OSMRE National Technology Transfer Team (NTTT), **Applied Science Fact Sheet***
U.S. Department of the Interior, OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT

Stream Ecosystem Response to Mining-Induced Salinization in Central Appalachia

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Project Description and Objectives:

This study was conducted to advance scientific understanding of how aquatic ecosystems respond to elevated levels of major ions/total dissolved solids (TDS), selenium (Se), and other trace elements in mining-influenced headwater streams.

Applicability to Mining and Reclamation:

This study identified seasonal patterns of change in TDS, analyzed TDS and biotic metrics for long-term trends, assessed TDS-biota associations, measured a key stream carbon processing function in relation to TDS, and quantified bioaccumulation pathways for selenium and other trace elements in mining-influenced headwater streams of the central Appalachians.

Methodology:

Twenty-four headwater streams in southwestern Virginia and southern West Virginia were studied from July 2015 through December 2016. Streams spanned a gradient of TDS where non-TDS stressors were not evident (Figure 1). At each stream, water was monitored at 30-minute intervals with *in-situ* data loggers for the TDS-surrogate specific conductance (SC), and quarterly water samples were obtained and analyzed for major ions and trace elements. Structural changes in benthic macroinvertebrate communities were assessed from samples obtained in Fall 2015 and Spring 2016. Leaf breakdown rate, a key carbon processing function, was determined by placing multiple leaf-litter bags in study streams, then retrieving them sequentially over a 270-day period, and calculating mass loss over time. Water, particulate environmental media (biofilm, sediments, and leaf detritus), and benthic macroinvertebrates (prey taxa, predator taxa, and crayfish) were collected from nine streams and analyzed for concentrations of the trace elements Al, As, Cd, Cu, Ni, Se, Sr, V, and Zn in Fall 2015 and Spring 2016. Additional biological and continuous conductivity data from prior study in the same 24 streams (2011 – 2015) were incorporated with the new data for trend analyses.

Conductivity data and benthic macroinvertebrate community metrics were analyzed for temporal trends. Seasonal cyclic patterns of SC were estimated for the 24 streams during 2011-2016. Leaf breakdown rates were calculated for each stream and regressed against mean SC to determine effects of TDS on carbon processing function. Trace-element concentration data were analyzed to calculate enrichment and trophic transfer factors that indicate bioaccumulation patterns, and those values were compared among reference and mining-influenced streams.

Highlights:

Salinity Exhibits a Cyclic Seasonal Pattern

The sinusoidal model identified a significant seasonal pattern of salinity, with minimum SC in late February and maximum SC in late August (Figure 2). This pattern is likely a natural response to interactions of hydrology, precipitation, and evapotranspiration, and was

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evident in both reference and mining-influenced streams.

Salinity-Biota Relationships are Persistent; Mayflies Most Sensitive Group; No Biological Recovery over 5 years

Throughout the 2011-2016 study period, stream SC levels were correlated negatively with certain macroinvertebrate community metrics, including total richness, and mayfly-influenced metrics, which were most sensitive to SC. There were no strong, consistent temporal trends in biological metrics.

Ion Concentration and Ratios Exhibit Inconsistent, Gradual Changes

More SC declines than increases were observed at mining-influenced streams, but SC declines were gradual. Some streams exhibited declining SO_4:HCO_3 ratios, suggesting gradual return to "natural background" ratios at those sites. However, strong and consistent patterns in water chemistry were absent.

Leaf Breakdown Function Not Affected by Salinity at Levels Observed

Leaf breakdown rates in salinized streams were comparable to those of reference streams. No significant relationship between salinity and leaf breakdown was observed.

Selenium Bioaccumulation Increases with Water-Column Dissolved Selenium Concentration

Selenium (Se) concentrations in all media were elevated in mining-influenced streams compared with reference streams. Particulate-media and macroinvertebrate Se concentrations in high-Se streams were elevated to levels that raise concerns of potential toxicity. Selenium bioaccumulation processes in mining-influenced and reference streams exhibited similar patterns. No other trace elements exhibited bioaccumulation as consistent as those produced by Se.

Results and Findings:

- Seasonality is a factor when monitoring mining-influenced streams; both water quality and benthic macroinvertebrate structural metrics vary among seasons.
- A major component of the carbon processing function of headwater streams – leaf breakdown – did not appear inhibited by salinity at the salinity levels observed, but other ecosystem processes may be affected at elevated salinities by the loss of mayflies.
- Salinity and related biological conditions exhibited little change over 5 years of study, suggesting that return of mining-influenced streams to natural-background conditions after mining is complete would occur very slowly at best.
- Selenium readily bioaccumulates in mining-influenced streams, and can reach levels of concern for potential toxicity to macroinvertebrates and fishes.

Ecosystem structural responses to elevated major ions and trace elements are evident in mining-influenced headwater streams of the central Appalachians, and certain of those responses vary seasonally. Although functional responses would also be expected, such was not observed for leaf litter breakdown.

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