, and IEA. We were able to use both their data and our own to answer questions and solve problems in the regarding our own community. By researching, and studying higher level databases, we were able to develop a greater understanding of the severity of global warming and climate change. We also learned preventatives against climate change, and by analyzing projects that displayed the issue by a larger grade, we were able to recognize the trend between global warming, and mass aquatic organism and habitat death or harm

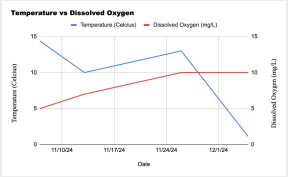
Results

Analyzing Data

To conduct this experiment, materials that were used include, a dissolved oxygen kit and probe from CHEMetrics model R-7512, a laboratory style thermometer, a water bucket, a local freshwater source, a beaker, a pipette, and a computer. We used the dissolved oxygen protocol and the water temperature protocol from GLOBE.gov.

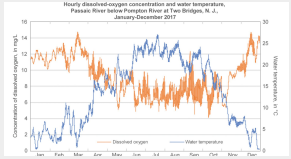
To analyze our data we created graphs to visually compare the tests to each other as well as outside sources. We will also use statistical analysis like standard deviation and standard error of the average.We collected data over 4 different trials. Each trial we sampled 25 mL of water, in order to determine dissolved oxygen levels, as well as collecting temperature data for each of the 4 trials. The number of trials is N=4.

Figure 1



Temperature versus dissolved oxygen data. Collected by Alexa Potts and Aurora Puskala.

Figure 2



Hourly dissolved-oxygen concentration and water temperature collected by USGS.

Discussion

Interpreting Data

If we were to do this project again, there are several ways that it could be improved. First, the data would be more accurate and clear if the data was collected over a longer period of time and more frequently. For example, collecting data 3 times per week for a year. Next, we could have taken three different measurements each time we collected data so we could get the average of the temperature or dissolved oxygen levels per water sample, allowing the data to be more precise and accurate. We also could have collected more data from other freshwater sources and compared them to each other to ensure our experiment's consistency. Our results, although not over a long period of time, still hold a significant amount of meaning that goes well beyond the classroom, as all nations are being affected by global warming and climate change-which is a severe threat. The stress from warming waters and lower dissolved oxygen levels are getting worse daily, and pushing many ecosystems into critical situations, and irreversible damages. A recent study by the Environmental Protection Agency (EPA) demonstrated the many dangers for aquatic ecosystems regarding rising temperatures on an organism's oxygen supply/well being. They were able to conclude that low dissolved oxygen is directly correlated to respiratory distress in aquatic organisms, and leads to the death of many species; like mayflies, stoneflies, caddisflies, and salmonid fish. (EPA, 2024) It also prevents important oxidation and redox reactions, which are essential for the availability of inorganic compounds. Without sufficient dissolved oxygen levels, and reduced inorganic compound availability, many species can't maintain a healthy metabolism. This can cause a chain reaction of issues including; decreased growth, stress, and even death/extinction. If we don't raise awareness and take action, these issues will continue to accelerate, and over time lead to mass fish and species killings. The EPA also states; "Certain human activities, such as agricultural, residential, and industrial practices, can contribute to DO depletion (or, less frequently, DO supersaturation) and subsequent biological impairment" (EPA, 2024). We can act by reducing chemical contaminants, organic loading, fertilizers, landfills, and resource degradation; while promoting sustainability, improving waste management, conserving biodiversity, and restoring ecosystems.

Conclusion

-From our data, we drew the conclusion that as temperatures rise, dissolved oxygen levels decrease, from a series of data collections, proving our hypothesis correct
-During data collection, we controlled the sampling area, time sampled, and used the same temperature probe and dissolved oxygen kit consistently
-By making a line graph, we identified a trend between the two environmental variables, and compared our findings with other published data
-The United States Geological Survey (USGS) found similar results after recording data from the Passaic River, although it was over a much longer period of time
-This experiment could improve by collecting data over a longer period of time and more frequently, taking more measurements, and collected from several sources
-The Environmental Protection Agency (EPA) also demonstrated the dangers for aquatic ecosystems regarding rising temperatures on an organism's, and concluded that low dissolved oxygen is directly correlated to respiratory

Bibliography

Carbon dioxide emissions from electricity. (2024, September 3). World Nuclear Association. Retrieved January 31, 2025, from https://world-nuclear.org/information-library/energy-and-the-environment/carbon-dioxide-emissions-from-electricity
Causes of global warming, explained. (2019, January 17). National Geographic. Retrieved January 29, 2025, from https://www.nationalgeographic.com/environment/article/global-warming-causes
Climate change impacts on the ocean and marine resources. (2025, January 23). EPA- United States Environmental Protection Agency. Retrieved January 16, 2025, from https://www.epa.gov/climateimpacts/climate-change-impacts-ocean-and-marine-resources
Dissolved oxygen. (n.d.). EPA. Retrieved March 3, 2025, from https://www.epa.gov/caddis/dissolved-oxygen#:~:text=If%20DO%20depletion%20is%20significant,a%20problem%20in%20certain%20situations.
Factors affecting dissolved oxygen. (n.d.). PHionics. Retrieved January 16, 2025, from https://www.phionics.com/2021/01/07/factors-affecting-dissolved-oxygen/#:~:text=Temperature%20and%20dissolved%20oxygen%20have,for%20changes%20in%20diffusion%20rate
Methane and climate change. (2022). IEA. Retrieved March 3, 2025, from https://www.iea.org/reports/global-methane-tracker-2022/methane-and-climate-change
NOAA. (2024, June 16). What is coral bleaching? National Ocean Service. Retrieved January 31, 2025, from https://oceanservice.noaa.gov/facts/coral_bleach.html
Poff, N. L., Brinson, M. M., & Day, J. W. (2002, January). Aquatic Ecosystems and Global Climate Change. Center For Climate and Energy Solutions. Retrieved January 16, 2025, from https://www.c2es.org/document/aquatic-ecosystems-and-global-climate-change/
Water Science School. (2017). Temperature affects dissolved oxygen concentrations. USGS. Retrieved February 28, 2025, from https://www.usgs.gov/media/images/temperature-affects-dissolved-oxygen-concentrations