Alternate Approach to Assessment of Benthic Health in a Sediment Limited System, South River, Virginia

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Introduction

Mercury (Hg) was used between 1929 and 1950 at a textile manufacturing plant in Waynesboro, Virginia, and was released and transported into surface water, sediments, soils, and biota of the South River. Benthic macroinvertebrate communities are an important indicator of habitat integrity and reflect the integration of environmental stressors, such as mercury, over time.

A benthic colonization study was implemented to assess potential impacts of the historical mercury (Hg) release on benthic macroinvertebrate communities in the South River. Two null hypotheses (H_0) were tested with data collected during this investigation:

- H_0: Benthic community structure does not differ among gradients of mercury within the same habitat type.
- H_0: Benthic colonization dynamics do not differ among gradients of mercury within the same habitat type.

Study Design

The benthic colonization study was developed based on procedures outlined by Klemm et al. (1990) and Clements et al. (1989). Benthic community structure and colonization dynamics were assessed through the use of uniform substrate-filled benthic colonization trays deployed for a six-week colonization period. The study was conducted from May to June 2011.

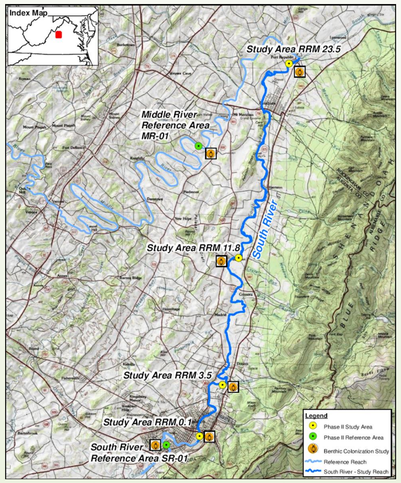
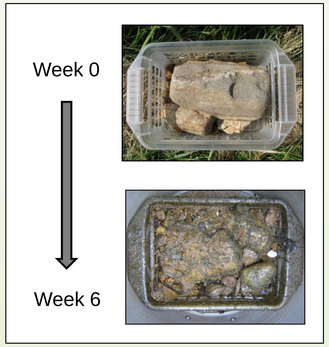


Figure 1. Study Locations

Methods

- Three study areas (RRM 0.1, RRM 3.5, and RRM 11.8) and two reference areas (SR-01 and MR-01) were sampled (Figure 1).
- Deployment location characteristics were standardized among study sites to the extent possible (*i.e.*, stream velocity and depth, substrate type, canopy cover, and distance from the nearest stream bank).
- Six randomized substrate trays were collected after 2, 4, and 6 weeks of exposure from each site, and sampled for benthic community.
- Benthic samples were processed using a 500 organism sub-count and organisms were identified to the lowest practical taxonomic level (*i.e.,* species) possible.
- Interstitial sediment was analyzed for total mercury (THg) and methylmercury (MeHg) at week 6.
- Colonization tray substrate material was analyzed for grain size distribution at week 6.
- Preliminary data analyses include univariate and multivariate statistical analyses on log (x+1) transformed species abundance data, benthic community metrics, and interstitial sediment Hg concentrations.

Tray Deployment (Week 0)



Substrate Tray Colonization

Results

Select Community Metrics

Over the course of the study period, abundance ranged from 171 to 762 individuals per sample in the study areas, and from 185 to 576 in the reference areas (Figure 2). Based on the data collected over the six-week colonization period, the relative abundance of Chironomidae decreased over time across study and reference areas, with a corresponding increase in the relative abundance of EPT taxa (Figure 3). Also noteworthy, Study Area RRM 11.8 showed nearly equal proportions of Chironomidae and EPT taxa throughout the study period (Figure 3).

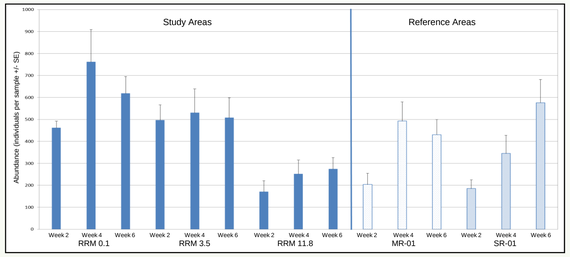


Figure 2. Abundance

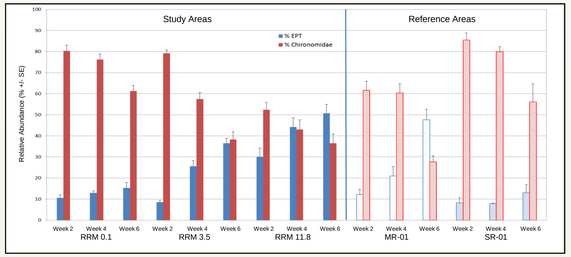


Figure 3. Relative Abundance (%)- Chironomidae and EPT

Table 1. Bray-Curtis Similarity Coefficient Matrix

	RRM 0.1 W2	RRM 0.1 W6	RRM 3.5 W2	RRM 3.5 W6	RRM 11.8 W2	RRM 11.8 W6	MR-01 W2	MR-01 W6	SR-01 W2	SR-01 W6
RRM 0.1 W2	--									
RRM 0.1 W6	0.49	--								
RRM 3.5 W2	0.34	0.47	--							
RRM 3.5 W6	0.55	0.33	0.45	--						
RRM 11.8 W2	0.52	0.55	0.52	0.54	--					
RRM 11.8 W6	0.62	0.44	0.58	0.44	0.44	--				
MR-01 W2	0.60	0.63	0.49	0.60	0.54	0.64	--			
MR-01 W6	0.67	0.54	0.59	0.51	0.63	0.53	0.52	--		
SR-01 W2	0.42	0.58	0.42	0.60	0.49	0.67	0.52	0.70	--	
SR-01 W6	0.51	0.21	0.48	0.33	0.54	0.45	0.61	0.55	0.55	--

Data Ordination

Using Log (x+1) transformed species abundance data, a Bray-Curtis dissimilarity correlation was used to evaluate the difference in species abundance between the beginning and end of the study period ("W2" and "W6") and also between study sites. The resulting coefficient matrix indicated that there were no significant differences in species composition between the beginning and end of the study period or between study sites (Table 1). To further explore the differences in species abundance, Nonmetric Multidimensional Scaling (NMDS) was used with the Bray-Curtis coefficients. The supporting descriptive statistics from the ordination included stress for each axis (n=3) based on empirical data and Monte Carlo randomized data. These results indicated that a 3-dimensional solution would appropriately represent the data (axis 3 mean stress level=2.9). The resulting ordination plot (not shown) indicated that the study sites partitioned in two ways; 1) beginning and end of the study period, and 2) the MR-01 reference area separating from the study areas and the reference area SR-01.

Mercury (Hg)

A non-parametric Spearman Rank correlation was used to test the hypotheses that Hg is not correlated with benthic community structure or colonization dynamics. Select community metrics and NMDS axis scores were evaluated against sediment Hg and colonization tray grain size distribution data. This analysis indicated that there was no significant correlation between the benthic community metrics used and Hg or colonization tray grain size (p>0.05)

Discussion

The results of this study identified gross trends in the benthic community structure and colonization dynamics with respect to sensitive and tolerant taxa in the South River. Among study and reference sites, it is evident that there is a shift between the relative abundance of tolerant taxa, such as Chironomidae, and more contaminant-sensitive taxa, such as Ephemeroptera, Plecoptera, and Trichoptera from the beginning to the end of the study period. Also, based on the results of the NMDS and Spearman Rank correlation, it can be concluded that reference area MR-01 is different from the study areas and the reference area SR-01, however this difference is not correlated with interstitial sediment Hg concentrations.

References

Clements, W.H., J.H. Van Hassel, D.S. Cherry, and J. Cairns, Jr. 1989. Colonization, variability, and the application of substratum-filled trays for biomonitoring benthic communities. Hydrobiologia 173:45-53.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1990. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.. EPA 600-4-90-030.