BEHAVIOR OF ARSENIC AND SELENIUM IN SOILS AND SEDIMENTS

Deborah Soukup

University of Nevada Las Vegas

ARSENIC MOBILITY AND TOXICITY

- **The mobility and toxicity of arsenic (As) in soils is highly dependent on redox state.**
- **As generally occurs in soils in two oxidation states:**
  - **As^{+3} in arsenite (primarily as $As(OH)_3^0$)**
  - **As^{+5} in arsenate (such as $H_2AsO_4^-$)**
- **The As^{+3} forms are significantly more mobile and toxic in the environment than the As^{+5} species.**
- **In general, As^{+5} compounds predominate in aerobic or oxic soils, and As^{+3} compounds in reduced or anoxic soils.**

ARSENIC CHEMISTRY IN SOILS

- **The behavior and chemistry of arsenate in the environment is very similar to phosphate (PO_4^{-3}).**
- **Arsenate, like phosphate has a high affinity for hydrous metal oxide surfaces, particularly under acidic conditions, and forms stable surface complexes over a wide range of pH values.**
- **Arsenate is also sorbed by noncrystalline aluminosilicates, and, to a lesser extent, by layer silicate clays.**
- **Therefore, the mobility of arsenate tends to be fairly low in acidic soils with high clay or oxide contents. In neutral to alkaline soils, As may be mobile as soluble Na arsenate.**

FACTORS THAT MAY AFFECT THE MOBILITY OF ARSENIC

Other factors to consider when evaluating the potential for arsenic to be mobilized and transported in soils include:

- **pH**
- **The presence of sulfate (SO_4^{-2})**
- **The presence of phosphate**
- **The presence of soil carbonates, including calcite ($CaCO_3$)**

SELENIUM MOBILITY AND TOXICITY

- **The mobility, bioavailability, and toxicity of selenium (Se) are controlled by its chemical speciation.**
- **Any one or all of the four oxidation states of Se may be present in soil and other environmental samples.**
  - **selanate (SeO_4^{-2})**
  - **selenite ($HSeO_3^-$ and SeO_3^{-2})**
  - **elemental (Se^0)**
  - **selenide (H_2Se and HSe^-)**
- **Although Se is a required mineral nutrient for animals and humans, there is a narrow gap between sufficient and toxic Se concentrations.**

SELENIUM CHEMISTRY IN SOILS

- The behavior and chemistry of Se in the environment is very similar to that of sulfur (S).
- Se may substitute for S in many inorganic and organic compounds, because they have the same ionic radius, and may exist in the same oxidation states.
- The selanate species (SeO_4^{-2}), like sulfate (SO_4^{2-}), is a mobile form of Se that is highly soluble. Selanates are the dominant form of Se occurring in alkaline, oxidized soils, and bond only weakly to oxides and other minerals.

SELENIUM CHEMISTRY IN SOILS (2)

- The selenite species ($HSeO_3^-$ and SeO_3^{-2}) are dominant in suboxic or mildly oxidizing soils, and in oxygenated, acidic (pH < 6) soil. Selenite species are less mobile than selanates, because they may be strongly sorbed by iron oxides, amorphous hydroxides, and aluminum sesquioxides. Selenite may also be reduced to elemental Se by reducing agents or microorganisms which limit its mobility and bioavailability.

- In wet, acidic, or humus-rich soils, elemental Se and the insoluble reduced forms of Se (H_2Se and HSe^-) predominate, thus restricting the mobility and bioavailability of Se.

FACTORS THAT MAY AFFECT THE MOBILITY OF SELENIUM

Other factors to consider when evaluating the potential for selenium to be mobilized and transported in soils include:

- **Microbial activity**
- **The presence of organic matter**
- **The presence of gypsum ($CaSO_4.2H_2O$)**
- **The presence of other sulfate minerals**