Selenium treatment with iron oxides at a surface mine in WV

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study area: Hobet mine, Lincoln Co.
the Hobet spoil experiment

- earlier research at Hobet shows that Se is leached from “hot” waste rock over 5-15 yr timeframe
- can this Se be sequestered by adsorption using Fe-oxide materials
- 30 identical “mesocosms” of overburden leaching
- varying thicknesses of basal Fe-oxide layers
- approximately biweekly sampling
- 6 replications per amendment
- installed 2010; still being sampled
materials

• pit-run carbonaceous shale from Stockton and Coalburg seams (Se-rich)
• thin topsoil layer (weathered brown sandstone)
• Fe-oxide from limestone-treated AMD wetland, New Stanton, PA
• lysimeters 5 x 7 m in size
• plumbed to collect leachate by gravity drainage in 350 gal tanks
• complete capture of leachate == interval sampling
• yields chemistry + flow rates but no speciation
dataset

- bi-weekly flows and water chemistry => monthly after 9/2012 => >1500 samples
- duration May 2010 to present
- freeze-up period in winter 2010-11 and 2014 (!) when samples were not collected
research questions

• will significant adsorption of Se occur? ✔
• what species of Se are present/dominant?
• what Fe-oxide application rates are needed? ✔
• application method (blending, layering) ✔
• will other ions compete for adsorption sites?
lysimeter construction
- 30 cells, 5 x 7 m x 1.3 m H
- plywood construction
- plastic-lined
- plumbed via ABS pipes to drain leachate to tank array
- periodic sampling of water from 350 gal tanks + volume measurement
lysimeter layout
treatment replicates

ferrihydrite layer thickness
A – zero (0% w/w)
B – 6.4 mm (0.2%)
C – 57 mm (1.5%)
D – 229 mm (6%)
E – 457 mm (12%)
gravity-drainage sampling tanks
sampling/average flow measurement
2010-2013 Se and flow data
raw Se concentrations (µg/L) for replicates
mean Se concentrations (µg/L) within replicate groups
mean Se flux (mg/day) 2010-12
cumulative average Se flux (thru 2012)

A (0.0% Fe oxide)
B (0.2% Fe oxide)
C (1.5% Fe oxide)
D (6.0% Fe oxide)
E (12.0% Fe oxide)
untreated
Se flux reduction (2010 to June 2012)

Se flux reduction (%) vs. Fe oxide amendment (weight %)

- 59.8%
- 76.9%
iron oxide mineralogy (mainly goethite)

![X-ray diffraction pattern showing peaks corresponding to goethite (Goe) and other minerals like gypsum (Gyp) and gibbsite (Gib)].
key results of Se time series

- unamended Se concentrations were up to 300-400 µg/L in years 1-2 – falls off to <50 µg/L in years 3-4
- in year 4, all but one Treatment D replicate was <10 µg/L (at most times <5 µg/L)
- Highest Se flux and flows in spring – “spring flush”
- thin Fe-oxide layers have little adsorption effect
- thick Fe-oxide treatments (D and E) were highly effective at reducing Se flux (through 2012: 59.8% and 76.9% cumulative reduction compared to untreated)
- replicates indicate results not an artifact of spoil heterogeneity or hydrology
utility for Se control

- special handling cells for “hot” spoil could greatly reduce effluent Se concentrations from >300 to <10 ppb in first 2-3 years, and perhaps in compliance thereafter
- dealing with spring “flushes” could be accomplished by innovative water management (dilution/blending)

problems to work out

- minimum Fe-oxide needs/optimal layering strategies
- scale-up issues
- long-term stability of adsorbed Se
- Were test cells so oxic that timeframes were accelerated?
questions
work in progress/pending

- continue long-term sampling
- harvest/characterize Fe-oxide beds from 2 cells
  - elemental chemistry/mineralogy
  - characterize adsorption sites
  - is Se adsorption reversible?
- scale up to large amendment piles
- test different layering strategies
raw Se concentrations ($\mu$g/L) for replicates
mean Se concentrations (µg/L) within replicate groups
mean Se flux (g/day)