Assessing Rice Creek water quality using stream macroinvertebrates

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ABSTRACT

Riverine health can be approximated using abundance and diversity of macroinvertebrates. Abundance of sensitive macroinvertebrates, biodiversity of macroinvertebrates on natural and artificial substrates, and abundance of macroinvertebrates on natural and artificial substrates were measured to approximate the health of Rice Creek, Oswego, NY, a creek branching off Lake Ontario. There are significantly more non-sensitive macroinvertebrates than sensitive macroinvertebrates (p=<0.0001). Diversity of macroinvertebrates are poor and significantly different between substrates (p=0.04). Abundance of macroinvertebrates are significantly lower in wood chip and plastic substrates (p=0.03).

INTRODUCTION

- Freshwater health is important because it offers a wide variety of services to the human population (Hanna et al, 2017). These ecosystem services, services that provide a benefit to humans (Wallace, 2007), fall into four different categories; cultural, provisioning, regulating, and supporting (Hannah et al, 2017).
- **Cultural services** are nonphysical benefits such as recreational activities, the beauty of nature, and spiritual fulfillment. **Provisioning services** are benefits from materials obtained directly from the ecosystem such as drinking water and fish. **Regulating services** are benefits from regulating forces within the environment such as water purification and erosion prevention. Lastly, **supporting services** are benefits from processes that are required for all other benefits such as nutrient cycling (Hanna et al, 2017).
- Riverine health can be assessed by using select chemical and physical tests (Norris and Thoms, 1999).
- Another way to approximate riverine ecosystem health is through macroinvertebrate abundance and diversity (Sumudumali, 2021). Low biodiversity is linked with low ecosystem services and thus low ecosystem health (Oguh et al, 2021).
- Benthic species of macroinvertebrates are good models for water quality due to their increased sensitivity to pollution (Kenny et al, 2009). Common sensitive species found in central New York that can be easily identified include aquatic snipe flies (Athericidae family), dobsonflies (Corydalinae family), alderflies (Sialidae family), riffle beetles (Elmidae family), waterpennies (Psephenidae family), stoneflies (Plecoptera order), and mayflies (Ephemeroptera order, Stroud Water Research Center).
- Riverine health may change in the future if plastic pollution were to continue. Plastic is a poor substrate and feeding source for macroinvertebrates in streams(Ferreira, 2024).
- Plastic pollution is a large problem affecting the Great Lakes (Mason et al, 2020).
- Lake Ontario has the highest amount of surface level plastics of all the Great Lakes, over five times as much as the second most polluted (Mason et al, 2020).

Objective

- I investigated abundance of sensitive and non-sensitive macroinvertebrates
- I investigated if the type of substrate affected the diversity and abundance of macroinvertebrates

Hypothesis

- Abundance of sensitive macroinvertebrates will be lower than abundance of tolerant macroinvertebrates.
- Overall biodiversity will be low, especially in plastic substrates.
- Abundance of macroinvertebrates will be lower in plastic than other substrates.

METHODS

- Experiments were conducted from September to early October at Rice Creek Field Station in Oswego, New York.
- Four different types of substrate (oak leaves, ash leaves, natural wood chips and plastic) of a standardized mass were put into mesh bags (n=16 each).
- Bags were tied shut and placed in two locations along the creek (low current, vegetation and stronger current, cobbles).
- After three weeks had passed, bags were recollected and brought back to the field station for assessment.
- Individual macroinvertebrates of each taxonomic group were counted within the bag.
- Due to time restraints and a limited number of researchers only a handful of bags were able to be processed.
- For vegetation, (n=5) oak leaves, (n=4) ash leaves, (n=5) wood chips and (n=4) plastic were processed. For cobble site, (n=3) oak leaves, (n=2) ash leaves, (n=2) wood chips and (n=3) plastic were processed.
- All data were analyzed by Graphpad Prism (La Jolla, CA).
- ANOVA was used to analyze abundance per substrate, a paired t-test was used to compare abundance of sensitive organisms versus non-sensitive organisms and the Shannon Index was used to measure biodiversity. ANOVA was used to test for differences between Shannon Indexes of each substrate.
- Shannon diversity index is an index used to quantify diversity by taking into account species richness and evenness. To calculate, find the proportion of each species within a sample, multiply it by the natural log of that proportion and then multiplying the sum of each calculation with a sample by negative one (Odum, 1971).

RESULTS and DISCUSSION

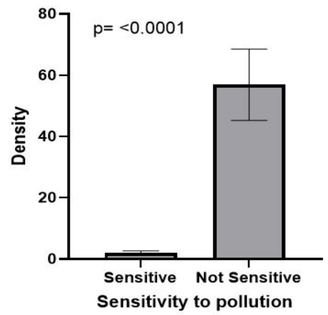

Figure 1. Abundance of pollution sensitive and pollution tolerant macroinvertebrates at Rice Creek, Oswego, NY. P-value is for t-test, error bars are standard error of the mean.

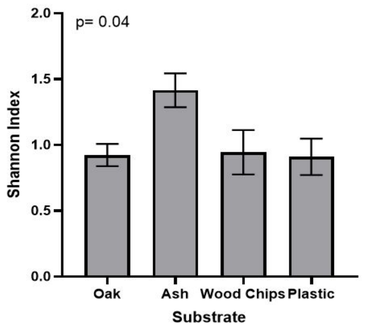

Figure 2. Shannon diversity Index for macroinvertebrates in four substrate types (oak, ash, wood chips, plastic) at Rice Creek, Oswego, NY. P-value is for ANOVA, error bars are standard error of the mean.

Sensitivity

- Low abundance of sensitive macroinvertebrates compared to non-sensitive macroinvertebrates can be a sign of poor water quality (Kenny et al, 2009).
- Poor water quality is an important concern because surface level freshwater is a valuable human resource (karr and Dudley, 1981, Keller et al, 2012).
- Even though this analysis focused on easily identified sensitive macroinvertebrates the clear difference is a concern for Rice Creek water quality.
- Significant difference between sensitive species and non-sensitive species (t=4.701, df=54, p=<0.0001, error bars are SEM, figure 1).

Biodiversity

- Samples whose index is under or around 1.5 are considered low in diversity (Ortiz-Burgos, 2016). Since none of the samples reach an index of two, biodiversity in Rice Creek is poor.
- Having low diversity implies an unhealthy ecosystem with a limited number of ecosystem services (Oguh et al, 2021).
- None of the indexes reach two and there is a significant difference between substrate types (F=3.144, p=0.04, error bars are SEM, figure 2).

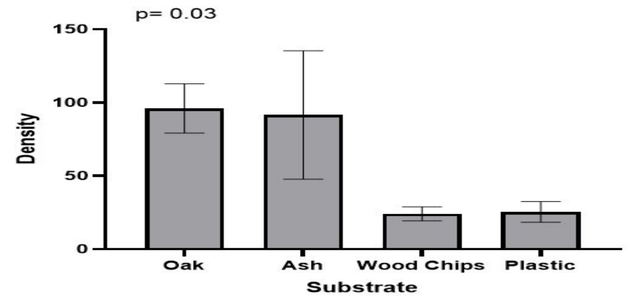

Figure 3. Abundance of macroinvertebrates for oak, ash, wood chip and plastic substrate. P-value is for ANOVA, error bars are standard error of the mean.

Abundance per substrate

- Plastic and wood chips have a lower abundance than oak or ash, implying that those substrates are not favored (F=3.534, p=0.03, error bars are SEM, figure 3).
- This is worrying if plastic pollution continues to enter the Great Lakes system. It is estimated that 10,000 metric tons of plastic enter the Great Lakes every year, with most of the plastic in Lake Ontario being microplastics, plastics under 5 mm (Mason et al, 2020).
- Plastics are poor substrate and lethal to some macroinvertebrates if ingested (López-Rojo et al, 2020).

Future Research

- Additional research on concentrations of plastics in Rice Creek and general water chemistry will help establish baselines for macroinvertebrate communities and water conditions.
- Approximating riverine health using macroinvertebrates, while a good start, does not replace proper water testing (Karr, 1991).
- An effort should be made to clean up the Great Lakes to avoid biodiversity loss in the form of macroinvertebrates. Microplastics are lethal to some macroinvertebrates so they should be cleaned up to avoid local extinctions (López-Rojo et al, 2020).
- River, stream and creek health is often positively correlated with the health of the entire watershed (Wang et al, 2011).

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