Comparing and Determining Water Quality of the Bronx River Through the Lens of Climate Change

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Introduction

The Bronx River, approximately twenty-four miles long, is the only fresh body of water in New York City. Since the industrial revolution, the Bronx River has been heavily polluted by industrial waste. While there are efforts in place to reduce the amount of pollutants entering the river, urban runoff continues to pose problems. Chemicals like nitrates, carbon dioxide, and phosphates are introduced after rain events which harm marine life (EPA, 2012). The Bronx River Water Coalition and Bronx River Alliance work to improve the quality of the Bronx River. They focus on improving water quality by: limiting storm runoff, controlling the level of sediment entering the water, restorating native vegetation, and managing habitats long term. Despite these efforts, the water quality of the Bronx River still remains threatened. We are interested in the impacts climate change may have on the future quality of the Bronx River.

Climate change causes global rising temperatures, heat waves, and natural disasters like storm surges, hurricanes, and droughts (Brigham, 2019). Storm surges lead to increased amounts of surface water runoff and wastewater which can influence the biogeochemical cycle, contribute to climate change, and conflate its effects (Bouldin, 2020). The presence of chemical pollutants in water has a negative impact on water quality as indicated by: excess algae growth, eutrophication, runoff polluted with herbicides, pesticides, other chemicals, and lower levels of dissolved oxygen (Barber, 2019). Evidence of these water quality indicators can be seen by measuring the levels of carbon, nitrogen, and other pollutants. Poor water quality weakens marine habitats and leads to the loss of biodiversity (Katano, 2013). Biodiversity loss impacts ecosystem functioning and affects human health by creating food insecurity, contaminating drinking water, facilitating the spread of disease, and destabilizing other resources. The same human activities that affect water quality, for example transportation, burning fossil fuel, agriculture, and deforestation, add new variables to the biogeochemical cycles and further worsen water quality. This study looks at how climate change has affected the water quality of the Bronx River and provides data to support future management plans.

Figure 4: Walking to Site 2 to collect water samples

Variable	Definition	Climate Indicator	Impact on Water Quality
pH	How acidic/basic the water is	Climate Change leads to more CO2 in the water which leads to decreased pH, acidifies (McNeal, 2006) can lead to less amount of nutrients, and can corrode metals.	As pH decreases, marine life is affected as aquatic life dies off. Majority live within the range of 6.5-9 pH level.
Temperature	The level of heat in the water	Temperature found to be increasing (Rossi, 2014) along with precipitation.	Temperature affects the rate of photosynthesis for the plants and dissolved oxygen lowers with high temperature. Pollutants can become more toxic with higher temperatures.
Dissolved Oxygen (DO)	Oxygen present in the water	Amount of oxygen in the water seems to decrease. As temperature increase, DO decreases (Taillie, 2019).	If dissolved oxygen is too low, the fish and aquatic organisms die. Concentrations above 6.5-8 mg/L are healthy.
Nitrates	Pollutant level of nitric acid, whose molecular formula is NO3-	Eutrophication can lead to more growth of algae and death in fish (Taillie, 2019)	Marine life is negatively affected, the eutrophication affects aquatic plant growth and changes in animals interacting.
Coliform	Bacteria and fecal matter present	An indicator for pathogenic bacteria and fecal matter, more polluted, fish die off (Taillie, 2019)	Indicator of how harmful the water may be. The presence of pathogenic bacteria may cause disease (such as, E-coli).

Figure 4: Table of variables tested to determine water quality.

Methods

Over the course of a month, we conducted water quality testing of the Bronx River. The variables we tested were as follows: temperature, pH, dissolved oxygen, nitrates, and coliform. Materials used were: camera traps, Go Direct probes (pH, temperature and dissolved oxygen) iPad, La Motte Nitrate Water Testing Kit, La Motte Coliform Testing kit, notebook, pen, tape, Sharpie, 4 sample water bottles, and map for directions. We chose sites that were varying distances from an outfall location to determine if this had an impact on the water quality. Site 2 is not in close proximity to an outfall while site 7 is. Samples were taken at the same times (morning and afternoon).

Water Sample Collection: We collected water samples twice a week for three weeks. On each day we collected two samples, one in the morning and another in the afternoon from our two research sites. After collecting the two samples from the sites, we ran different water quality tests. We used probes to collect measurements for pH, temperature, and dissolved oxygen. We measured nitrate levels using a water testing kit which required adding a mixed acid and nitrate-reducing agent to our sample. The color of the sample would change based on the nitrate level. We used a comparator bar to determine the ppm level of nitrates in the sample, also known as the nitrate N-level. To measure the presence of coliform, we added 10 ml of our water sample to a bottle that contained an indicator reagent. The bottle needed to sit for 48 hours before the indicator reagent changed colors to indicate presence or absence of coliform.

Fauna Tracking: We placed one camera trap at each site to keep track of mammals and waterfowl as species present in the water. Camera traps were left to record the sites for two nights at a time.

Research Questions & Hypotheses

Research Questions: How has climate change affected the water quality in the Bronx River?
Site Level: How does the threat of climate change affect water quality in the Bronx River?
Nested Questions:

- In what ways did Covid-19 affect water quality in the Bronx River?
- In what ways did climate change affect pollution levels in the Bronx River? In what ways has water quality affected vegetation along the Bronx River?
- In what ways has water quality affected vegetation, species diversity (ex: insects), soil type, animal occurrence - waterfowl?

Hypothesis: As climate change brings increased temperatures, water quality will decrease because of decreased dissolved oxygen and pH levels. We also hypothesized as climate change brings increased storm surges, the Bronx River will have increased levels of pollutants such as coliform and nitrates because of increased CSO events. Lastly, we hypothesized if water quality in the Bronx River decreases, then biodiversity of animal and plant species will decrease because poor water quality directly affects an organism's habitat quality and thus their survival.

Figure 4: Geese seen at Site 7

Results

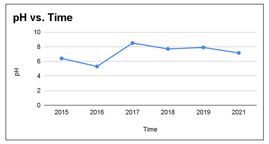

Figure 4: We compared the average pH of the Bronx River from the months of June through August from 2015 to 2021. Figure 2 shows a slight increase in pH over the span of 6 years. The pH started out acidic with a pH of 6.4 in 2015 and was most acidic at a pH of 5.3 in 2016. The pH of the Bronx River then sharply rose to its most basic with a pH of 8.5 in 2017. In 2021, the pH of the Bronx River is slightly more basic than neutral at 7.15. There is a gap in available data for the year 2020 due the COVID-19 pandemic and collection interruption.

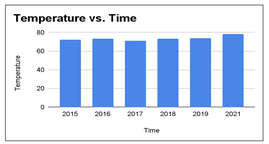

Figure 5: We compared the average temperatures of the Bronx River from the months of June to August from 2015 to 2021. Figure 5 shows a slight increase through the years. The water temperature was at its lowest in 2017 at 71.08° F and its highest in 2021 at 78.38° F - an increase of 7.3° F. There is no data for the year 2020 due the COVID-19 pandemic and collection interruption.

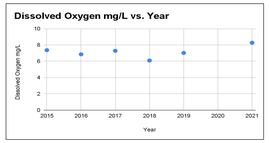

Figure 6: We compared the average dissolved oxygen concentrations from the months of June to August from 2015 to 2021. When comparing the change of dissolved oxygen concentrations from 2015 to 2021, there is an overall increase. In 2018 the dissolved oxygen levels reached their lowest, 6.09 mg/L. In 2019 there is a steady increase in dissolved oxygen levels, at 7.02 mg/L and in 2021 it reaches its peak, 8.27 mg/L. (There is no data for the year 2020)

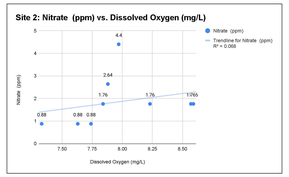

Figure 7: Site 2
Figure 7 shows the relationship between the levels of nitrates and dissolved oxygen in the Bronx River. The trendline shows a positive relationship - as nitrate levels increase dissolved oxygen levels increase. However, the R^2 of 0.068 shows a weak positive correlation between these two variables.

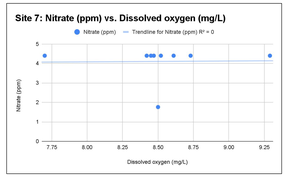

Figure 8: Site 7
The graph shows no relationship between nitrate levels and dissolved oxygen. This is indicated by the R^2 value of 0.

Variable	2021 Status
Water Temperature (Average)	78.38 F
pH (average)	7.15
Nitrate (Average)	2.6 ppm
Dissolved Oxygen (Average)	8.27 mg/L
Coliform (Presence)	100% Presence
Waterfowl Species Abundance	Blue Heron, Raccoons (2), Robin, Geese (16)

Figure 9: 2021 Average
Above is the summary table that includes the averages from 2021 (June - August) for all variables.

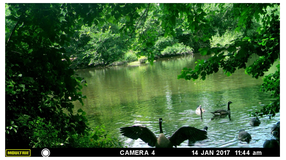

Figure 10: Site 7, July 27 2021 - July 29 2021
Geese swimming in the river, towards the right, as one is stretching its wings out.

Figure 11: Site 2, July 20, 2021 - July 22, 2021
A blue heron taking a step in the water

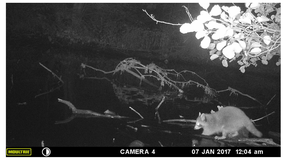

Figure 12: Site 2, July 20, 2021 - July 22, 2021
Two raccoons using branches and logs to wade in the river

Discussion

pH: During the period from 2015 to 2021, average pH levels during summer months in the Bronx River fluctuated between a low of 5.3 and a high of 8.5. Reasons for changing pH levels in bodies of water can include rainfall, surface runoff, sewage outflow, and natural processes such as cellular respiration and photosynthesis. From summer 2016 to summer 2017, there was a noticeable increase in average pH level, meaning the water became less acidic. This may have been due to a decrease in acid rain or rain storms which cause chemical runoff into the river. Additionally, it has been found that nitrification—the process of creating nitrates—can cause water to become more acidic (Wilczak et al. 1996). Since 2017, there has been a steady decrease in pH level in the river.

Temperature: In 2015, the Bronx Rivers' average water temperature was 72.4 F, and it now measures 78.38 F in 2021. A cause for the increase in water temperature could be air temperature/ heat transfer from the atmosphere. It is known that average summer temperatures are rising due to climate change. For instance, The National Weather Service provides data that indicates the average temperature each month of Central Park since the late 1800s. According to historical data provided by The Bronx River Alliance, the months June-August of 2015 to 2020, the average temperature follows a pattern of having a slight increase from 2015 to 2016, followed by a small decrease in 2017 and then a steady increase from 2017 to 2020 (Bronx River Alliance, 2021). From this data, we can see that the average air temperature of June, July, and August from 2015 to 2020 (Figure 9) correlates to the water temperature data (Figure 5) we collected for 2015 to 2021, suggests that the air temperature of the atmosphere has an effect on the water temperature in the Bronx River.

Dissolved Oxygen: From the data collected during the summer months from 2015 through 2021, the DO concentration fluctuates with a high of 8.27 mg/L (2021) and a low of 6.09 mg/L (2018). The factors that lead to this fluctuation in DO, include: water temperature, biological oxygen demand, and fertilizer runoff (Oram, 2014). There was an overall increase in DO, showing that as time goes on the river's water quality is increasing. Comparing the data we collected this summer from sites 2 and 7, the DO is higher at site 7 compared to site 2. The average concentration for site 7 was 8.55 mg/L while site 2 was 8.0 mg/L. One factor that might have influenced this was the temperature of the water. This is because the average temperature for site 2 was 79.84 F versus 76.91 F for site 7. Climate change can lead to unhealthy amounts of DO in water which leads to loss of biodiversity and in extreme conditions no aquatic life in the river.

Nitrates vs. Dissolved Oxygen: As water runs from Site 7 to Site 2, it passes through vegetation which can remove nitrates from the water, thus stimulating plant growth. The increased plant life at Site 2 may be a factor in the lower levels of nitrates found at that site. Also, nitrification can lead to reductions in dissolved oxygen levels (EPA, 2002). This is because oxygen in the water is used in the chemical process that turns nitrogen in the form of ammonia into nitrates (Huron River Watershed Coalition, 2015). Thus, one could predict that, having higher levels of nitrates than Site 7, Site 2 would indicate higher levels of dissolved oxygen at Site 7 as well. Unexpectedly, Site 2 has both lower average levels of nitrates and lower average levels of dissolved oxygen than Site 7 in 2021.

Coliform: The data we collected indicated that coliform was present in the Bronx River. Fecal contamination may be a result of combined sewer overflows, sewage infrastructure failures, inadequate sewage treatment, urban runoff, septic system failures, agricultural runoff, and wildlife (Riverkeeper, 2016). These factors contributed to fecal matter being present in the Bronx River.

Conclusion

We tested various factors that contribute to the quality of the Bronx River's water. Climate change is worsening as highlighted by the research being done to reveal its impacts on ecosystems. By testing the Bronx River's water quality we are able to see the effects climate change is having locally like an increase in water temperature. This research can be taken into consideration when testing water quality in the future and researchers can see how these variables have changed over the years. Along with using the data we collected to compare with future data, other groups could also test variables we were unable to test: such as salinity and conductivity.

The data that we used from Bronx River Alliance was collected from a site which is located inside the New York Botanical Garden and not the Bronx Zoo. There were multiple gaps in available data provided by the Bronx River Alliance, and this should be taken into account when analyzing our data. For example, there is no data for pH or water temperature for 2020; this may be due to the COVID-19 pandemic. We were also unable to compare data over a longer period of time (prior to 2015) because of limited availability of data collected during summer months.
During the process of collecting data at the zoo, there were various limitations. About 2-3 times, we were unable to test the collected samples for water temperature until 15-20 minutes after we collected the water from the sites. This may have allowed the samples to change temperature before we used the probes. Also, when testing our samples for nitrate levels, we were required to reuse the same test tube(s). This may have contaminated our water samples with residue from a previous sample, reagents added to the previous sample, or the tap water that we used to rinse out the test tubes between samples. Thus, the results of each nitrate test may not be completely accurate. Also, the tool used to determine the nitrate level of a water sample needed to be held up under a light source. When comparing the color of the sample to approximate the nitrate concentration, the lighting varied as we were indoors and/or outdoors during testing. This may have led our results to be inaccurate as we could not precisely determine the color of the sample in poor lighting conditions.

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