Effective Monitoring and Assessment of Total Dissolved Solids as a Biotic Stressor in Mining-Influenced Streams

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Executive Summary:

With total dissolved solids (TDS) increasingly identified as a candidate stressor to aquatic life in mining-influenced streams, there is an immediate need for a scientifically sound method for monitoring TDS and assessing its effects on biota in streams influenced by coal-mining activities. Our research goal is to improve industry- and agency capability to monitor and assess TDS for the purpose of characterizing biotic effects of TDS in streams influenced by coal-mining activities.

To accomplish our goal, we sought to characterize how temporal variability of TDS affects the biological community. We selected headwater streams with elevated TDS where non-TDS stressors were not evident, where we measured monthly TDS and component ions, along with specific conductance (SC or "conductivity"; a TDS surrogate) at 15-minute intervals for up to 36 months. We measured benthic macroinvertebrate community structure seasonally and quantified associations between biological and conductivity metrics.

A rigorous and extensive site selection effort enabled us to characterize biological response to TDS independent of significant influence from covariate stressors. Analyses provided no evidence that non-TDS stressors significantly influenced SC – biota correlations at our study sites. Test sites were comparable to reference sites with respect to water quality and physical habitat.

Continuous conductivity monitoring allowed us to characterize the temporal variability of TDS at our study sites. Specific conductance varied temporally over the study period, exhibiting a seasonal pattern of highest SC in fall and lowest SC in spring, with inter-annual consistency. Dilution spikes associated with precipitation events frequently lowered SC greatly for short durations throughout the year. Stream water grab-samples collected at multiple times during the study period revealed that test-site waters were composed primarily of the anions SO_4^{2-} and HCO_3^- and the cations Ca^{2+} and Mg^{2+}. Use of SC as a surrogate for TDS is reasonable given the strong relationship we observed between the two parameters, provided the ion matrix being described by SC is consistent among sites.

Changes in benthic macroinvertebrate community structure were significantly and often strongly correlated with increased SC, characterized by declines in taxa richness and relative abundance of sensitive taxa, with mayfly taxa exhibiting the strongest responses. These SC-biota associations were consistent in consecutive years. Spring data produced stronger and more frequently significant correlations with SC than did Fall data.

Our findings suggest that an effective plan for monitoring and assessing TDS as a biotic stressor will take the following approach:

- Sample the benthic macroinvertebrate community in the spring for maximum SC sensitivity.
- Measure SC at multiple times during the year for a more accurate accounting of stressor levels influencing biota.
- Maintain consistency of chemical and biological sample timing when making comparisons through space or time.

Such an approach may enhance the ability of resource managers and regulators to assess, predict, and control biological impacts from TDS.

References and Related Publications:

Boehme, Elizabeth Ann. 2013. Temporal Dynamics of Benthic Macroinvertebrate Communities and Their Response to Elevated Specific Conductance in Headwater Streams of the Appalachian Coalfields. M.S. Thesis, Forest Resources and Environmental Conservation.

Boehme E.A., C.E Zipper, S.H. Schoenholtz; D.J Soucek, A.J. Timpano. Temporal dynamics of benthic macroinvertebrate communities and their response to elevated specific conductance in Appalachian coalfield headwater streams. (Manuscript in Review).

Timpano A.J., S.H. Schoenholtz, D.J. Soucek, C.E. Zipper. 2015. Effective Monitoring and Assessment of Total Dissolved Solids as a Biotic Stressor in Mining-Influenced Streams. Final Technical Report submitted to U.S. Office of Surface Mining Reclamation and Enforcement. (The above Executive Summary is from that report).

Timpano A.J., Schoenholtz S.H., Soucek, D.J., Zipper, C.E., 2015. Salinity as a limiting factor for biological condition in mining-influenced Central Appalachian headwater streams. Journal of the American Water Resources Association 51: 240-250.

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