EFFECTIVE MONITORING AND ASSESSMENT OF TOTAL DISSOLVED SOLIDS AS A BIOTIC STRESSOR IN MINING-INFLUENCED STREAMS

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Project Description and Objectives

With total dissolved solids (TDS) increasingly identified as a candidate stressor to aquatic life in mining-influenced streams, this project sought to improve industry and agency capability to monitor TDS and assess its biological effects. Accurate assessment of TDS allows managers to better predict and minimize biological effects of TDS in streams influenced by mining activities.

Applicability to Mining and Reclamation:

Most field studies of mining-origin TDS effects have relied upon water quality measurements taken infrequently; usually just one or two measurements per year at the time of seasonal biological sampling. However, water chemistry and biological condition vary throughout the year in mining-influenced streams, thus timing of sampling can affect conclusions regarding how TDS affects biota. Accounting for temporal variability of TDS and biota will improve accuracy and consistency when assessing TDS effects and when making comparisons through time or across landscapes.

This project was conducted in Central Appalachian headwater streams influenced primarily by coal surface mining and valley fills, but the recommendations have broad applicability across the Appalachian coalfield region where mining land uses and stream conditions are similar to those studied here.

Methodology:

Twenty-five headwater streams were selected in southwestern Virginia and southern West Virginia, consisting of five reference streams and 20 streams with elevated TDS where non-TDS stressors were not evident (Figure 1). This method for selecting study sites allowed attribution of biological effects primarily to TDS, rather than other mining-related stressors such as low pH and stream sedimentation. Monthly measurements of TDS and component ions were made to characterize the ionic composition of TDS and establish a relationship between TDS and its surrogate, specific conductance, which was used to represent TDS in all analyses. In each stream, an automated datalogger was installed to measure specific conductance at 15-minute intervals for up to 36 months (Figure 2). Biological effects were quantified using benthic macroinvertebrate community structure sampled seasonally, once each spring and fall. Correlations between specific conductance and biological community metrics were calculated using traditional seasonal data, as well as continuous data.

Highlights:

Ionic Composition of TDS

Major ions present in streams with elevated TDS were primarily the anions SO_4^{2-} and HCO_3^- and the cations Ca^{2+} and Mg^{2+}. Specific conductance was highly correlated with TDS, justifying use of specific conductance as a surrogate for TDS when the ionic composition is consistent among sites.

Biological Effects of TDS

Changes in benthic macroinvertebrate community structure were significantly and often strongly correlated with elevated specific conductance. High-TDS streams were characterized by declines in diversity and abundance of sensitive organisms, with mayflies exhibiting the strongest responses. These TDS-biota associations were consistent in consecutive years.

Temporal Variability of TDS

Continuous conductivity monitoring allowed characterization of the temporal variability of TDS in each stream. Specific conductance varied temporally during the study period, exhibiting a seasonal pattern of fall maxima and spring minima, with inter-annual consistency. Dilution spikes associated with precipitation events frequently lowered specific conductance greatly for short durations throughout the year (Figure 3).

Accounting for Temporal Variability

Spring biological data produced stronger and more frequently significant correlations with specific conductance than did fall data. Most conductance-biota correlations were slightly stronger when using continuous data as compared to traditional seasonal data. In addition, analyses of continuous data suggest that chronically elevated TDS, rather than transient spikes, is driving biological effects.

Results/Findings:

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 TDS sensitivity.

- Measure TDS/specific conductance at multiple times during the year for a more accurate accounting of stressor levels influencing biota.
- Maintain consistent timing for chemical and biological sampling when making comparisons among sampling sites, or when seeking to assess condition of an individual sampling site during an extended time period using multiple samples.

Such an approach should enhance capability to assess, predict, and control biological impacts from elevated TDS originating from coal surface mines.

Website Information:

The final project report and links to supporting documents can be found at:
http://www.osmre.gov/programs/tdt/appliedscience/projects.shtm

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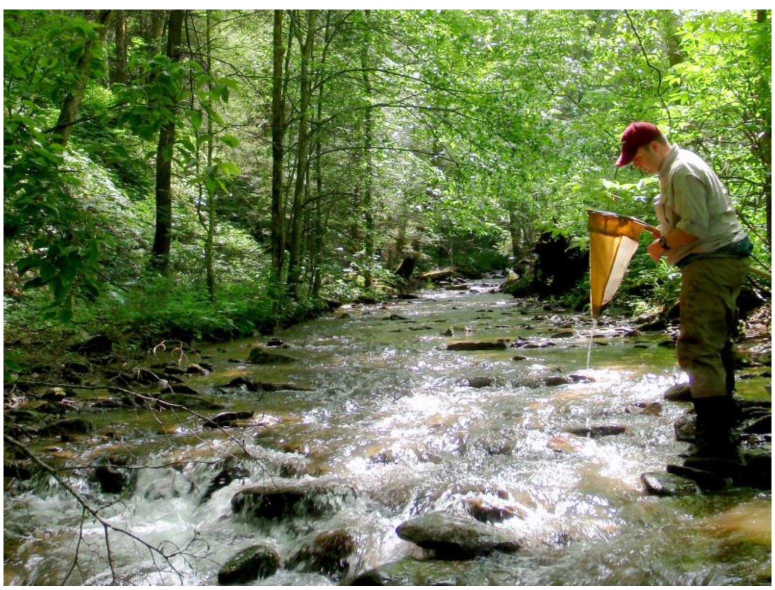

Figure 1. Benthic macroinvertebrates being sampled from a high-TDS stream. Note the high-quality in-stream and riparian habitat. Non-TDS stressors were minimized to reduce confounding of TDS effects.

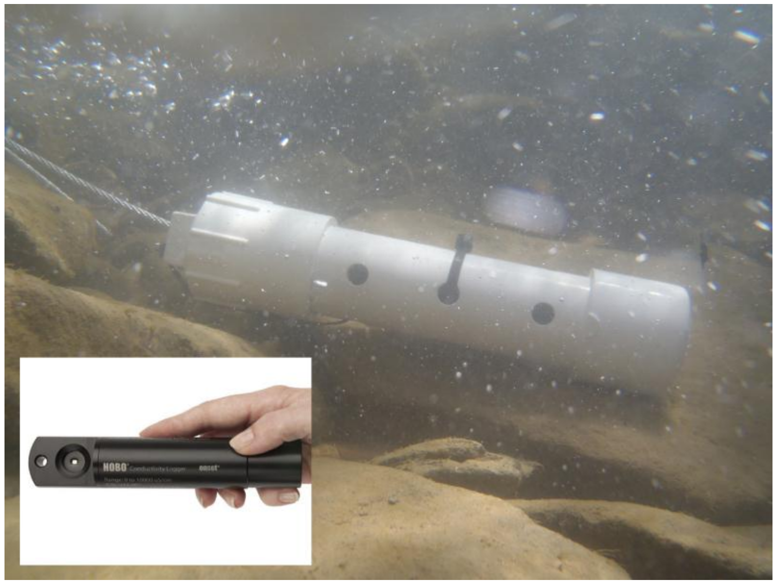

Figure 2. HOBO Conductivity Loggers (U24-001) were installed at each stream, recording conductivity every 15 minutes for up to 36 months.

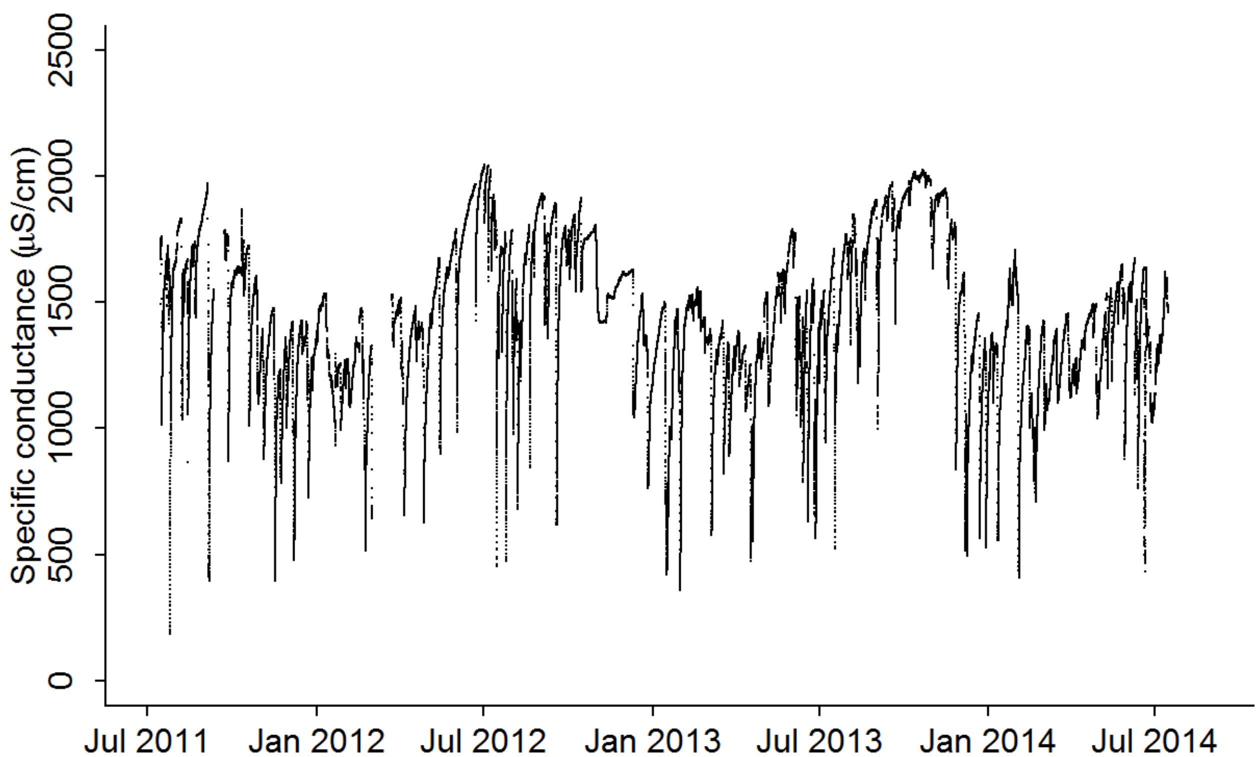

Figure 3. Specific conductance pattern typical of high-TDS streams. Note seasonal pattern with spring minima and fall maxima, and frequent dilution spikes.