A Water and Soil Analysis to Assess Vulnerability of Biodiversity, of a Campus Riparian Zone, to Human Activities.

Team: Jayci Robbins, Isa Rodriguez, Emily Torres, Luca Ferrara

Izzy Almas, Lael Alvarado, Ty Cleveland, Andrew Jones

All Saints' Episcopal School

The GLOBE Program — Global Learning and Observations to Benefit the Environment

Abstract

Riparian zones are important ecosystems with high ecological value. The health of these ecosystems is important for the organisms that live there. Our campus RANGE contains a riparian zone and this study focused on collecting soil, water, and macroinvertebrate data from 3 separate sites to assess its health and thus the biodiversity of the habitat. Our results indicated human activities impacting Dissolved Oxygen levels as well as a macroinvertebrates diversity that allowed us to determine the quality of water which ranged from excellent to poor across the study site.

Research Question

- How does human activity impact the vulnerability of biodiversity to pollutants?
- We believe this question captures the breadth of our study by considering the outcomes of certain human activities that occur on or around our campus and the dependent variable, biodiversity.

Introduction

- All Saints' Episcopal School is surrounded by a beautiful riparian zone. Our campus' diverse natural sites have been negatively impacted by outside influences such as residential housing, a fracking site and heavily fertilized sports fields.
- The importance of our research is to assess the vulnerability of biodiversity in different areas of our campus' riparian zone. Our goal is to use our findings to inform our community of issues that may be occurring and what can be done to limit impact on these natural zones.
- We have found through our research review that excessive moisture can increase the mobility of certain contaminants, such as pesticides, heavy metals, or chemicals from fertilizers allowing them to be transported through soil and potentially contaminate groundwater or surface water ("Soil and Water Relationships," EPA).
- The chemical characteristics of water such as dissolved oxygen, phosphates and nitrates play a crucial role in the health and survival of macroinvertebrates, which are small organisms like insects, crustaceans, and worms that inhabit aquatic environments ("Indicators: Benthic Macroinvertebrates," M.Callisto et.al.).
- According to the University of Arkansas at Pine Bluff's "Understanding Your Fish Pond Water Analysis Report" (Stone & Thomforde, n.d.), Macroinvertebrates have specific pH requirements, and deviations from their preferred pH range can significantly impact their survival. Acidic or alkaline waters can disrupt the internal pH balance of organisms, impairing their metabolism, reproduction, and overall health.

Research Methods

Site Selection and Research

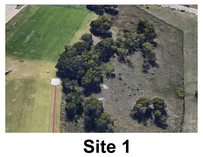
- Three sites were selected along our campus riparian zone. Sites were selected based on GLOBE Protocols and proximity to anthropogenic activity. Site leads were chosen to monitor data collection.
- Once sites were selected, *Site Definition Sheets* were completed for each, focusing on site type, hydrosphere and pedosphere.
- Background research was completed to determine the scope of testing and to identify specific field and lab protocols that would be used.
- Samples were collected in the Fall of 2022 and Spring of 2023.

Campus Riparian Zone in Blue

Field methods

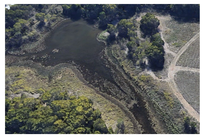
Three activities were performed at each site:

1. Soil Samples using the *Depth Profile Soil Moisture Protocol.* Containers were labeled on site. Soil samples were taken at 5, 10, 30, 60 and 90 cm.
2. Water samples using the *Hydrosphere Protocols and Data Sheets.*
3. Macroinvertebrates were collected using the *Freshwater Macro-invertebrate Sampling* and *Multi-habitat Freshwater Macroinvertebrate Protocols.* A 1m x 1m Quadrat was used in sampling. Samples were kept in trays with water from the site collected.



Site 1

Site 2



Site 3

Lab Methods

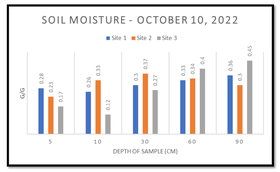
- Each soil sample was massed and dried in a 105° oven for 12 hours and massed again to determine the % water. Moisture data for each site was recorded on the *Soil Moisture Data Sheet.* Data were compared to SMAP data collected on the same date and time.
- Water samples were tested for Dissolved Oxygen(DO), Nitrates, Phosphates, and pH using LaMotte Water Test Kits. Data for each site was recorded on the *Hydrosphere Investigation Data Sheet.*
- Macroinvertebrates were place in petri dishes, identified and counted using the *Freshwater Macroinvertebrate Identification Data Sheet.*
- Macroinvertebrate data were entered into the Stroud Biotic Index Calculator to determine the Pollution Tolerance Index Score and Pollution Tolerance Index Rating.

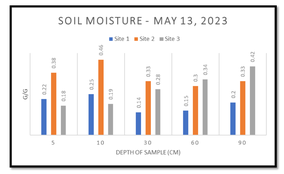
Results

Soil moisture data show:

- Soil moisture across all sites were within typical ranges between 0.05-0.50 grams of water per gram of dry soil per GLOBE Gravimetric Soil Moisture Protocol.
- Soil moisture increases as the depth of sample increases.
- Soil moisture tends to vary greatly to 10cm between Fall and Spring values for Site 2.

Figure #2 Soil Moisture Data

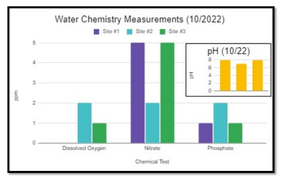




Water chemistry test data show:

- DO levels in Sites 1-3 were at or below 2 ppm.
- Nitrate levels in Site 2 were at 5ppm for both sample periods
- Nitrate levels for Site 3 were a 5 ppm from first sample period and 0ppm at the second.
- Nitrate levels in Site 2 rose from 2 ppm to 5 ppm between sampling periods.
- pH in sites 1 and 3 were slightly alkaline

Figure #3 Water Chemistry Data



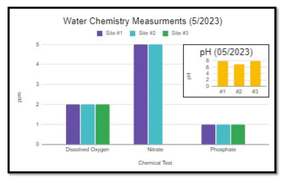
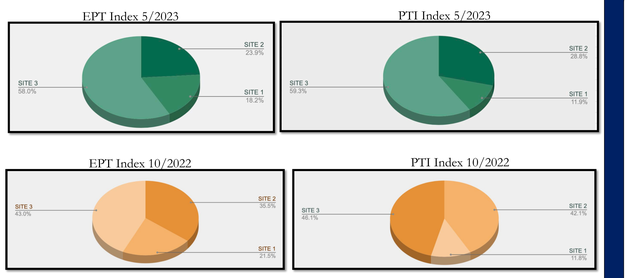


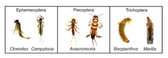
Figure #4 Macroinvertebrate Sampling Data – Organisms collected 10/2022 and 5/2023



Macro-invertebrate collection and identification data show:

- Site 3 had the highest EPT index values at 43% and 58% and the highest PTI index values 46.1% and 59.3%.
- Site 1 had the lowest EPT index values at 21.5% and 18.2%. PTI values were 11.8% and 11.9%.

EPT Index is the total number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) divided by the total number of individuals across all taxa. Many species within these three groups are sensitive to changes in water quality. In general, the more EPT taxa, the better the water quality.
The Pollution Tolerance Index (PTI) is a comparison of the abundance of taxa and their tolerance to environmental stress. The index can indicate organic and nutrient pollution. The higher the PTI, the better the water quality.



Discussion

The most impactful results from our study are:

1. DO levels at Sites 1-3 were all at or below 2 ppm. Values of 5-6 ppm are required for normal growth and activity in aquatic life. Values below 4 ppm negatively impact macroinvertebrates. Values below 2 ppm will not support aquatic life. Macroinvertebrates, like other aquatic organisms, rely on dissolved oxygen in the water for respiration. Insufficient oxygen, often caused by pollution, eutrophication (excessive nutrient enrichment), or high-water temperatures can lead to hypoxia (low oxygen) conditions. These conditions are detrimental or even fatal to macroinvertebrates. A freshwater study conducted by Tampo et.al looked at a total of 21 water quality parameters including DO. The researchers found that low DO often indicates the presence of organic pollution and nitrates in the water.

2. Macroinvertebrate diversity and population data show a correlation between the distance from sources of pollution and water quality. Based on EPT and PTI data, Site 1 (closest to sources) had the lowest water quality, whereas Site 3 (furthest from sources) had, by far, the highest water quality. Site 1 had an EPT of 21.5% and PTI Index value of 11.9%. This means organisms that are sensitive to pollution cannot thrive at this site. Site 3 had the highest EPT (58%) and PTI Index of 59.3% providing better water quality for sensitive organisms. Sites 1 & 2 are most likely being impacted by pollutant runoff from the fracking site, residential areas, and fertilized sports fields on campus. These three sources of pollutants are nearest to Site 1 (lowest biodiversity) and farthest from Site 3 (greater biodiversity).

3. Site characteristics also seem to play a role in biodiversity susceptibility to pollutants. Sites 1 and 2 have greater inclines and are surrounded by concrete surfaces contributing to increased runoff. Site 3 is much flatter, has less tree cover, and more ground cover allowing water to infiltrate into the soil. Site 3 is also more of a wetland with an abundance of cattails. Research by the USGS shows that wetlands and specifically cattails, aid in reducing the amount of pollutants in the water.

Conclusion

- Our conclusion, based on the data collected, is that the biodiversity of the RANGE riparian zone is vulnerable to pollutants from human activities, specifically in the areas of DO and macroinvertebrate diversity.
- Our study can be improved by increasing sampling throughout the year in order obtain a more thorough assessment of the cycling of nutrients and pollutants in our study area.
- Our data supports research indicating the benefits that wetlands play in removing pollutants.

Bibliography

References

- GLOBE website and any other literature GLOBE Protocols used are listed in Research Methods section; GLOBE.gov
- Stroud Biotic Index Calculator, https://leafpacknetwork.org/biotic-index/
- Global Water Sampling Project, https://ciesc.org/curriculum/waterproj/
- Berezina, Nadezhda. (2001). Influence of Ambient pH on Freshwater Invertebrates under Experimental Conditions. Russian Journal of Ecology. 32. 343-351. 10.1023/A:1011978311733.
- Tampo et.al, Macroinvertebrates as Ecological Indicators: Their Sensitivity to the Water Quality and Human Disturbances in a Tropical River, https://www.frontiersin.org/articles/10.3389/frwa.2021.662765
- USGS Importance of Cattails in Wetlands, https://www.usgs.gov/media/videos/importance-cattails-wetlands#:~:text=Despite%20the%20negative%20impacts%2C%20cattail,the%20production%20of%20biofuel%20material.

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