Evaluating recovery of stream ecosystems from mining pollution: integrating biochemical, population, community and ecosystem-level indicators

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Cu, Cd, Zn
Map of Sampling Stations
Upper Arkansas River Basin

East Fork of the Arkansas River
California Gulch
Arkansas River

EF5
AR1
AR3
AR5

Scale (Km)
Concentrations of metals in water (ug/L)
Critical Questions

• What level of cleanup is necessary to restore and protect aquatic communities?

• What are the relevant indicators of recovery across levels of biological organization?
  • Biochemical → Populations → Communities → Ecosystems
Examples of Benthic Macroinvertebrates
Responses of sensitive and tolerant taxa

The graph shows the number of organisms per 0.1 m² across different stations (EF5, AR1, AR3, AR5, AR8) at varying Zn concentrations. The data indicates a decline in number as Zn concentration increases, particularly noticeable at station AR3.
Genetic Diversity of Mayflies

![Genetic Diversity Bar Chart]

- **EF2**: Genetic Diversity
- **EF5**: Genetic Diversity
- **EF6**: Genetic Diversity
- **AR1**: Genetic Diversity
- **AR3**: Genetic Diversity
- **AR6**: Genetic Diversity
Metal Levels in Caddisflies

Station | EF1 | EF5 | AR1 | AR2 | AR3 | AR5 | AR8
---|---|---|---|---|---|---|---
Zn Concentration (ug/g) | 200 | 300 | 400 | 500 | 600 | 700 | 800
Metal Concentrations in Caddisflies: Influence of DOC

- Zn concentration in Arctopsyche
- DOC

$r^2 = 0.42$ for Zn
$r^2 = 0.25$ for DOC
Influence of Landscape Features on DOC

Mean DOC (mg/L) vs. Percent Forested Area

- \( r^2 = 0.59 \)
Biomass of Brown Trout

### 1994

- AR1: ~100 lbs/acre
- AR3: ~20 lbs/acre
- AR4: ~90 lbs/acre
- AR5: ~80 lbs/acre

### 1997

- AR1: ~140 lbs/acre
- AR3: ~15 lbs/acre
- AR4: ~100 lbs/acre
- AR5: ~60 lbs/acre

### 1998

- AR1: ~80 lbs/acre
- AR3: ~10 lbs/acre
- AR4: ~70 lbs/acre
- AR5: ~60 lbs/acre

### 1999

- AR1: ~70 lbs/acre
- AR3: ~20 lbs/acre
- AR4: ~60 lbs/acre
- AR5: ~60 lbs/acre
Recovery following remediation of LMDT (Station EF5)

![Graph showing the recovery of Heptageniidae and Zn concentration over years. The graph displays a decline in Zn concentration after remediation and a subsequent increase in Heptageniidae abundance.]
Little Evidence of Recovery below California Gulch (Station AR3)
Trays colonized for 40 d
Transferred to microcosms
Exposed to metals for 10 d
Community-level responses to metal mixtures in stream microcosms

Number of Heptageniidae per Stream

- $Zn$: $r^2 = 0.003$
- $Zn + Cd$: $r^2 = 0.23$
- $Zn + Cd + Cu$: $r^2 = 0.63$
Goals of the Current HSRC Research

• Examine recovery (or lack thereof) of aquatic communities in the Arkansas River

• Determine what biological indicators are most appropriate for assessing recovery

• Determine what level of cleanup is necessary to restore and protect aquatic communities in metal-polluted streams