Using Benthic Macroinvertebrate Families for Monitoring in the Upper Main Stem of the Susquehanna River: Is Family-Level Identification Adequate?

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Introduction

- Benthic macroinvertebrates (BMI) are significant indicators of river health (Flotemersch, et al. 2006) and integrate environmental conditions over annual cycles.
- Diversity of the BMI taxa allows for tolerances to pollution to be assigned (Hilsenhoff, 1988).
- Non-wadeable rivers have rarely been monitored due to high variability between reaches and complex substrate mosaic (Flotemersch, et al. 2006).
- Both active and passive sampling methods are used in order to capture the BMI samples that varied in times of collections and results.
- Passive methods of biomonitoring BMI include artificial habitats using natural substrates that they colonize until collection following six weeks (Johnson, et al. 2006).
- Active methods include disturbing the substrates using D-frame nets utilizing stream flow for the immediate capture of the BMI.
- This research focuses on the efficacy and comparison of three BMI collection methods along the same reach of a large, non-wadeable river during a long-term assessment of the upper main stem, along the North and West Branch Plumes, of Susquehanna River.

Site Description

- The sample sites are accessible through Shady Nook in Hummels Wharf, PA about seven kilometers below the confluence of the North and West branches of the Susquehanna River (Figure 1).
- The samples were collected along the west shore in the West Branch Plume (WBP; Site 1) as well as the east side of the channel in the North Branch Plume (NBP; Site 2).
- The sample locations are physically as well as chemically distinct in the WBP and NBP.

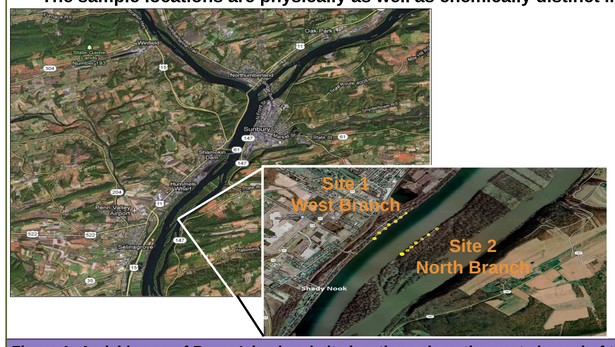

Figure 1: Aerial image of Byers Island and site locations along the west channel of the upper main stem of the Susquehanna River. The active methods were employed in six locations at each site, 100m apart and above the passive sites. The passive methods were used in the most southern location on either side.

Active Collection Sites

- Six sites were designated 50m above the primary sites across a 500m reach.

Passive Collection Sites

- Site 1 receives water from the WBP.
- Site 2 receives water from the NBP.

Abstract

Benthic macroinvertebrate (BMI) families were collected as part of a longstanding monitoring program each summer and fall, from 2009 to present, on a reach of the Susquehanna River between Selinsgrove and Sunbury, PA, at Byers Island, near Shady Nook. The transect occurs below the convergence of the North and West Branches of the Susquehanna River, and they mix only weakly such that both branches can be identified by distinctive values of conductivity, turbidity, alkalinity, and pH. During this study during fall 2014, BMI collections were made both actively, using D-nets by directly kicking the river bed, and also passively using Hester-Dendy samplers and rock baskets, which were both immersed in the river for 6 weeks. Overall, Family Richness for these sites was moderately low: active sampling collected 12 BMI families, while passive sampling found 5. In samples taken by active means, Chironomidae dominated in Site 1 ($\bar{x}$=36.7%), while those in Site 2 were dominated by Heptageniidae ($\bar{x}$=26.7%). Chironomids dominated also in passive collections at Site 1 with Hester-Dendy samplers ($\bar{x}$=46.4%). These values were reflected in %EPT for samples taken at Sites 1 and 2 by active sampling, (24% and 39%, respectively) but only 8% Site 1 in samples taken by passive means. We did see a small difference in the Shannon Diversity Index (SDI) values, in which samples taken at Sites 1 and 2 by active sampling were 1.59 and 1.86, respectively. SDI for passive samples at Site 1 was 1.29. Unlike %EPT, the Hilsenhoff Biotic Index (HBI), at Sites 1 and 2 was 4.71 and 5.14, respectively, while passive samples from Site 1 had an HBI of 6.52. Thus, there is great variability in common metrics according to method of collection within a single site. Even though these plumes of water are distinctive chemically and physically, common biotic metrics cannot distinguish them when using BMI families.

Methods

Field Methods (Flotemersch, et al. 2006)

Active Methods

- D-frame nets (DN) were used along the allotted 500m reaches on either side of the river.
- Nets were positioned facing upstream and the substrate was then kicked to release samples.
- Organisms were then collected into containers and submerged in 95% ethanol.

Passive Methods

- Deployed six rock baskets (RB) filled with limestone rock at both sites 1 and 2. Three at each site were placed directly on the substrate, while three were placed on cement blocks.
- Three Hester-Dendy multiplate (HD) samplers were attached to a cement block at each site.
- The baskets were collected after a six week period of monitoring.
- A sieve bucket was used to catch the BMI during the cleaning of the rock baskets and Hester-Dendy samplers. Storage of these BMI in 95% ethanol followed.

Laboratory Methods

- Collected BMI were separated into labeled glass vials and identified to the Family level using Peckarsky, et al. (1990), Voshell (2002), and Merritt et al. (2008), .
- Pollution Tolerance Index (PTI) values were assigned based on Family (Hilsenhoff, 1988).
- Using the Pennsylvania Department of Environmental Protection's Benthic Index of Biotic Integrity (2009), the following metrics were employed: Percent EPT (%EPT), Hilsenhoff Biotic Index (HBI), and Shannon Diversity Index (SDI).

	DN-1	DN-2	RBT-1	RBB-1	RBT-2	RBB-2	HD-1	HD-2
DN-1								80-100%
DN-2	66							60-70%
RBT-1	44	49						40-59%
RBB-1	39	43	88					20-39%
RBT-2	42	35	58	55				0-19%
RBB-2	27	32	65	66	82			
HD-1	67	60	30	25	27	13		
HD-2	74	60	52	46	44	36	50	

Figure 5: Proportional Bray-Curtis Similarity Index showing the percent similarity between the BMI communities, collected during the fall of 2014, at the two sites on the West and North Branches of Byers Island and the methods based on taxa frequency. Each cell is coded to the similarity they share with each taxa at each site.

Figure 6: Identifying the BMI taxa from field collections to the Family level using a dissecting microscope.

Discussion

Percent EPT (Figure 2)

➔Low EPT percentages throughout active sampling (~24-39%)
➔High EPT in RB passive sampling (~71-92%)
➔Very low EPT in HD passive sampling (~8-30%)
➔Difference of percentages explained by method advantages and disadvantages

Hilsenhoff Biotic Index (Figure 3)

➔ Active method (avg. = 4.93) had slightly higher HBI values than passive RB method (avg. = 3.47), while passive HD method had the highest HBI values (avg. 5.37) yet the fewest amount of taxa.
➔ Active method falls into "good" water quality, and passive methods fall into "poor" and "fair" water quality, respectively (Hilsenhoff, 1988)

Shannon Diversity (Figures 4)

➔Higher Shannon Diversity values correspond with higher taxa richness
➔ Active methods collected more taxa than passive methods
➔ Percent compositions give insight into the strengths of each methods
- Active methods collect all types of BMI notwithstanding their ecology
- Passive methods collect BMI that migrate, and they neglect organisms that are sessile

Bray-Curtis Similarity Index (Figure 5)

➔Low to moderate similarity between active and passive methods (~27-74%)
➔ High to very high similarity amongst passive and active methods separately (~65% DN-88%RB)
➔D-Net and rock baskets displayed top percent similarities relating to species richness (~66-88%)

D-nets are moderate methods of active collection due to a greater diversity of organisms at both sites, however, they had a much lower frequency of relatively sensitive BMIs.

The passive rock baskets yielded the highest frequency of sensitive BMIs, yet had lower HBIs and an overall lower SDI than the active sampling.

Both active and passive methods should continue to be employed along the same reach at each site, as each method offers a variety of metrics results as well as number and diversity of taxa observed.

For the D-Nets in Site 1, the most prevalent taxa were Gammaridae, Chironomidae, and Heptageniidae, while in Site 2 it was Oligochaete, Chironomidae, Heptageniidae, and Ephemeridae. In both Sites 1 and 2 the dominant taxa collected by the Rock Baskets were Heptageniidae and Isonychiidae. The Hester-Dendy samplers collected mainly Gammaridae and Chironomidae at both sites.

Family-level identification is adequate to yield usable results to calculate the multiple metrics needed to determine whether or not there are differences between Sites 1 and 2; these results conclude that they are different.

Results

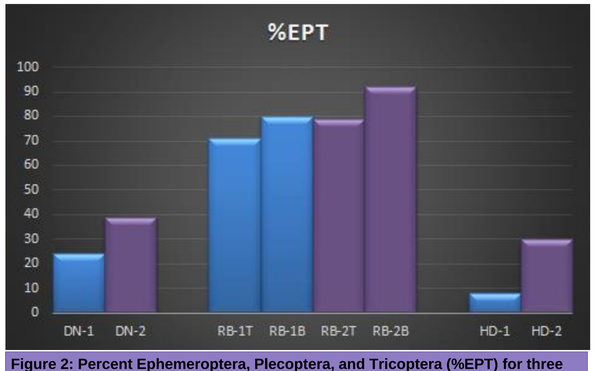

Figure 2: Percent Ephemeroptera, Plecoptera, and Tricoptera (%EPT) for three collection methods , D-Nets (DN), Rock Baskets (RB), and Hester-Dendy Samplers (HD). On top of cinder block (T), Bottom/on Substrate (B). Site 1(1) is blue, and Site 2 (2) is purple. %EPT describes the observed pollution sensitive taxa.

Figure 3: Hilsenhoff Biotic Index values for three collection methods , D-Nets (DN), Rock Baskets (RB), and Hester-Dendy Samplers (HD). On top of cinder block (T), Bottom/on Substrate (B). Site 1 (1) is blue, and Site 2 (2) is purple. HBI describes the water quality by reference to the BMI collected.

Figure 4: Shannon Diversity Index values for three collection methods, D-Nets (DN), Rock Baskets (RB), and Hester-Dendy Samplers (HD). On top of cinder block (T), Bottom/on Substrate (B). Site 1(1) is blue, and Site 2 (2) is purple. SDI describes the diversity of taxa collected at each site on these two branches.

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References available upon request.