

Associations between Biological Metrics, Physical Habitat and Water Chemistry in Virginia's Mountain Ecoregions

Jason Hill, Michael Scanlan, George Devlin, Mary Dail, and Larry Willis
Virginia Department of Environmental Quality, 3019 Peters Creek Road Roanoke, Virginia 24019



RESULTS

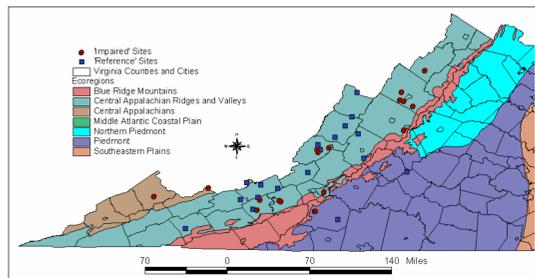
INTRODUCTION

The purpose of this study was to improve our knowledge of stressors to benthic macroinvertebrate communities and to assist in the development of biological Total Maximum Daily Load (TMDL) studies in Virginia. A key issue in TMDL development involves determining which parameters should be collected and at what levels these parameters cause adverse impacts to the biological community. To address these questions, the Virginia Department of Environmental Quality (VDEQ) evaluated the associations between water chemistry, Rapid Bioassessment Protocol (RBP) habitat metrics, and biological metrics at numerous 'reference' and 'impaired' sites. In addition, these analyses will help determine stressor screening values for water quality parameters which currently have no standards.

- The EPA's Stressor Identification Guidance Document encourages:
- Using summary statistics (i.e., medians) to summarize measurements
 - Quantifying relationships between variables using correlation and regression

Station Locations

We used thirty-seven biological monitoring stations located in the Ridge and Valley, Central Appalachian, and Blue Ridge Ecoregions of Virginia. These stations were co-located with ambient chemical monitoring stations and located in 2nd - 4th order streams.



METHODS

Data Reduction

- All reference stations were identified in Tetra Tech's Stream Condition Index report (SCI) (Tetra Tech 2003). Impaired stations were identified using the EPA 303(d) report and VDEQ biological assessments. Reference stations typically had an average SCI score ≥ 60 and impaired stations had average SCI scores ≤ 40 . In addition to the SCI, six other biological metrics were compared to the chemical and habitat parameters.
- Chemical data was collected 4 - 12 times per year at all stations between 1994 and 2002. Medians were calculated for each parameter for the year prior to each biological sample to which it was compared.
- Seventeen chemical parameters were collected including field parameters, nutrients, solids, Alkalinity, Total Chloride, and BOD5. Due to a limited data set, heavy metals and organics were not analyzed.
- Ten RBP habitat metrics used in the analyses were collected at the same time as the biological samples.

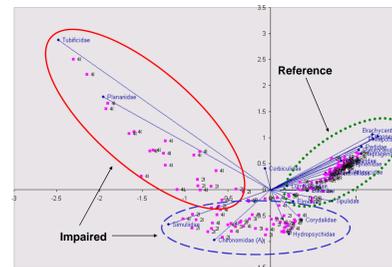
Statistical Analyses

- Ordination** techniques were used for data reduction and to identify patterns. Correspondence analysis was performed with 'Bi-Plot' software (Smith 2001) and nonmetric multidimensional scaling was performed using PC-ORD (McCune 1999).
- Box-and-whisker plots** (not shown here) were made with Statistica 5.1 and used to compare medians and data distributions between reference and impaired sites.
- Scatter plots** were created with Statistica 5.1 and used for trend analyses between biological and chemical/habitat parameters.
- Spearman rank correlations** were calculated with Statistica 5.1 and were used to quantify relationships between biological and chemical/habitat parameters.

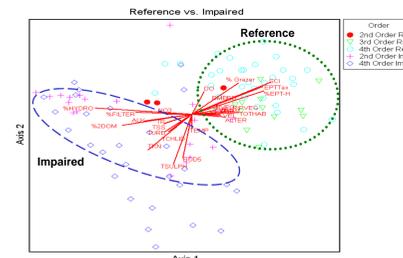


Ordination

Correspondence Analysis showing separation of macroinvertebrate families from reference and impaired stations

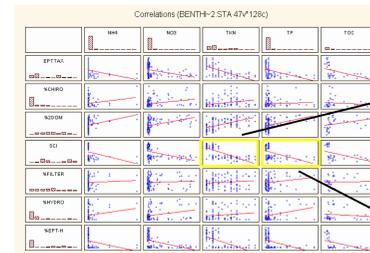


Nonmetric Multidimensional Scaling Ordination showing separation of benthic samples by habitat and chemical parameters



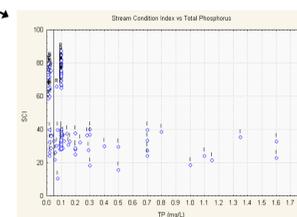
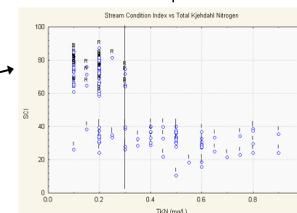
Scatter Plots & Spearman Rank Correlations

Correlations - Biological Metrics and Nutrients

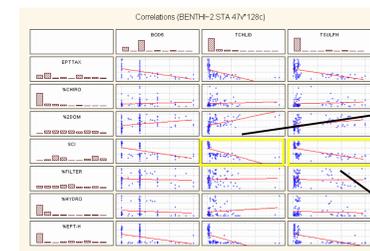


	NH4	NO3	TKN	TP	TOC
EPTTaxa	-0.37700	-0.37209	-0.70899	-0.45922	-0.66472
%Chiro	0.10879	0.29398	0.34275	0.07489	0.15091
%2 DOM	0.40177	0.50250	0.58872	0.34561	0.54612
SCI	-0.43865	-0.41560	-0.73375	-0.45421	-0.61017
%Filter	-0.01835	0.04845	0.10022	0.22058	0.04434
%Hydro	0.05041	0.24715	-0.00594	0.15820	-0.04316
%EPT-H	-0.39126	-0.40871	-0.68933	-0.44537	-0.66932

Potential Screening Values for Total Kjeldahl Nitrogen and Total Phosphorus

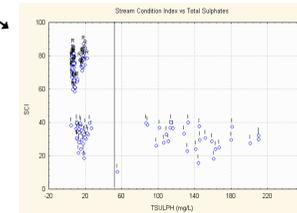
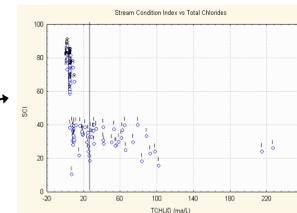


Correlations - Biological Metrics and Total Chloride and Total Sulphate

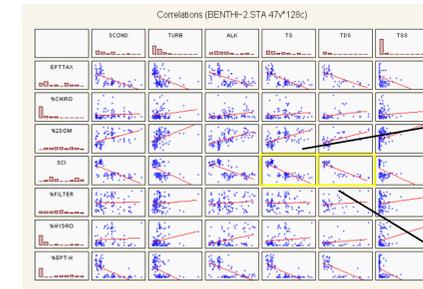


	BOD5	TCHLID	TSULPH
EPTTaxa	-0.34021	-0.80164	-0.55395
%Chiro	0.19531	0.43667	0.27681
%2 DOM	0.25108	0.71006	0.40632
SCI	-0.37356	-0.83467	-0.56833
%Filter	-0.00549	0.05423	0.03075
%Hydro	-0.09409	0.04425	-0.01344
%EPT-H	-0.32858	-0.81499	-0.64725

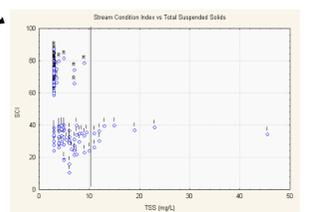
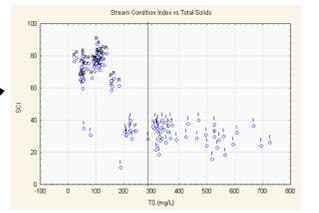
Potential Screening Values for Total Chloride and Total Sulphate



Correlations - Biological Metrics and Solids



Potential Screening Values for Total Solids and Total Suspended Solids



	SCOND	TURB	ALK	TS	TDS	TSS
EPTTaxa	-0.68161	-0.53352	-0.60717	-0.71909	-0.68296	-0.62757
%Chiro	0.24977	0.23221	0.42884	0.34735	0.50045	0.34474
%2 DOM	0.53078	0.57988	0.60914	0.57463	0.58182	0.58790
SCI	-0.66583	-0.55409	-0.65160	-0.72895	-0.70475	-0.63366
%Filter	0.04256	0.12497	0.06831	0.02177	-0.01555	0.05595
%Hydro	-0.00794	0.16589	0.15736	-0.01898	-0.06669	0.12974
%EPT-H	-0.73289	-0.48840	-0.64552	-0.77790	-0.75733	-0.58984

CONCLUSIONS

Stressor Screening Values

Parameter	Screening Value
Nitrate-Nitrogen*	1.5 mg/l
Total Kjeldahl Nitrogen*	0.3 mg/l
Total Phosphorus**	0.05 - 0.07 mg/l
Total Chlorides	30 mg/l
Total Sulphates	50 mg/l
Total Suspended Solids	10 mg/l
Turbidity	10 NTU
Total Solids	300 mg/l
Total Habitat	120 (Qualitative Score)

*Total Nitrogen Screening Value of 2.0 mg/l

**Total Phosphorus needs further evaluation due to the low detection level used in most of the dataset

The Stream Condition Index showed the best overall response to chemical and habitat parameters and has proven to be a useful tool in the mountain ecoregions. The results of this study recommends the co-location of biological and ambient monitoring stations and that appropriate chemical parameters need to be collected in potential TMDL watersheds for use in stressor identification. Statistical analyses show that several parameters were consistently different at reference versus impaired stations and the difference in water chemistry and habitat are impacting the benthic community scores. Further research using probabilistic data is recommended due to the small data set used in this study.

Parameters that appear to be good indicators of stress to biological communities include: Nitrate-Nitrogen, Total Kjeldahl Nitrogen, Total Phosphorus, Total Chlorides, Total Sulphates, Total Suspended Solids, Turbidity, Total Solids, and Total Habitat Score.

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