The Effects of Physical and Chemical Water Quality Parameters on the Distribution of Aquatic Invertebrates within the Carmans River on Long Island, New York

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Abstract

While the Carmans River is one of few pristine aquatic ecosystems on Long Island, New York, roadside run-off, fertilizers, septic systems and groundwater contaminants all threaten to degrade its condition. Using physical and chemical variations of water quality in addition to benthic macro-invertebrate distributions, the ecological integrity of the Carmans River can be more accurately attained. Sensitive populations such as invertebrate species serve as indicators of biological integrity and can be useful for identifying problems in water quality. Using a Surber sampler, aquatic invertebrate samples were collected. Samples were then preserved, sorted, and identified using a compound light microscope and taxonomic keys. A YSI 650 MDS electronic water quality meter was used to measure the real-time water data. By comparing the data collected from each site, invertebrate distributions were correlated with environmental parameters. Annual variations were determined through a statistical comparison of results from 2008 and 2009 data sets. Activities such as sampling in the same exact locations, kayaking, fishing, and other disruptions could have been an element in shifting the results. Seasonal sampling may be a more effective alternative which would give the river a longer recovery time between sampling activities. Using data from this investigation, areas of concern can be targeted for future projects to improve water condition of the Carmans River.

Introduction

Aquatic insects have been a major focus of ecological studies in freshwater habitats for over 100 years. Invertebrate populations play important roles in the functioning of freshwater ecosystems and directly affect human welfare. Invertebrates regulate rates of decomposition, water clarity, and nutrient cycling in lakes, streams, and rivers [2]. Macro-invertebrate assemblages are good indicators of localized conditions because many benthic macro-invertebrates integrate the effects of short-term environmental variations and have limited migration patterns or a sessile mode of life. Because of this they are particularly well-suited for assessing site-specific impacts (upstream-downstream studies) [4].

The water quality-based approach to pollution assessment requires various types of data. Biosurvey techniques, such as the rapid bioassessment protocols (RBPs), are best used for detecting aquatic life impairments and assessing their relative severity [5]. Habitat quality is an essential measurement in any biological survey because aquatic fauna often have very specific habitat requirements independent of water-quality composition [1]. Habitat alteration is a primary cause of degraded aquatic resources. Therefore preservation of an ecosystem's natural physical habitat is a fundamental requirement in maintaining diverse, functional aquatic communities in surface waters [3].

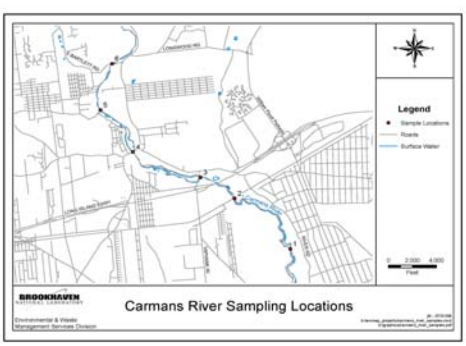
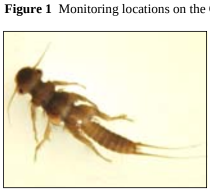
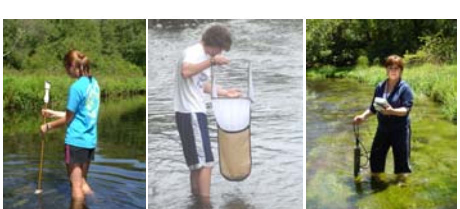


Figure 1 Monitoring locations on the Carmans River.

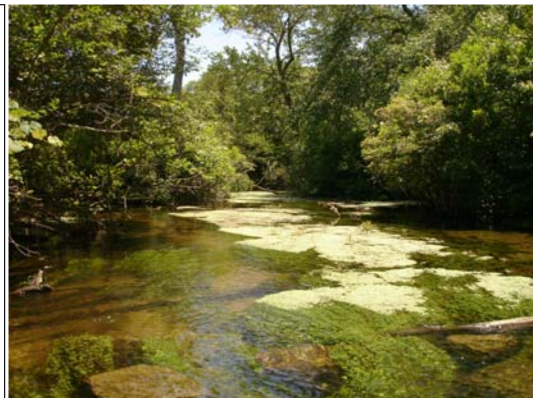


Plecoptera (Stonefly Larva)

Tricpotera (Caddisfly Larva)



From left to right; Mellissa Winslow using the flow probe, Glen Bornhoft with the Surber sampler, and Vicky Giese with the YSI meter.



Carmans River, Site 5, Warbler Woods

Methods

A YSI 650 MDS probe was used to obtain real-time field data at site locations weekly. The average water velocity for the habitats (riffles, runs, and pools) at each site was measured using a Flow Probe. In the laboratory water samples were analyzed using a HACH digital titrator and tested for nitrite, nitrogen, alkalinity, acidity, and total, Ca and Mg hardness. Analysis for nitrite, nitrate, ammonia, phosphorous, and suspended solids were accomplished using a HACH colorimeter.

Full samples of aquatic invertebrates were obtained using a Surber sampler at each site and habitat. Samples were carefully sifted using a standard testing sieve from 180 µm down to 45 µm. The aquatic invertebrates were then picked from the sediment using a compound light microscope. The samples were then sorted into groups by taxonomic order and preserved in 70% ETOH solution. The biodiversity was calculated for each site and habitat using the Shannon Diversity Index. In addition to full sample analysis, rapid bioassessment was conducted in order to reinforce the results. Data collected from 2008 and 2009 were correlated to show trends between years.

Shannon Diversity Index: $$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Results

Water quality data collected weekly was averaged for each location along the Carmans River for 2008 and 2009. Although 2009 averages for DO are relatively higher than 2008 results, both years show decreasing trends from downstream to upstream. Average temperature increases from site 1 to site 4, and decreases from site 5 to 6 for both 2008 and 2009. The average water velocity decreases from the riffles, to runs, to pools.

Results from ammonia, nitrite, nitrate, and phosphorous showed little variation between all six sites and the variance between these values were deemed negligible. Calcium and magnesium hardness tend to follow a linear trend with little fluctuation between sites. The alkalinity concentration shows a slight bell curve for 2008. There is an inverse relationship between alkalinity and acidity concentrations for 2008. The alkalinity and acidity data for 2009 was inconclusive and therefore not used.

Diversity indices were calculated for each full sample based on the macro-invertebrate taxonomy at the order level. In figure 2, diversity indices from full samples 1 and 2, as well as from the rapid bioassessment procedure were correlated with habitat type. In 2008, biodiversity decreased from site 1 to site 6 (Figure 2). However, in 2009, there was not a significant difference in diversity between sites 1 through 6 (Figure 2). There is not a consistent correlation between diversity results derived from a comparison of the sampling techniques (Figure 2).

In order to determine the relationship between water quality and diversity the data was correlated with water temperature. In the run habitats, there is a direct relationship between temperature and diversity and there was not a well defined relationship between temperature and diversity in the riffle and pool habitats.

From the water quality and invertebrate data collected in both 2008 and 2009 the diversity and velocity correlation was determined. Velocity can be positively correlated to diversity in the run and pool habitats and negatively correlated in the riffle habitats from 2008 data. In 2009 there was a positive correlation between velocity and diversity in all three habitats.

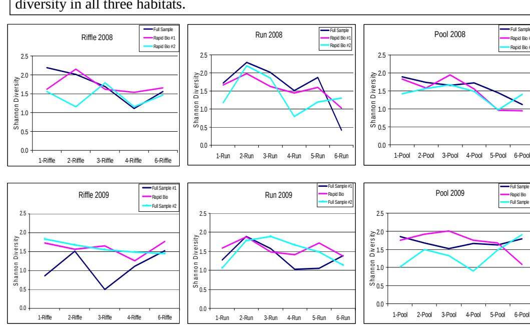


Figure 2. shows correlation between full sample 1, rapid bioassessment, and full sample 2 diversity by habitat type for 2008 and 2009 data collections.

Discussion

Comparison of water quality data with EPA and DEC standards for rivers that fall into the "AA" category such as the Carmans River showed that both DO and pH readings fell within the standard range. DO readings from 2009 were considerably higher than 2008. In 2009, pH readings were slightly more acidic than 2008 which may be due to the excessive amount of precipitation during June 2009. In 2008, conductivity steadily increased downstream except for site 6. In 2009 the averages for each site were within a smaller range. Storm run-off could have the potential to impact the waters natural conductivity readings within the river.

The findings for nitrite, ammonia, and nitrate levels were dramatically lower than the standard averages recommended by the EPA for both 2008 and 2009. This indicates that the Carmans River is generally well protected from excess fertilizers. Ca and Mg hardness, which compensate for total hardness had low averages for all six sites and show a similar trend between 2008 and 2009. Total hardness acts as a buffer to stabilize the acidity and alkalinity of the river.

An ANOVA test was performed to correlate statistical differences between the diversity results from 2008 and 2009. The outcome showed a 90% confidence interval that all samples in 2008 and 2009 were the same. The variance of 2009 diversity is much less than the variance of diversity in 2008.

The statistical analysis for diversity and water temperature did not show a high correlation between the two parameters. It is evident that the upper and lower lakes have an effect on the diversity of riffles and pools but do not significantly affect the diversity of the run habitats. It is possible that the biota will react differently to temperature based on the habitat type. There was also not a significant correlation between diversity and velocity by habitat for 2008 and 2009.

Irregular data in 2009 could have been the byproduct of disturbances to the river bed. Activities such as sampling in the exact same locations, kayaking, fishing, and other disturbances could have resulted in variations in the data. Seasonal sampling may be a more effective alternative which would give the river a longer recovery time between sampling activities. Future planning will focus on recapping the six designated sites concluding if there are any variations in water quality, water chemistry, and/or macro-inverebrate biodiversity.

Diptera (Black Fly Larva)

Citations

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