THE EFFECTS OF RUNOFF ON BLIND BROOK AND ITS POTENTIAL IMPACT ON THE LONG ISLAND SOUND

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ABSTRACT

Eutrophication of the Long Island Sound has become a major environmental issue in recent years. Eutrophication of the Sound is caused, mostly, by runoff that contains nitrogen left by human activity. Input of nitrogen into marine and freshwater ecosystems is only increasing as human populations grow. A runoff water quality study of Blind Brook in Harrison, New York shows that nitrogen is in greater abundance after rainfall. The results of this study did not show that nitrogen levels are in greater concentrations after large industrial areas such as town, airports or major roadways.

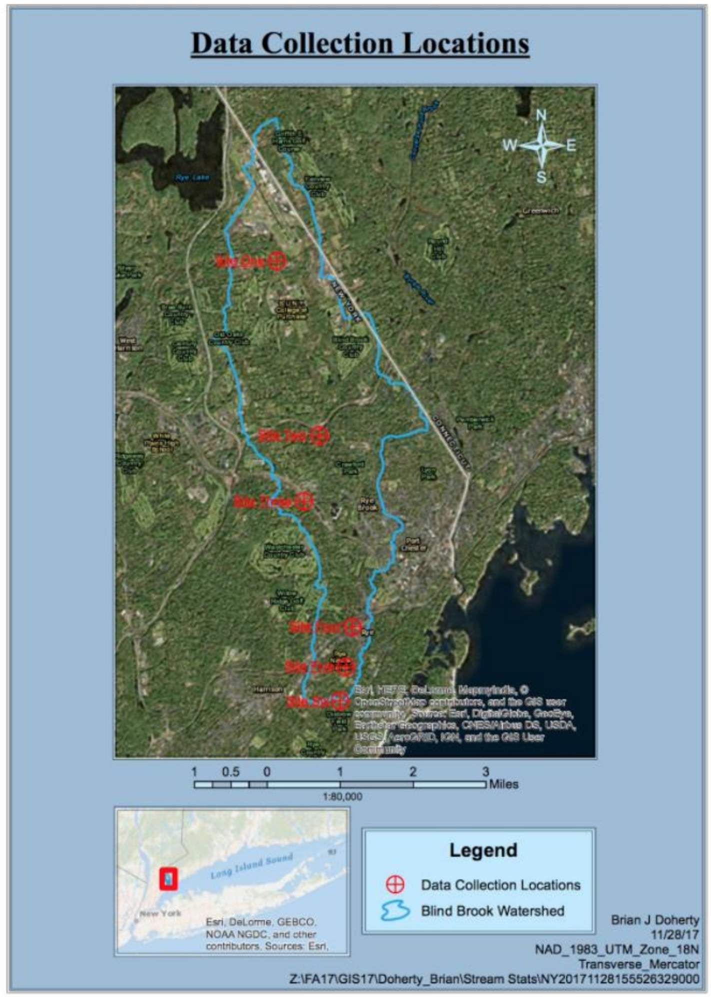
Keywords: Blind Brook, eutrophication, Long Island Sound, runoff, water quality

INTRODUCTION

All life on Earth depends on clean water for survival. This vital molecule has been on Earth for millions of years, untouched and unpolluted. Since the start of the Industrial Revolution, water quality has drastically decreased. Industrialization and the increase of human activity has had major impacts on water supplies and natural ecosystems. Industrialization has decreased pH levels, resulting in acid rain, and increased the levels of nitrogen being deposited into natural bodies of water. This has lead to many downstream problems. An increase in nutrients, such as sulfates and nitrates, results in many sublethal and lethal effects on the organisms living in these ecosystems. Research has proven that excessive levels of nutrients can decrease biodiversity by making the ecosystem less habitable for species that are unable to adapt (Sun et al. 2017).

The Long Island Sound is an estuary, which mixes the saltwater from the Atlantic Ocean and freshwater from nearby rivers. Within its 1,268 square miles, and with some parts being as deep as 299 feet, the Long Island Sound supports a wide range of species. With such a diverse ecosystem, it allows for different communities of organisms to live in unison. Unfortunately, the Long Island Sound has a long history of eutrophication, making it difficult for species to thrive as they once had. Research, that began in the early twentieth century, has shown that there has been a steady decline in water quality of the Long Island Sound due to contamination from anthropogenic sources (Parker et al. 1991). These sources include the weathering of buildings, renovation, demolition, fertilizer and pesticide use, city fires, and traffic. Runoff from roadways and rooftops has allowed for the transport of these contributors and pollutants. Pollutants vary depending on the source, and studies have shown that pollutants from road runoff tend to have a higher concentration of total suspended solids (TSS) and chemical oxygen demand (COD), whereas roof runoff holds higher concentrations of dissolved heavy metals, particularly zinc (Gnecco et al. 2005).

The Long Island Sound is a large basin, receiving water from neighboring states. With runoff coming from miles away, there is plenty of time for pollutants to be collected in large concentrations. Particle bound pollutants, such as nitrates, collect on top of impervious surfaces, which are then easily picked up by stormwater and transported into waterways (Morten Jartun et al. 2008). This collection of nitrogen has created a very serious problem for the Long Island Sound. As a result, the Western Long Island Sound has seen decreasing levels of dissolved oxygen within the last few decades due to eutrophication (Parker et al. 1991). Excess nitrogen stimulates the rapid and excessive growth of algae, outcompeting other plants that then die. Respiring bacteria decompose the dead biomass. With more dead biomass from aquatic plants, there is also a steady increase in bacteria, ultimately causing a decrease in available oxygen for other species. This lack of oxygen can, in extreme cases, lead to dead zones. Known as hypoxia, this lack of oxygen can also lead to a loss in biodiversity by creating less suitable habitats for species and increasing competition for oxygen. Surviving organisms are subjected to stresses that can cause extinction, such as “reduced growth and reproduction, physiologic stress, forced migration, reduction of suitable habitat, increased vulnerability to predation, and disruption of life cycles” (Vaquer-Sunyer et al. 2008).



Map 1: Blind Brook Watershed and Data Collection Locations

Recent research on the Western Long Island Sound has noted that hypoxia is a relatively new issue (O'shea et al. 2000). To conduct further research about the flow of excess nutrients into the Long Island Sound, data was collected from a local stream, called Blind Brook. Blind Brook runs from the Westchester County Airport, through several major runoff sites, such as the Hutchinson Parkway, straight into the Long Island Sound. It was predicted that elevated levels of nitrate would be detected after major roadways and industrial locations, such as airports or towns with high human activity. It was also predicted that there will be a gradual decrease in water quality further downstream.

METHODS

A total of six sites were chosen to be sampled. Choosing evenly distanced sites to sample proved to be difficult due to the fact that Blind Brook often runs through private property. The six sites were spread down the entire length of Blind Brook, starting at Westchester County Airport and ending at the beginning of the marshlands just West of Rye Playland. Data collection was conducted on three days: October 11th, October 25th, and October 29th of 2017. On each day of data collection, several tests were used at each site. A DIGITAL Professional Series, Pro DSS YSI Meter was used to collect the temperature, salinity, TDS, and pH of each site. Before collecting the YSI readings, the sensor sat fully submerged in the water for five minutes, allowing for a more accurate reading. The LaMotte Nitrate-Nitrite kit was used to collect the nitrate levels of each site: two nitrate samples were taken at each site in the field. A HACH Pocket Turbidimeter was also used at each site to collect turbidity levels: two samples were taken in the field. On each day of data collection, two samples of water were collected at each site and stored in a iced cooler for transport back to the lab, where we performed the HACH Dissolved Oxygen Test. These samples were stored in airtight glass bottles to prevent any contamination of oxygen that could alter our readings.

Table 1: Coordinates of Sample Sites

Site	Longitude, Latitude
Site 1	41.0560, -73.7044
Site 2	41.0212, -73.6940
Site 3	41.0082, -73.6938
Site 4	40.9832, -73.6861
Site 5	40.9753, -73.6879
Site 6	40.9686, -73.6895

RESULTS

When organizing the data for each day, the temperature, pH levels, nitrate levels, turbidity, and dissolved oxygen were taken into consideration.

Temperature Results

When reviewing the temperatures of the three collection days, it was found that the average temperature on day one was higher than the average temperatures of days two and three. Temperature on day one averaged out to 18.45°C , temperature on day two averaged out to 17.04°C, and temperature on day three averaged out to 16.53°C.

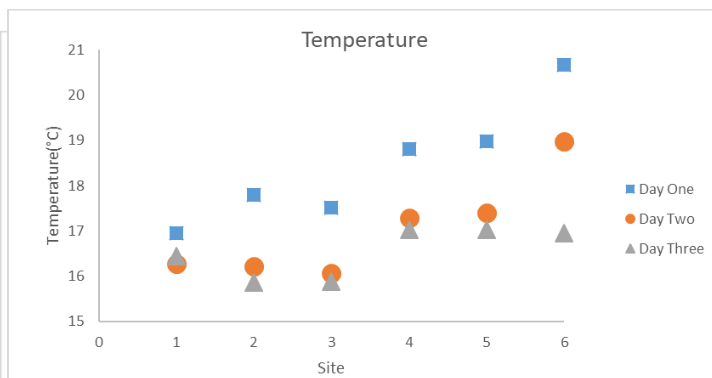


Figure 1: Temperature at each site for each day of sampling.

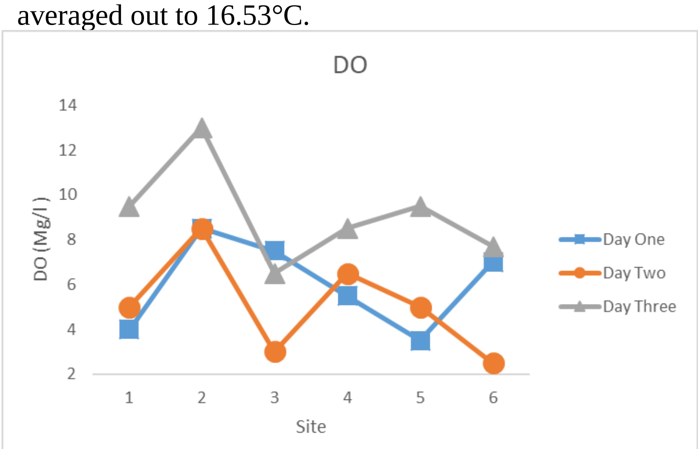


Figure 2: Dissolved oxygen at each site for each day of sampling.

Dissolved Oxygen Results

The average dissolved oxygen on day three was higher than the average dissolved oxygen of days one and two. Average dissolved oxygen of day one was 6 Mg/L, average dissolved oxygen of day two was 5 Mg/L, and average dissolved oxygen of day three was 9.1 Mg/L *pH Results*

The first two days of data collection consisted of an average pH value of 7.11. For day one, average pH value was 7.1 and on day two average pH was 7.12. Days one and two were dry sampling periods, and day three data was taken during a rainstorm which produced 1.68 inches of rain. Average pH of day three was 5.04. During a rainstorm, average pH was more acidic than during dry days.

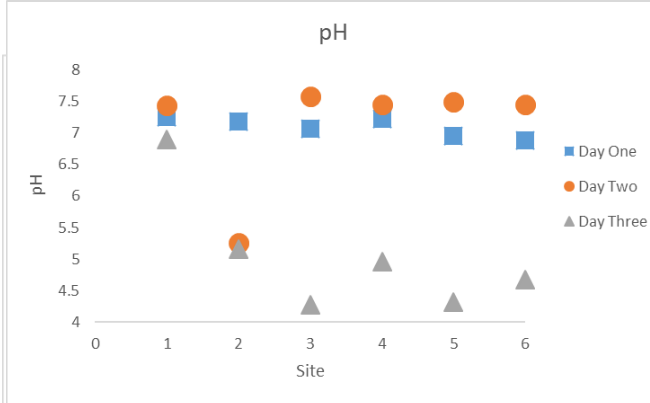


Figure 3: pH levels at each site for each day of sampling.

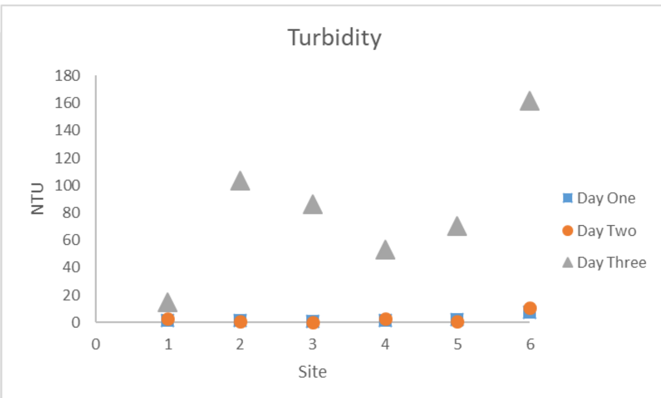


Figure 4: Turbidity at each site for each day of sampling.

Turbidity Results

Turbidity was found to be much higher on day three than on days one and two. On day three, the average turbidity was 81.7 NTU, with the highest value being 161.9 at site 6. In comparison, the turbidity on days one and two were 2.4 NTU and 3.1 NTU, respectively.

Nitrate Results

No levels of nitrate were detected during the first two days of data collection. On day three, a minute level of nitrate was detected, but no nitrate was detected at site one. Sites two through six each had a nitrate level of 1.

Table 2: Nitrate levels at each site based on day of data collection

Location	Day One	Day Two	Day Three
Site 1	0	0	0
Site 2	0	0	1
Site 3	0	0	1
Site 4	0	0	1
Site 5	0	0	1
Site 6	0	0	1

DISCUSSION

The results only partially support the hypothesis. It was hypothesized that elevated levels of nitrates would be detected after major runoff sites, and that water quality will decrease further downstream. While elevated nitrate levels were detected, they were miniscule, and they were only found during a storm event. The first flush, the initial surface runoff of a rainstorm when water pollution entering water bodies is most concentrated, is the only point in which elevated nitrate levels were observed.

Nitrate Discussion. Considerable concentrations of nitrate were not observed during the three days of data collection. The difference in nitrate levels between the three data collection days are most likely due to the increased amounts of runoff from heavy rainfall. The increased runoff allows for more contamination from anthropogenic sources. On day three, nitrate levels were higher downstream. This is likely due to the sources of runoff. For site one, which had no nitrate, the water was flowing directly from the Westchester County Airport. The other five sites were further downstream and closer to major roadways, which could affect the amounts of nitrate. Site one only gets runoff from the Westchester County Airport and above, at the river's source, but site two gets runoff from the Hutchinson Parkway as well as the water that has traveled downstream from site one. Sites further down continue to acquire runoff from various sources. Being closer to major roadways increases the chances that the runoff is contaminated. This is due to a high density of heavy human activity.

High nitrogen commercial products, such as fertilizer and de-icer, quickly become an environmental issue when used in excess. The use of fertilizers has a direct linear relationships with nitrogen overabundance. These products, that are sprinkled on lawns and icy roads, soak into the soil as well as get swept away by water and are deposited into water systems, both fresh and marine systems. It is expected that pollutants from the airport will increase during the winter, when the airport uses its de-icer. Rainfall and snowmelt runoff are the primary mechanism by which airport de-icer enters waterways, and it is shown that higher nitrate and ammonia concentrations coincided with ground frost and snow, suggesting that airport de-icer is a major cause of this (Turnbull et al. 1995). Additionally, it has been shown that pollutant concentrations are higher in winter, not just due to de-icer pollutants, but because snowmelt is an added method of runoff in the winter, and increases corrosion (Helmreich et al. 2010).

A major issue with inorganically produced nitrates, such as deicer, is the bypassing of the natural process of nitrogen fixation. Large scale nitrogen use increases the amount of fixed nitrogen in the environment by directly pumping fixed nitrogen into ecosystems rather than it being regulated by natural cycles. Humans have disrupted the nitrogen cycle by drastically increasing the amount of fixed nitrogen in ecosystems since the 1940's (Bernhard 2010). This excess of nitrogen that is deposited into water bodies, such as the Long Island Sound, becomes available for plants to use after the process of nitrogen fixation. Many microorganisms are capable of breaking apart the fixed nitrogen molecules that are released by humans. This process, known as nitrogen fixation, is necessary for all life on Earth. Unfortunately, an overabundance of nitrogen leads these aerobic microorganisms to constantly fix nitrate into a form plants can utilize. This increased amount of fixed nitrate then leads to an overabundance of marine plants that deplete the oxygen levels, creating harsh environments for marine species. (Taylor pers comm).

pH Discussion. Between the three days of data collection, an interesting relationship was found. On the first two days of sampling, pH was on average 7.09 on day one and 7.11 on day two. The pH on these two days was much higher than that of day three, which had an average pH of 5.04. The first two days of data collection were the dry days. This increase in acidity is most likely due to acid deposition in the form of acid rain. Acid rain "is comprised of sulfuric and nitric acids" and these chemicals "are largely emitted to the atmosphere by the burning of fossil fuels and by agriculture" (Driscoll et al. 2003). These chemicals are either dispersed into the atmosphere as gas or directly transferred into soils. The chemicals dispersed into the atmosphere are the beginnings of acid rain.

When water vapor begins condensing, these chemicals get trapped into the water particles that then are incorporated into rain. Once this acid rain reaches terrestrial and marine ecosystems, it "alters soils, stresses forest vegetation, acidifies lakes and streams, and harms fish and other aquatic life" (Driscoll et al. 2001). Fortunately, the discovery of chemicals that cause acid rain has led to political and societal changes over past decades; this was not always the case. Prior to the discovery of acid rain and its causes, society continued to push technology and business forward blind to the detriments of the by-products. Studies conducted in 1979 have found ice cores from pre industrial revolution have a pH ranging from 6 to 7.6, a healthy pH level for water (Likens 1979). When comparing the pH from these pre industrial revolution ice cores to post industrial revolution water sample, the post industrial revolution sample show a drastic increase in acidity with level of pH near 5. This is due to increased pollution of sulfates into the atmosphere from factories. This discovery reiterates the negative effects humans have had on the environment. We have created acid rain from sulfate pollution. Previously pristine waters have been drastically changed, and this increase in acidity is a direct effect of human activity.

Turbidity Discussion. Turbidity was exceptionally higher on the third day of data collection, when it rained heavily. This is likely because the rain increased streamflow, increasing the movement of sediments and introduced new ones. Site six, when compared to the other five sites on their respective days, has a fairly higher turbidity. This is due to site six being in a tidal estuary. Days one and two were sampled during times of lower tides while day three was taken at a higher tide. This also affected our salinity readings in that site six values were much greater.

Tide Cycle Times

10/11/17 High Tide: 3:54 AM, 4:08 PM

Low Tide:10:11 AM, 11:12 PM

10/25/17 High Tide: 3:25 AM, 3:28 PM

Low Tide: 9:23 AM,10:06 PM

10/29/17 High Tide: 6:56 AM, 7:12 PM

Low Tide: 12:52 AM, 1:12 PM

Temperature Discussion. The changes in temperature over the days are likely due to the weather for that day as well as the current water levels. On day one, the temperature was high 25°C and low 15.5°C , day two 19.4°C and 14.9°C, and day three 19.4°C and 15.5°C. The weather corresponds with the water temperature fairly well. Water levels also probably affected temperature, as the lower the water level, the slower it moves and the easier it is for it to warm. On day one, the water levels were quite low compared to days two and three, and the temperature was fairly higher.

DO Discussion. The results for dissolved oxygen show that on day three oxygen levels were higher than that of the first two days. This increase in dissolved oxygen is most likely due to rainfall. The rain that falls oxygenates the water bodies around it leading to increased oxygen in Blind Brook. The increased rainfall also increases the flow and churning of the water, also causing aeration. One oxygen reading on day three came back as extremely high, but this is most likely due oxygen contamination either during transport or testing in the lab.

Improvements For Future Studies. Although the results didn't show that there were excessive levels of nutrients in Blind Brook, there is still an issue that needs to be solved in the Long Island Sound. More research needs to be conducted to see the full effects of these excessive levels of nutrients on freshwater and marine ecosystems. Further studies on nitrate toxicity should also take other influences, such as salinity, pH, temperature and DO, into consideration when determining the full effects of nitrate on these ecosystems (Julio Camargo et al. 2003). The more research that is conducted about the effects of nitrate and human activity on the Long Island Sound will lead the path for policy change. Such changes can preserve ecosystems for years to come. Without the necessary policy changes, the Western Long Island Sound may become a dead zone, which would impact local ecosystems and the organisms that habitat these ecosystems and would devastate the local economy.

For future studies, it would be beneficial to take samples at different times of day and throughout the year. This study is best suited to be a long term study, so the full effects of seasonal differences and changes can be observed. More sample sites would be ideal, as this would lead to more accurate and indepth data.

CONCLUSION

This study has failed to support the hypothesis that Blind Brook is a major contributor of nitrate levels in the Long Island Sound. The results show that although Blind Brook does transport nitrate, these levels are not above a level of immediate concern. This study also shows a relationship between rainfall and overall water quality. During and immediately after it rains, pollutant concentrations in Blind Brook are significantly higher than usual, suggesting that pollutants make their way into the brook and quickly flow out into the Sound.

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