The Use of Ephemeroptera, Plecoptera and Chironomidae as Indicators of Total Phosphorus Water Quality in the Winooski and Lamoille River Basins

Stowe High School Team – Kelly Chambers and Connor Meehan –Teacher Advisor: Don McDowell

Total Phosphorus:
Accumulation in Streams

Phosphorus is an essential element to life within streams and other bodies of water, but when there is too much of it the process of eutrophication (a reduction in dissolved oxygen in water caused by an increase in nutrients) is sped up. This can create an oxygen-deprived environment within aquatic environments, causing certain organisms to struggle for survival. Excess phosphorus enters water largely due to human activity – it is a common constituent of agricultural fertilizers, manure and organic wastes in sewage and industrial effluent. Therefore soil erosion is a major contributor to phosphorus levels, especially bank erosion during floods (Hurricane Irene hit Vermont hard this past fall). By comparing our version of the EPT index to phosphorus levels, we were able to identify the macroinvertebrates that could or could not endure such oxygen-deprived environments and analyze them as indicators of water quality.

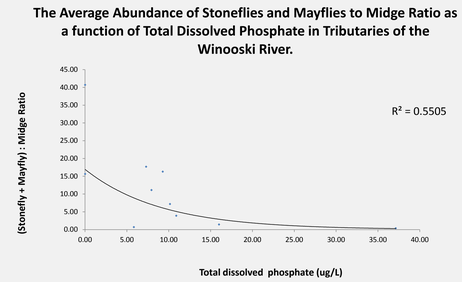
Abstract

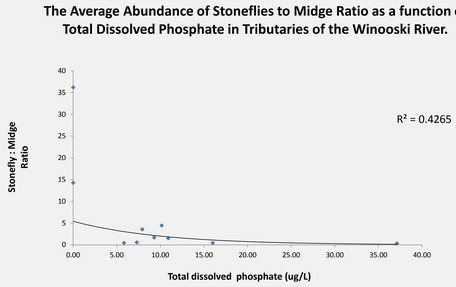
After noticing the abundance of certain types of benthic macroinvertebrates as we sorted through the samples from our own streams, we decided to use a form of the commonly used EPT index to decide which macroinvertebrates were the best indicators of water quality within two river basins in the Lake Champlain Watershed. The EPT index is calculated as the sum of the number of macro invertebrates belonging to the orders of Ephemeroptera, Plecoptera and Trichoptera divided by the total number of midges (Diptera: Chironomidae).

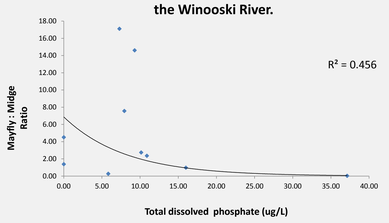
Our own samples had limited numbers of Trichoptera, so we instead focused on the Ephemeroptera and Plecoptera as indicators of water quality in a ratio against the Chironomidae found in each sample. Water quality was assessed only in the context of the total dissolved phosphorus (ug/L) found in the streams (other water quality data such as E. Coli and TSS had very small amounts of data). Limited by the amount uploaded field data on the VT Streams Project database, we ended up using 10 streams from the Winooski River Basin and 9 from the Lamoille River Basin that had usable data for both phosphorus levels and macroinvertebrates (and also with elevations higher than 350 feet). Elevation was important to us because we wanted to compare similar stream sites in order to limit the number of variables affecting phosphorus levels and macroinvertebrates.

The six graphs to the right display the Ephemeroptera and Plecoptera to Chironomidae ratios separately and combined for each of the river basins. By fitting an exponential function to the data, we determined the level of correlation between macroinvertebrate abundance and phosphate concentration in an attempt to determine the best indicator of water quality.

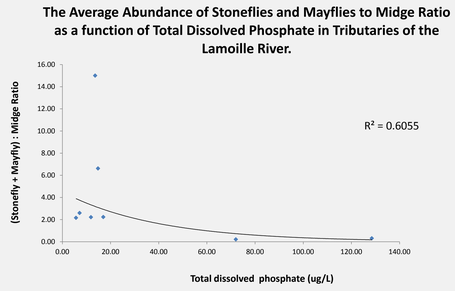
Winooski River Basin

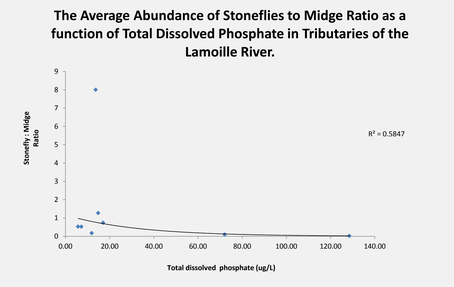


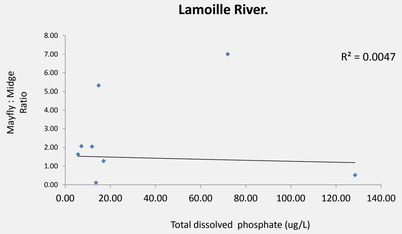




Lamoille River Basin







Midges

The Chironomidae, or midges, are worm-like creatures found in streams across Vermont. They are known for their abundance in polluted streams, primarily because of their high tolerance of excess nutrients in comparison to other macroinvertebrates. In their larval state, midges are an important part of the food chain. A molecule similar to hemoglobin can be found in their blood, which allows for the midges to survive in environments with low oxygen levels. As a result, they are often found in streams with lower quality water, which is often characterized by low oxygen content and high nutrient levels. The midges are frequently nestled within the detritus of a stream, so they are constantly exposed to toxins found within the stream's organic matter. Water quality can be judged based on the abundance of midges found within a body of water. Put simply, Chironomids are often found in environments where eutrophication has begun.

Mayflies

Mayflies, or Ephemeroptera, are known for having a mixed tolerance for water quality. Therefore, they are not as indicative of good or poor water quality as Plecoptera and Chironomidae. However, they are generally thought to have more stringent living conditions than other macroinvertebrates, meaning they usually act as good water quality indicators. To judge water quality, the *sum* of Ephemeroptera, Plecoptera and Trichoptera is often compared to the abundance of Chironomids in a stream. Mayflies, caddisflies and stoneflies, have external gills that are relatively intolerant to low dissolved oxygen concentrations.

Stoneflies

The order Plecoptera, stoneflies, are known for being excellent water quality indicators. "Plecoptera is one of the best indicators of human interventions in streams" (Krno 2007). They are given this title because of their low tolerance for oxygen depravity. The Plecoptera, along with Ephemeroptera, have external gills that require large amounts of oxygen to satisfy oxygen needs. As a result, these macroinvertebrates cannot survive as well as chironomids in lower-quality bodies of water. This relationship can be used to draw conclusions regarding the overall water quality in a stream. High levels of Plecoptera and low levels of chironomids mean good water quality. High levels of Chironomids and low levels of Plecoptera mean poorer water quality.

Conclusion

The above graphs display the compilation of data we created to determine if stoneflies and mayflies were accurate water quality indicators when related with total phosphorus levels. It was consistent throughout both river basins that the ratio involving both mayflies and stoneflies gave the strongest correlation. However, when graphed separately, it can be concluded that in general the stoneflies were better indicators of water quality. Though the correlations were similar within the Winooski River Basin, a distinct difference was present between the R-squared values of stoneflies and mayflies in the Lamoille River Basin - with an R-squared value of 0.5847 and 0.0047respectively. In conclusion, the EP:C ratio was predictive of water quality as defined by phosphate concentration and stoneflies seemed to be the most significant indicator.

Streams Used in Our Analysis

Winooski River Basin
- WR_JoinBrk_360
- WR_AlInBrk_361
- WR_CrstBrk_467
- WR_GoldBrk_952*
- WR_SlBrk_711
- WR_SlBrk_714
- WR_ThchrBrk_1251
- WR_MillBrk_754
- WR_MillBrk_940
- WR_WBLRTribA_725*

Lamoille River Basin
- LR_BrewRv_1048
- LR_BrwnRv_535
- LR_BrwnRv_859
- LR_DeeBrk_365
- LR_WiBranch_1212
- LR_TribA_374
- LR_FrnchHl_922
- LR_GihRiv_476

*The Stowe High School Team was responsible for collecting water samples and macroinvertebrate data for these streams

Water Quality Sources

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Picture Sources

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