Comparison of Water Quality in Richland Creek and the Little Harpeth River in Nashville, Tennessee

Joseph Elbon[1,2], Aleyna Loughran-Pierce[1,3], Katie Madole[1,3]

Vanderbilt University[1], MNPS Homeschool[2], Hume-Fogg Academic Magnet High School[3]

INTRODUCTION

Rivers contain 0.49% of the volume of the world's fresh water (Gleick, 1993). While this seems like an infinitesimal portion, rivers support the Earth in an abundance of ways. Historically, humans have always settled near moving bodies of water because of their uses such as irrigation, sources of fresh water, and food sources. Additionally, rivers are home to immense biodiversity in plants, animals, and other organisms, which depend on rivers and streams that host unique habitats vital to these organisms' health and existence. However, as human civilization further develops and advances, these bodies of water have started to become polluted and particularly, for some species, uninhabitable. In particular, as the population of the greater Nashville area increases and urban growth intrudes on natural areas, such as streams and rivers, water health can become questionable due to an influx of pollutants. These natural bodies of water have a significant impact on communities and ecosystems, as they are commonly used to catch groundwater and boost biodiversity.

APPROACH

To compare urban streams to more rural waterways, this study compared water quality from Richland Creek, which runs through a suburban area of Nashville, to the Little Harpeth, which runs through a nature reserve outside of the city. Several different metrics were evaluated in the two creeks, including nitrate, phosphate, and dissolved oxygen levels. Measurements were taken weekly at a single point in both creeks for sixty-second intervals for ten weeks over the span of five months. Water samples were collected weekly for testing at the lab. For statistical analysis, Kruskal-Wallis Non-Parametric ANOVAs were utilized to compare raw water quality data, such as flow. ANCOVAs were conducted to examine the relationships among various pairs of metrics in both streams to understand the dynamics of eutrophication. Additionally, the average of the water quality metrics calculated was compared to EPA standards if they were available (Tennessee Department of Environment and Conservation, 2013). Lastly, a principle component analysis (PCA) was conducted to observe variance in water quality by date in both streams and to determine the degree to which two common independent variables impacted the data collected. All water quality metrics were entered into a PCA, sorted by date, and then divided into two components.

RESULTS AND DISCUSSION

Contrary to expectations, the results revealed no statistically significant differences between the streams among any of the metrics measured, highlighting that despite Richland Creek having a closer proximity to the effects of urbanization, the more rural stream, Little Harpeth, still had similar water quality, as supported by Paul and Meyer (2001). These results raise questions about how the effects of urbanization and human impact may still be affecting water quality, even in more remote areas. Notably, nitrate levels (11.1 mg/L) exceeded the maximum EPA nitrate level standard allowed for fishing and recreational use (10 mg/L) in Richland Creek, indicating potential eutrophication (Tennessee Department of Environment and Conservation, 2019). Furthermore, Richland Creek's proximity to urbanized areas could be connected with the higher observed nitrate levels.

Additionally, Analysis of Covariance (ANCOVA) tests were conducted based on all water quality metrics data. When conducting the ANCOVA using the variables flow and nitrate, it was found that flow had a significant impact on nitrate ($p = 0.03$). Although there was no statistical difference between flow and nitrate in each stream or between the flow of each stream, Richland Creek was observed to have a stronger trend of nitrate increasing as flow increases than the Little Harpeth ($R^2 = 0.42$ and $R^2 = 0.12$, respectively). Further, an ANCOVA comparing nitrate and phosphate highlighted that although there were no statistically significant differences, Little Harpeth demonstrated more consistent nitrate values (8 mg/L) despite phosphate increasing which varied from the trend typically seen in these comparisons as well as Richland Creek (Richland Creek $R^2 = 0.19$, Little Harpeth $R^2 = 0.01$). Additionally, a principal component analysis (PCA) revealed variations in the metrics among the sample collection dates, indicating that more frequent measurements are necessary in order to draw conclusions. Richland Creek's dates were more clustered on the bottom half of the graph, meaning they were more similar. In contrast, Little Harpeth's dates were more spread apart and thus, less similar than Richland Creek. The PCA depicts both streams on opposite sides of the x-axis, suggesting that the streams may not be as different as previously hypothesized. Lastly, suggestions were provided for stream remediation based on field observations and lab results.

INTRODUCTION

- Richland Creek is assumed to have poor water quality[1].
  - Close to urbanized areas
  - Overflow of storm water (sewage)
  - Water withdrawal exceeding intake
- The Little Harpeth River is assumed to be healthier.
  - Goes through Edwin Warner Park, a nature preserve
  - Further from most human impact than Richland Creek
- Rivers and streams are important to the community.
  - Species Biodiversity
  - Drinking water
  - Groundwater used in communities
  - Food sources for both humans and organisms residing in it
- Poor water quality can affect biodiversity of streams and eventually lead to the collapse of ecosystems.
- If we compare these two streams and find that one has better water quality than the other, we can evaluate human impact and modify activities to prevent further damage.
- *Hypothesis: The Little Harpeth will have better water quality than Richland Creek.*

Figure 1: Richland Creek

Figure 2: Little Harpeth

METHODS

- Sampling at both sites every week (February 6 through April 10, 2019 with two summer dates of May 30 and June 3, 2019).
- On Site: Dissolved Oxygen, Flow, and Conductivity were measured using Vernier probes for 60 seconds. Air Temp, Water Temp, and pH were also tested.
- In the Lab: Water samples were collected. Nitrogenous compounds and phosphate were tested for with Hach WaterPerm Chem Test kits. Salinity was tested for with a refractometer and turbidity was tested for with a Vernier probe.
- Site conditions were evaluated using scoring methods inspired by U.S. Department of Agriculture criteria but modified to meet our needs [2].

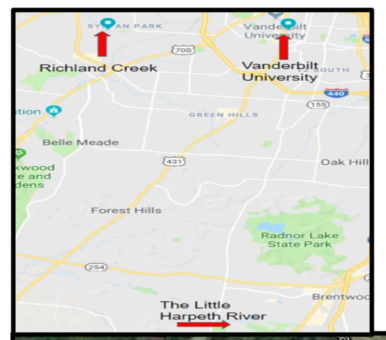

Figure 3: Map of Nashville, TN with sampling locations and Vanderbilt University indicated by arrows.

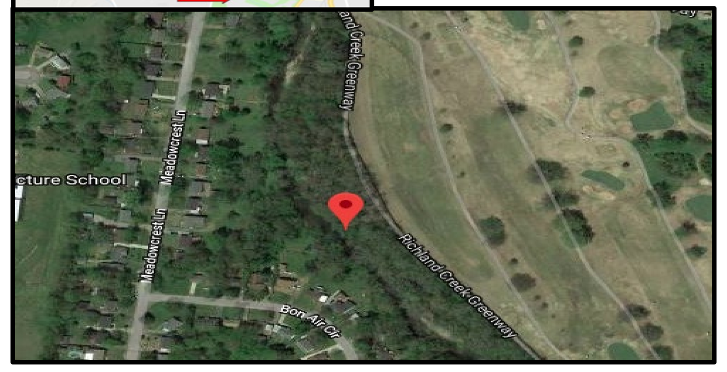

Figure 5: Little Harpeth Sampling Site: (36.050806, -86.917504)

STATISTICAL ANALYSES

- Kruskal-Wallis Non-Parametric ANOVAs were used to compare raw data.
- ANCOVAs were used to analyze relationships among water quality metrics using JMP.
- Water Quality metrics for both streams were compared to EPA standards if available.
- A PCA was conducted on water quality metrics from both streams using MiniTab 2018.

RESULTS

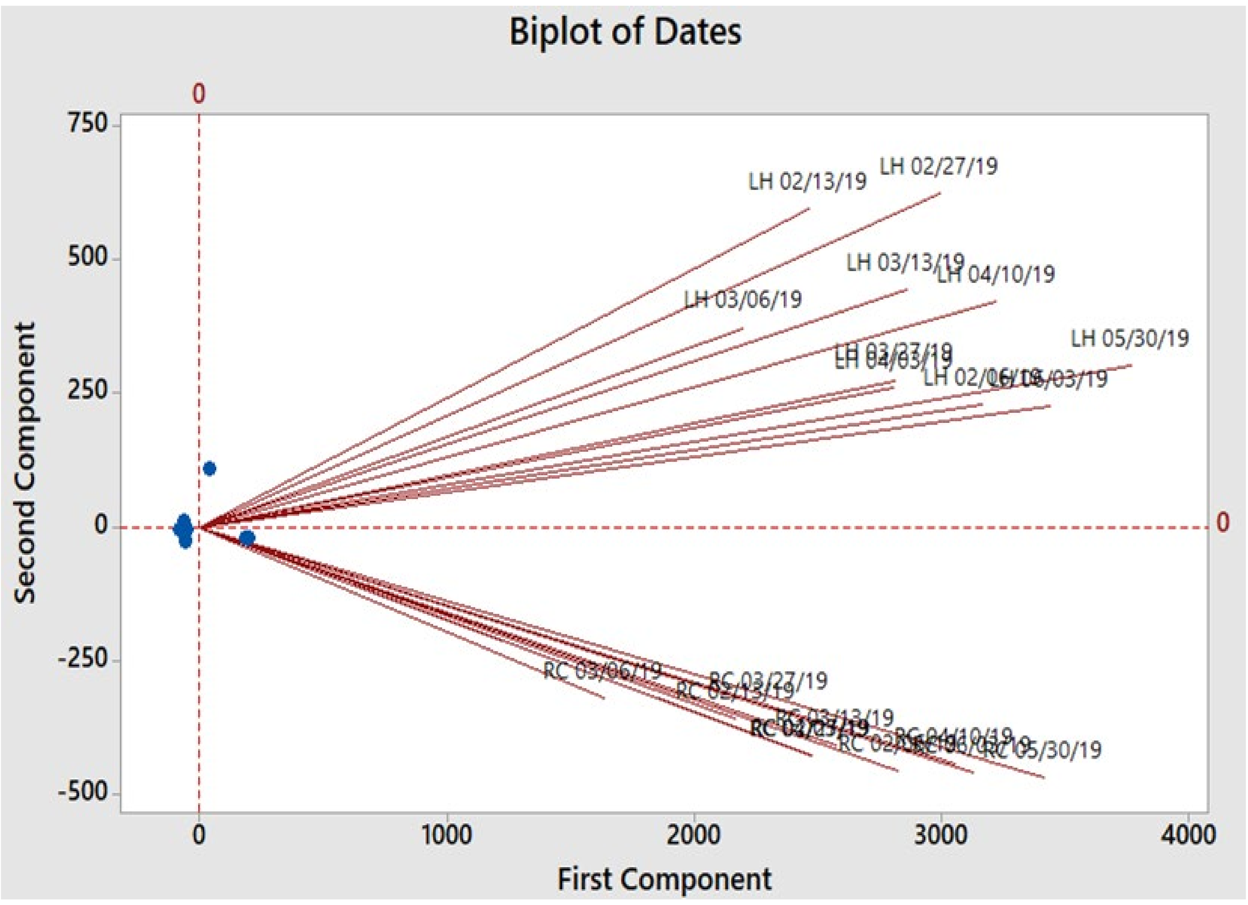

Figure 6: Principal Component Analysis of metrics separated by date.

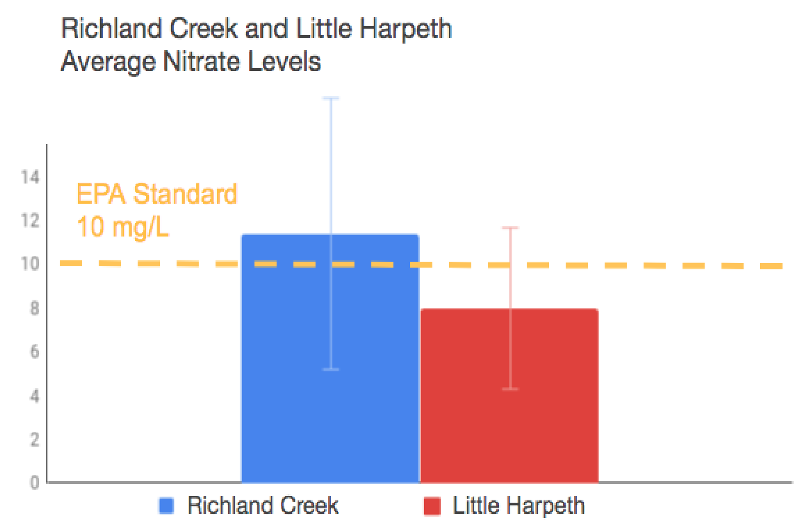

Figure 7: Comparison of Nitrate Averages of Richland Creek and Little Harpeth. Although the streams are not statistically different, Richland Creek still exceeds the EPA standards of less than 10 mg/L of nitrate in streams.

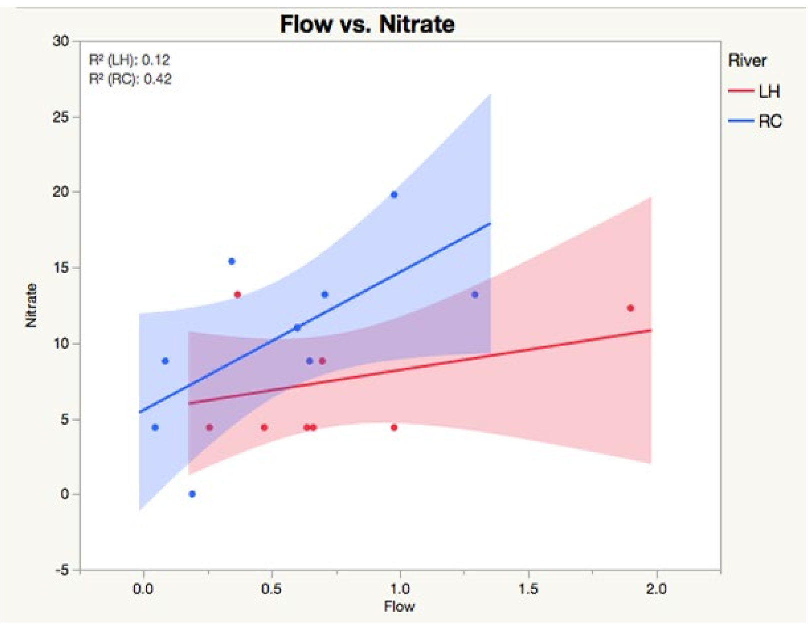

Figure 8: Comparison of Flow to Nitrate in both streams. The R^2 value for Richland Creek is 0.42 and the R^2 value for Little Harpeth is 0.12. Flow: $F_{(3,17)}$= 5.96; p = 0.03; River: $F_{(3,17)}$ =3.88; p=0.07; River*Flow: $F_{(3,17)}$=1.78; p= 0.20

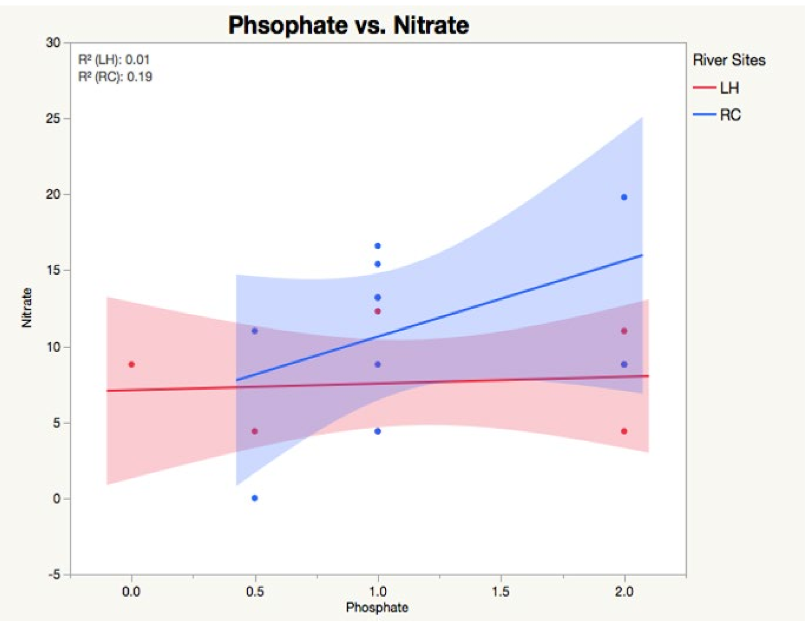

Figure 9: Comparison of Phosphate to Nitrate in both streams. The R^2 value for Richland Creek is 0.19 and the R^2 value for Little Harpeth is 0.01Phosphate: $F_{(3, 19)}$= 1.92; p=0.19; River Site: $F_{(3,19)}$= 2.87, p=0.11; River Site*Phosphate:$F_{(3,19)}$= 1.34, p=0.264

CONCLUSIONS

- We found that creeks are more similar than originally hypothesized.
- Both Creeks were locationally similar in regards to situational factors.
- There was a difference in similarity of dates (Figure 6).
- Limitations:
  - Only collected in one area of each stream per week
  - Malfunctions in probes
  - Access to sites dependent on weather
- Future Directions:
  - Sample more often
  - Increased emphasis on bioindicator diversity
  - Work with organizations to improve health of both creeks
  - Reduce influence of golf courses or sewage leakage
  - Examine seasonality in both streams
- Recommendations for Remediation:
  - Use less fertilizer, or explore alternative fertilization methods (organic).
  - Change pedestrian areas near river to avoid excess nitrate leaking into water.
    - One of the best ways to do this would be to use elevated wood boardwalks instead of asphalt.
  - Avoid modifying the riparian buffer.

Figure 11: Richland Creek on February 6, 2019

Figure 12: Richland Creek on June 3, 2019

ACKNOWLEDGEMENTS

Thank you to Dr. Haag, the SSMV, the Richland Creek Watershed Alliance, Metro Nashville Parks and Recreation and Warner Parks, Dr. Due- Goodwin, Jimmy Smith, Dr. Deweese, and Dr. Chris Vanags.

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Contact: Katie.Madole@Vanderbilt.edu