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 a few pristine aquatic ecosystems on Long Island, roadside run-off, fertilizers, septic systems and groundwater contaminants all threaten to degrade its condition. Sensitive populations such as invertebrate species serve as indicators of biological integrity and can be useful for identifying problems in water quality. The physical and chemical variations in water quality were compared for six different locations and among three habitat types selected along the Carmans River. Water samples taken at each location were then tested in areas of varying water velocities. A Yellow Spring Instruments (YSI) 650 MDS water quality meter was used to measure the real-time data for temperature, pH, dissolved oxygen, conductivity, and turbidity. Water samples were analyzed using a HACH Company Digital Titrator and colorimeter. Using a Surber sampler, aquatic invertebrate samples were collected, preserved, and then sorted and identified using a compound light microscope and taxonomic keys. Rapid bioassessment, another technique used to assess invertebrate diversity provided supplementary data needed to create a more accurate biodiversity index. By comparing the data collected from each site, invertebrate distributions were correlated with environmental parameters. The results from this experiment showed that with movement downstream, the diversity of invertebrates increases with increasing habitat complexity, as expected. Also, from our data it can be concluded that upstream locations are more affected by runoff and other sources of contaminants than downstream locations. Using data from this initial investigation of the Carmans River, areas of concern can be targeted for future projects to improve water condition.

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 primary production, decomposition, water clarity, thermal stratification, and nutrient cycling in lakes, streams, and rivers [2]. Macroinvertebrate assemblages are good indicators of localized conditions because many 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].

After analyzing the acquired data, the similarities and differences among the six sites selected along the river (Figure 1) as well as the three habitats within each site were compared. Habitats were selected based upon water velocity measurements.

Figure 1 Monitoring locations on the Carmans River.

Aquatic Invertebrate: Tricoptera (Caddisfly Larva)

Carmans River, Site 5, Warbler Woods

Methods

A Yellow Spring Instruments, Inc. (YSI) model 650 MDS probe was used to obtain field data on pH, turbidity, conductivity, dissolved oxygen (DO) and temperature at the site locations weekly. The average water velocity for the habitats (riffles, runs, and pools) at each site was measured using the Flow Probe (FP101). Water samples were obtained weekly for six weeks at each site and habitat. In the laboratory the water samples were analyzed using a HACH Digital Titrator Model 16900 and tested for nitrite, nitrogen, alkalinity, acidity, calcium (Ca) and magnesium (Mg) hardness, and total hardness. Analysis for low range nitrite along with Nitrogen (NO_3) was accomplished using a HACH kit model DR 890 colorimeter.

Full samples of aquatic invertebrates were obtained using a Surber stream bottom sampler at each site and habitat. Samples were carefully sifted using a standard testing sieve from 180 micrometers down to 45. The aquatic invertebrates were then picked from the sediment using a Nikon SMZ800 high-powered, compound microscope. The samples were then sorted into groups by taxonomic order and the specimens were placed in labeled specimen vials with 70% ETOH solution. The biodiversity was calculated for each site and habitat using the Shannon Index. In addition to full sample analysis, two trials of the RBP were conducted in order to reinforce the results. This was done through a comparison of the invertebrate biodiversity produced by these two methods.

Results

Water quality data collected weekly was averaged for each location along the Carmans River. The averages for conductivity and DO show a decreasing trend from site 1 to site 6, from downstream to upstream, where as pH and Turbidity shows an increasing trend starting from site 1 upstream to site 6. Average temperature seems to increase from site 1 to site 4, and decreases from site 5 to 6.

The average water velocity decreases from the riffles, to runs, to pools. The riffles have the highest water velocity at 2.34 ft/sec, runs have a moderate velocity of 1.17 ft/sec, and pools have a low water velocity of 0.41 ft/sec.

The highest concentration of nitrite is at the most upstream location in the Carmans River, at 0.016 mg/l, and the lowest is at the most downstream location, at 0.006 mg/l. Nitrogen concentration also follows an increasing trend from site 1 to site 6, the highest concentration of nitrogen is upstream and the lowest measured concentration is downstream. Calcium hardness and magnesium hardness tend to follow a linear trend with little fluctuation between sites. Total hardness appears to be the highest at sites 3 and 4 at an average of 40 mg/l and the lowest at sites 1 and 6 with an average hardness of 38.3 mg/l at site 1 and 34.4 mg/l at site 6. Concentrations of acidity and alkalinity from sites 1 through 6 show an inverse relationship.

Diversity indices were calculated for each full sample based on the macroinvertebrate taxonomic order. The invertebrate distribution results using the Shannon-Weiner equation showed a general trend that as velocity increases between habitat types (riffle, run, and pool), diversity and richness also increases. The biodiversity is the highest at site 1 which is the most downstream location and the lowest at site 6, which is the most upstream location on the Carmans River. Generally, pool habitats have the lowest diversity index out of the three habitats and riffle habitats have the highest diversity (Figure 2). Diversity indices for trials one and two for the rapid bioassessment method of invertebrate sampling also shows a decreasing trend from upstream samples to downstream samples.

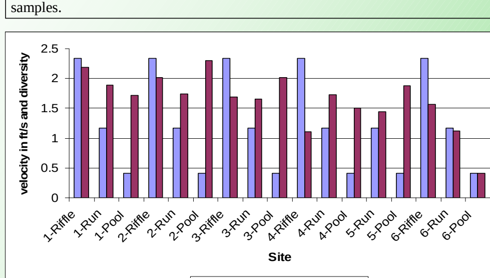

Figure 2 shows the invertebrate distribution from the full sample method from sites 1 through 6 along the Carmans River compared with the average velocity for each habitat.

Discussion

With movement downstream the pH and turbidity decreases as the DO increases. These alterations could be due to a larger amount of run-off entering the sites located further upstream. The high levels of turbidity could be due to human activities, variation due to the weather, or phytoplankton growth, which all increase the sediment content in the water. Conductivity on the other hand was steadily increasing downstream except for site 6. Storm run-off could have impacted the waters natural conductivity readings at that precise location.

The findings for nitrite and ammonia/nitrogen levels were dramatically lower than the standard averages recommended by the EPA. There is a noticeably higher value for both nitrite and ammonia/nitrogen within site 6 which could be due to the abundant amount of run-off it receives from the roadside. The calcium and magnesium hardness, which compensate for the total hardness have relatively low averages for all six sites. Together, the calcium and magnesium hardness act as a buffer to stabilize the acidity and alkalinity of the river.

As expected, the diversity of benthic macroinvertebrates increases with water movement downstream. This is due to the increasing complexity of microhabitats downstream from the water source. Increased habitat complexity has generally been found to increase species richness and diversity at whatever spatial scale, both in freshwater and in terrestrial communities [3]. The location of site 6 at East Bartlet had an effect on the invertebrate diversity because of direct runoff of roadside contaminants. It is evident that the nitrite and nitrogen concentrations were significantly higher at this site than at the other five. The rapid bioassessment method for collecting macroinvertebrates provided less definitive results. Trials 1 and 2 were comparable; each site and microhabitat had similar diversity indices for both.

This research is the initial investigation of a longitudinal study, which may be used for management of the Carmans River. There are plans to examine the sites and see if there is variation between each season. Future planning will focus on recapping the six designated sites annually concluding if there are any variations in water quality, water chemistry, and/or macroinverebrate biodiversity.

Aquatic Invertebrate: Diptera (Black Fly Larva)

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