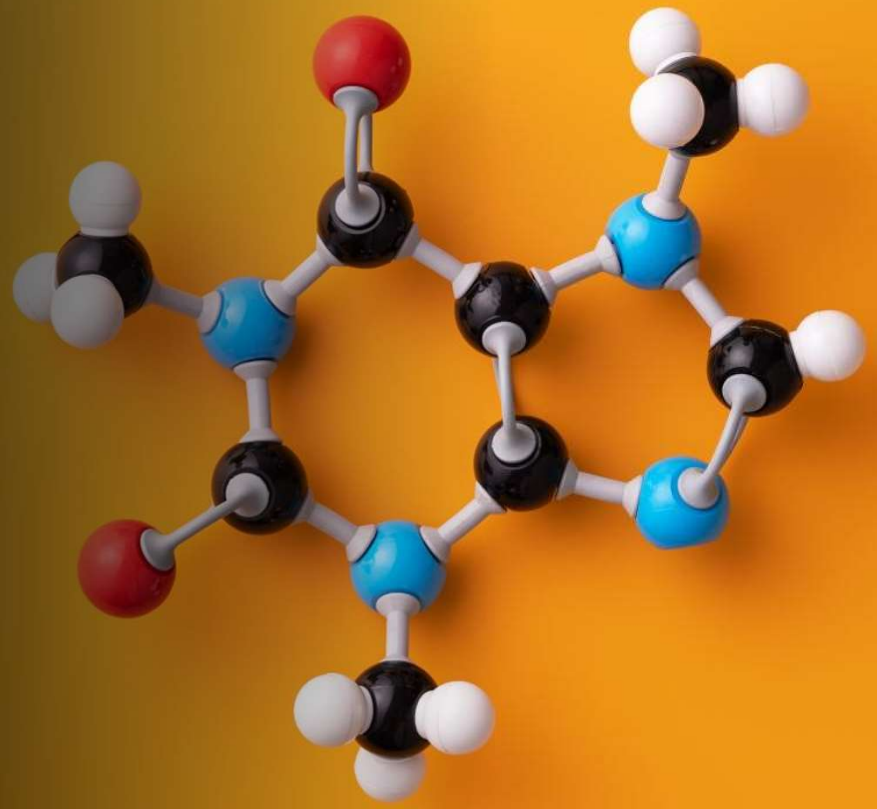
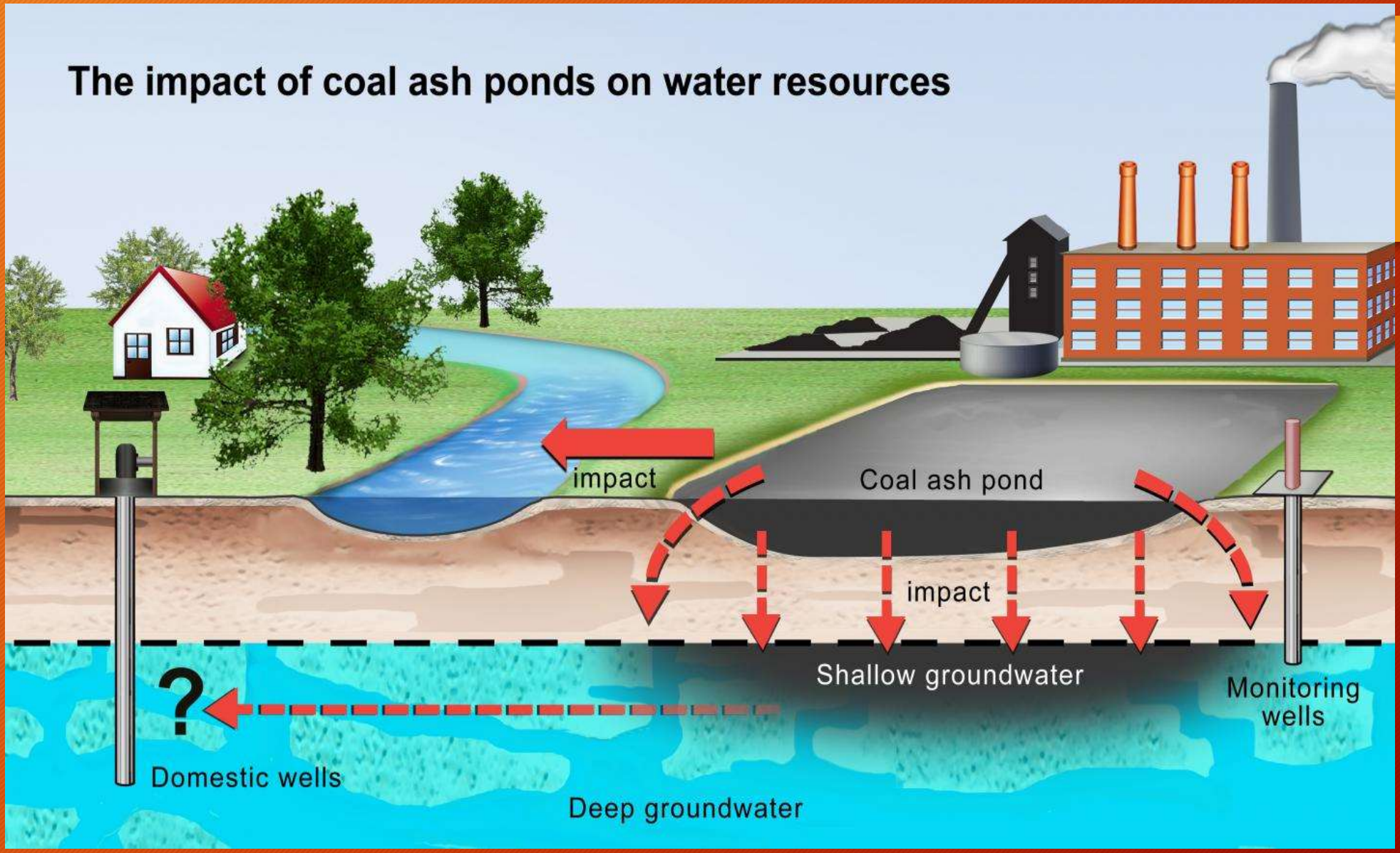
In-situ Remediation of Sulfate Contamination Using Low Molecular Weight Organic Compounds



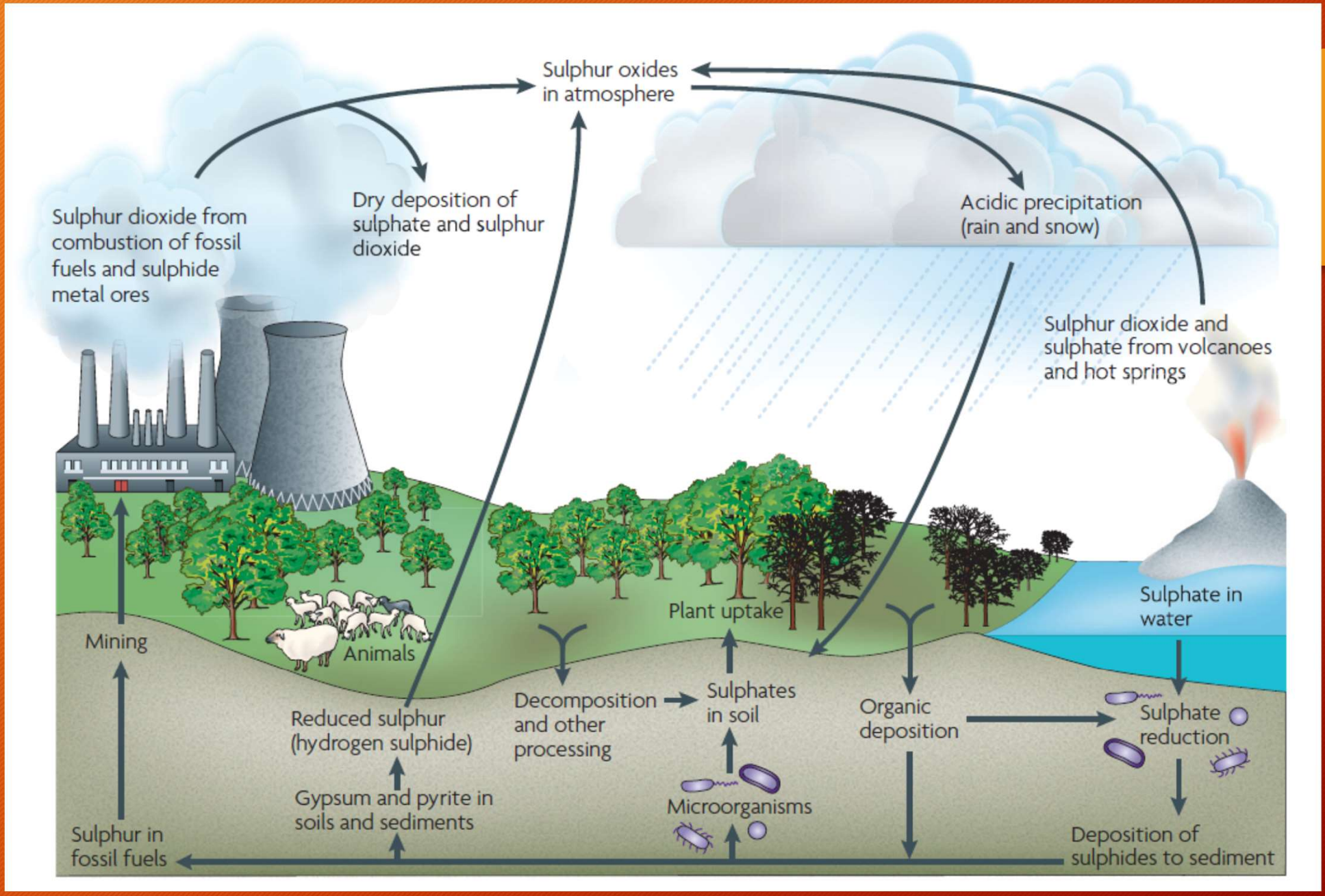
Phoenix Environmental Research in collaboration with Key Environmental

By Dr. Alex Krichevsky

May 2022



Harkness et al (2016) Evidence for Coal Ash Ponds Leaking in the Southeastern United States Environ. Sci. Technol. 50 (12) 6583-6592



The Sulfur Cycle, Muyzer, G., Stams, A. The ecology and biotechnology of sulphate-reducing bacteria. Nat Rev Microbiol 6, 441-454 (2008).

Contemporary Solutions for Sulfate Remediation

- Chemical treatment
- Reverse osmosis
- Ion exchange
- Bioreactors
- Limited attempts at *in-situ* treatment

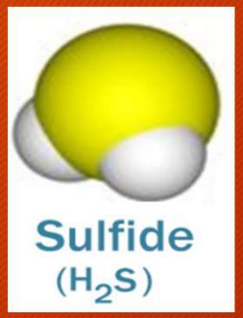
Electron donor (*organics, hydrogen*)

Sulfates

Sulfate Reducing Bacteria (SRB)

Hydrogen sulfide (H_2S)

pH Increase



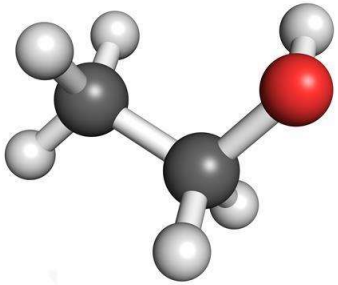
Precipitation of metals as metal sulfides

Precipitation of metals as metal hydroxides

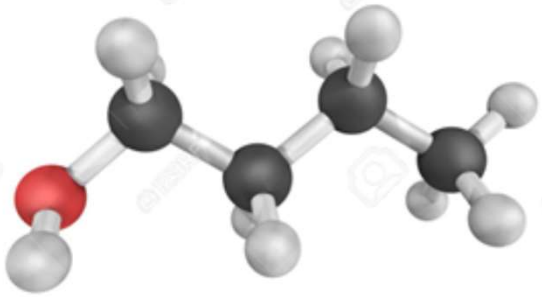
Types of Electron Donors ("food")

- **SRB lithotrophs** – utilize molecular hydrogen
- **SRB organotrophs** – utilize organic low molecular weight substrates, such as salts of organic acids or alcohols.
- **Low molecular weight compounds used in our bench scale study**:

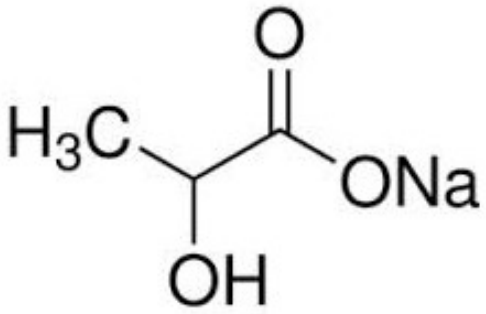
Butanol

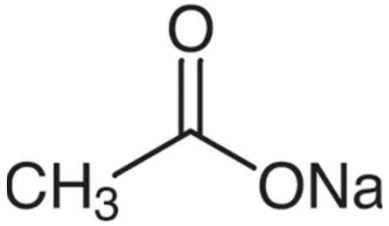


Ethanol



Sodium Acetate





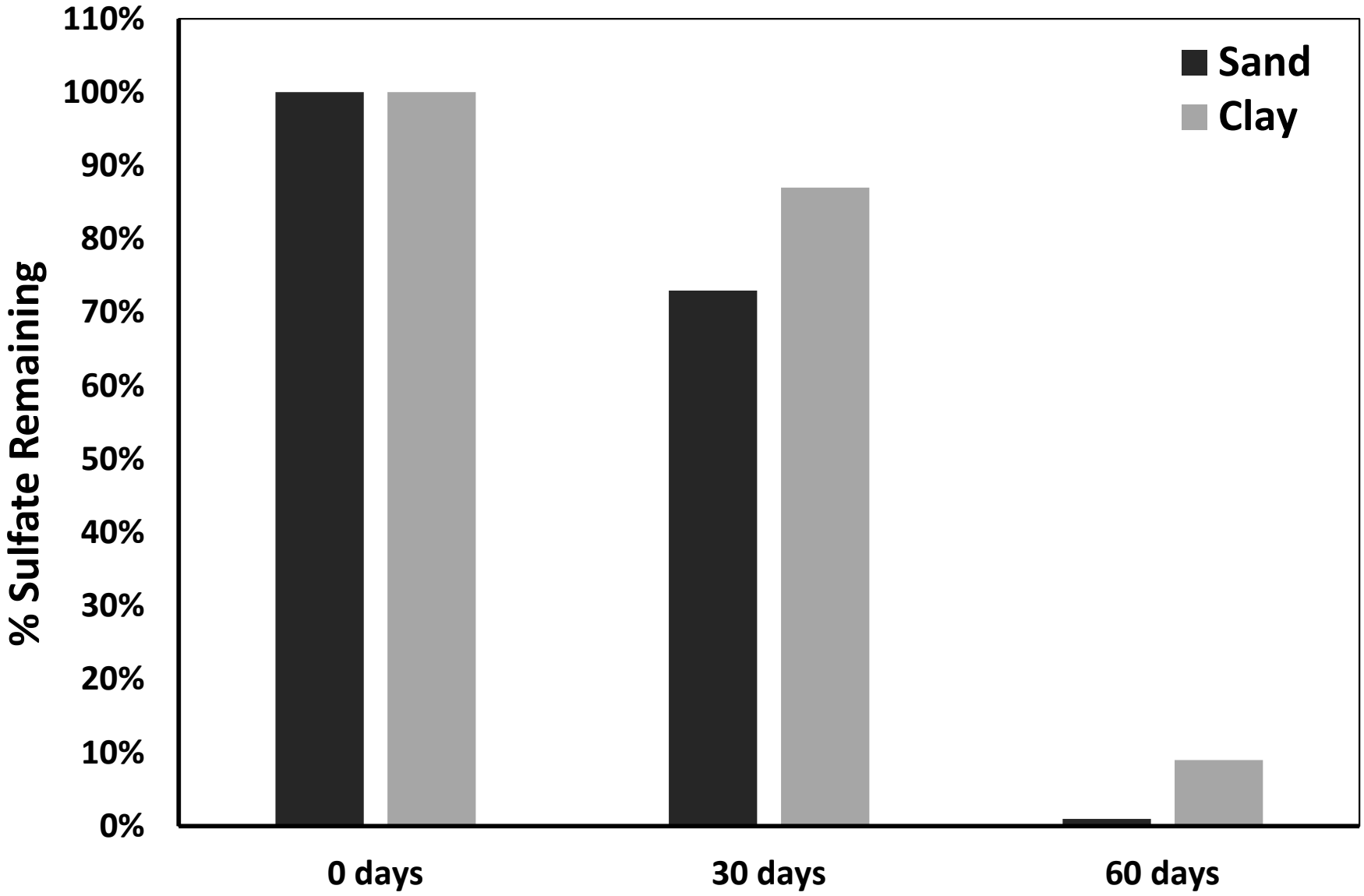
Sodium Lactate

Experimental Setup

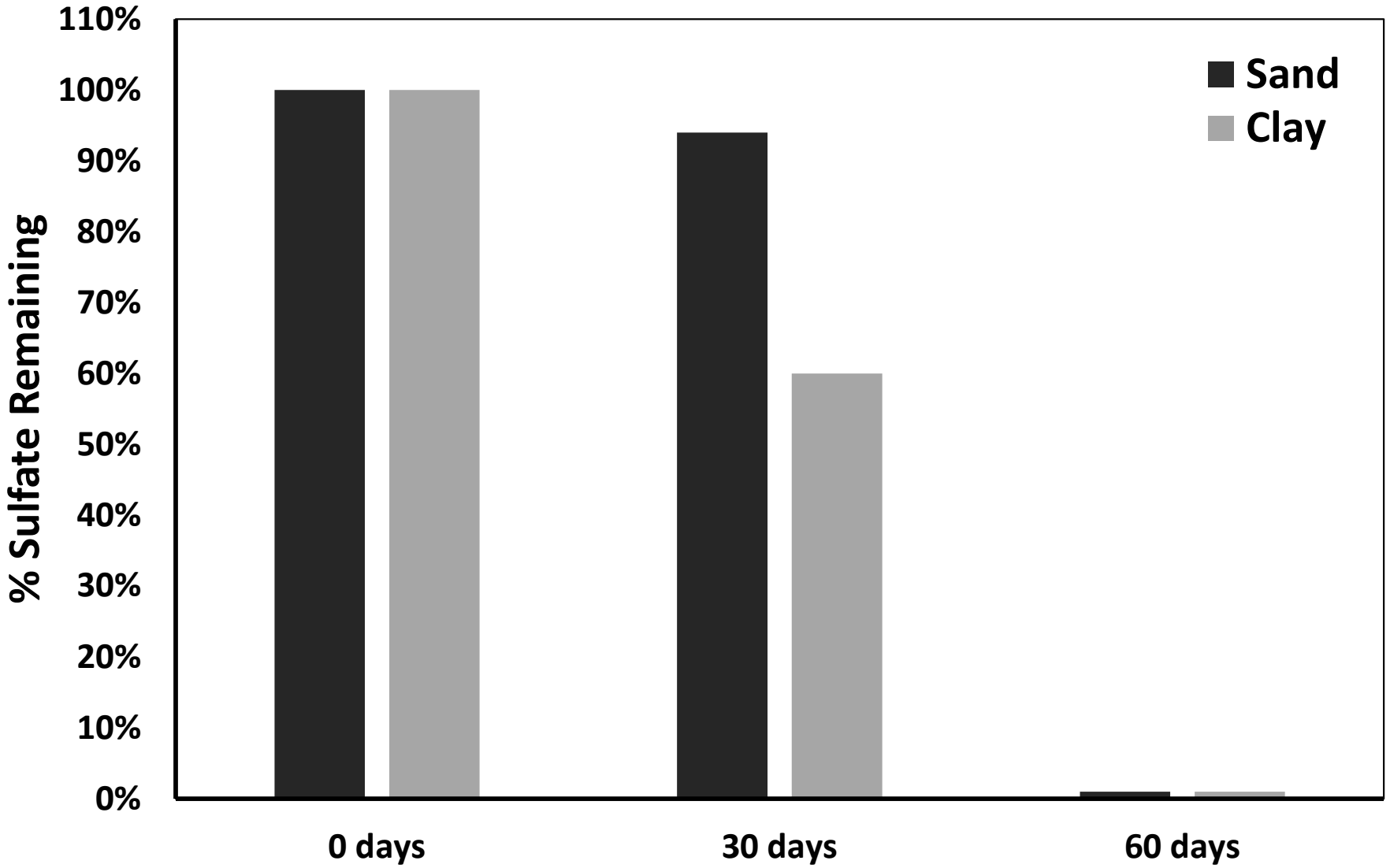
- Soil samples (sand and clay) from the test site were collected into laboratory flasks.
- A combination of lactate/acetate was added to some of the samples, and ethanol/butanol to others.
- Samples were for 60 days, with sampling and testing at 30 and 60 days.
- Testing was done for sulfates and metals.

Sulfate Reduction Results

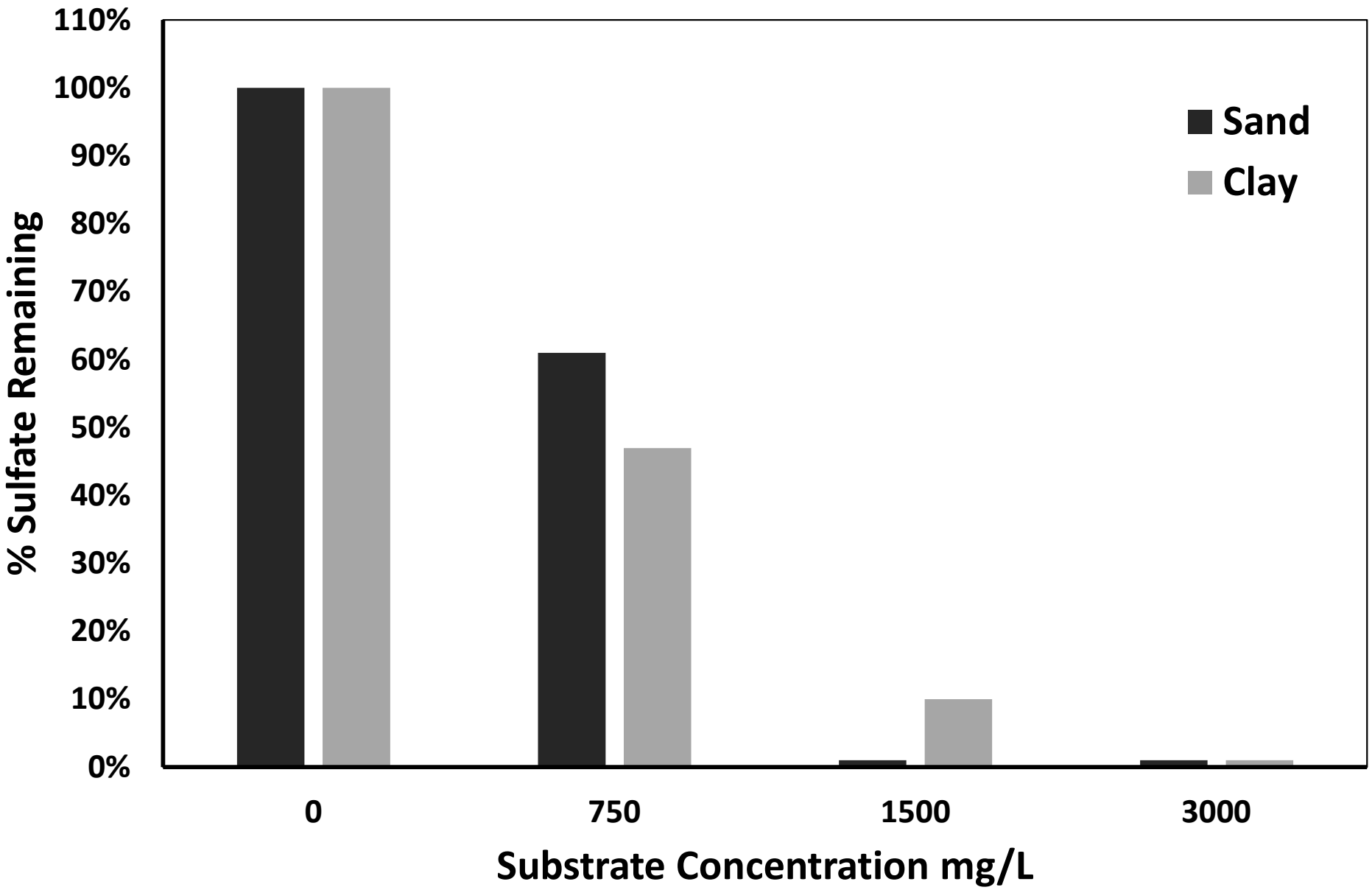
Sulfate Reduction Over 60 Day Period Using Lactate/Acetate as a Substrate for SRB



Sulfate Reduction Over 60 Days Period Using Ethanol/Butanol as Substrate for SRB

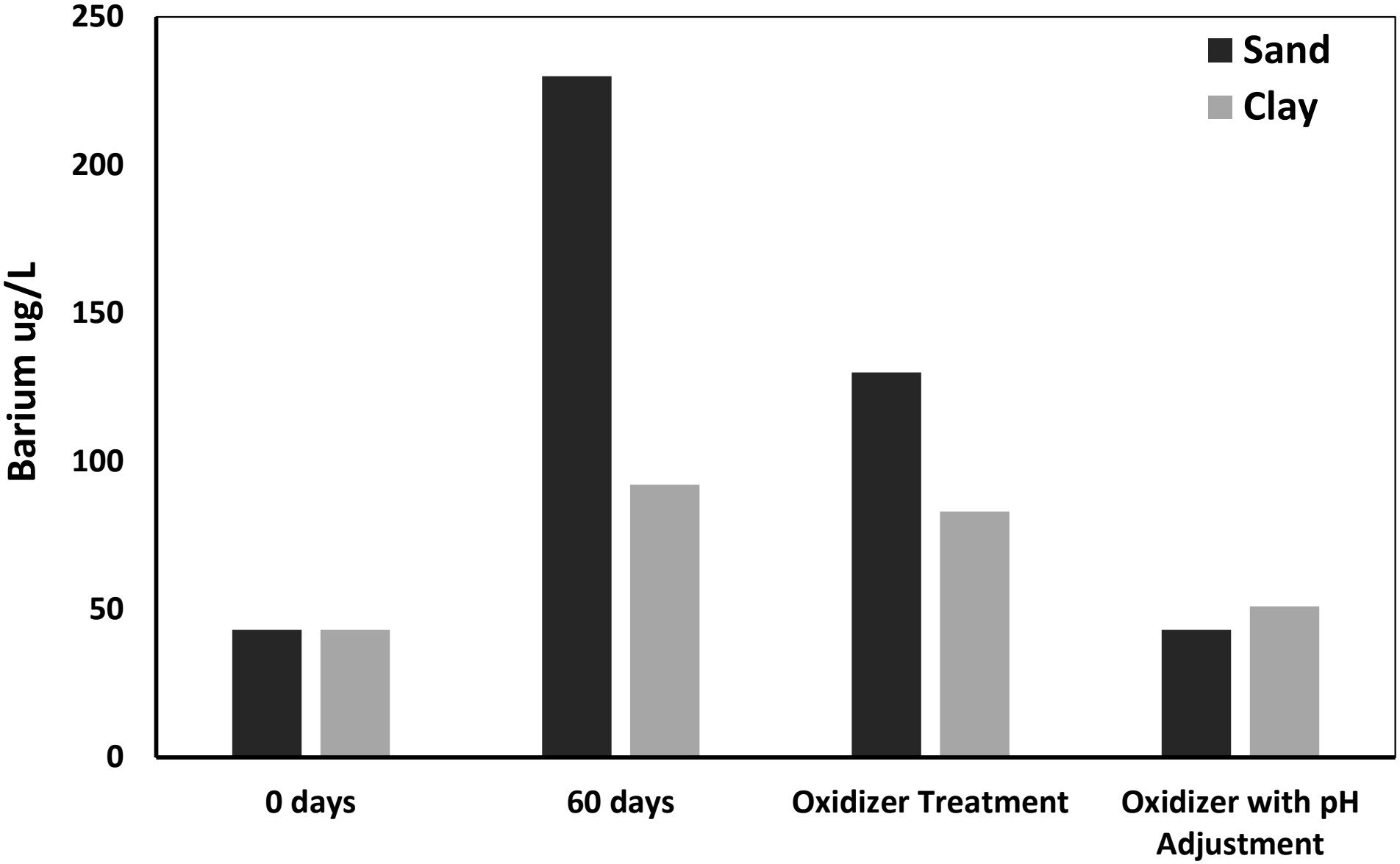


Optimizing Substrate Concentration

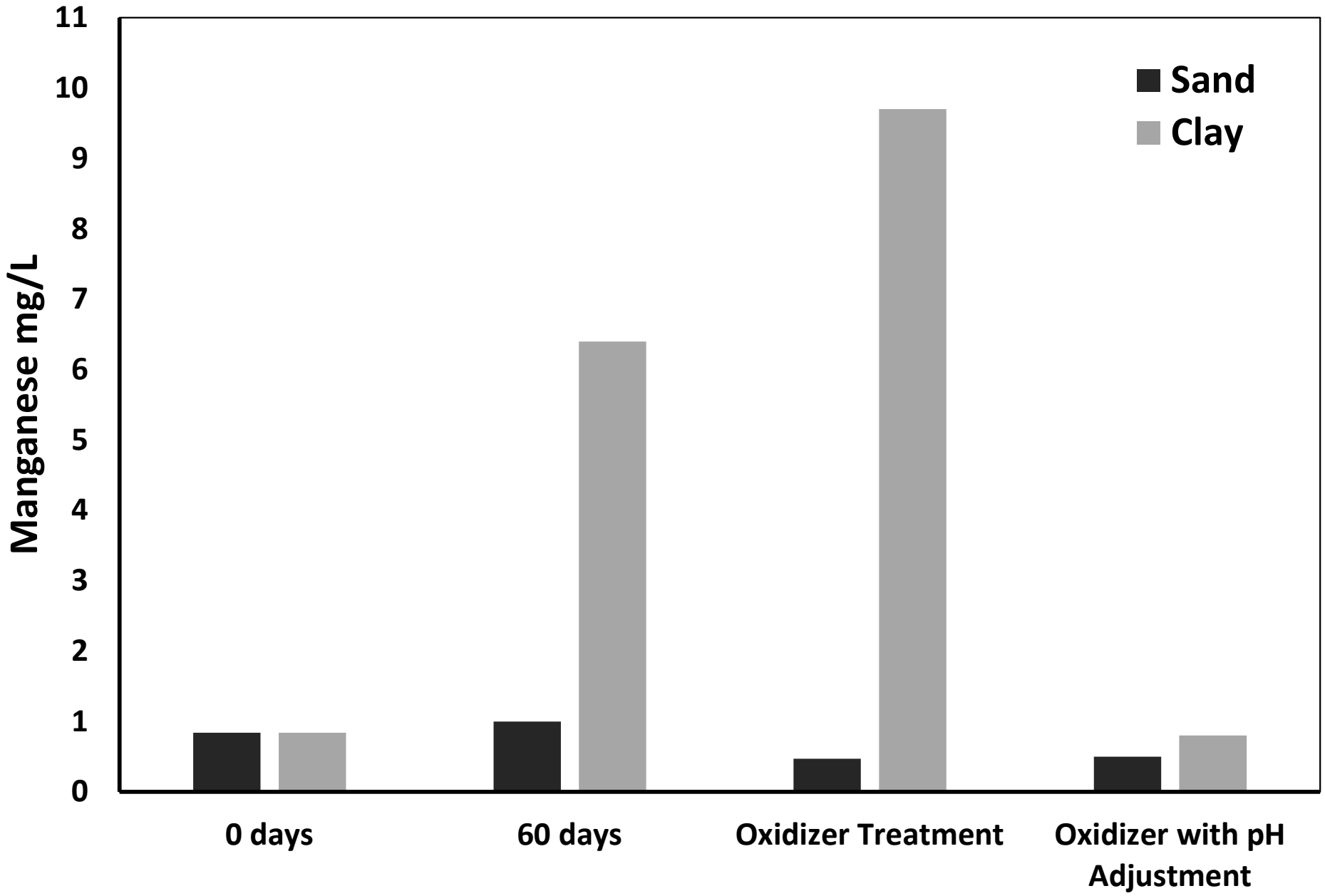


Unexpected Effects of Sulfate Reduction on Metals

Effects on Barium



Effect on Manganese



Summary

- Highly effective technology capable to remove over 90-100% of sulfates within 60 day *in-situ*
- Simple, cost effective and environmentally friendly.
- Working substate concentrations for the remediation applications were established.
- Successful resolution of increased metal concentrations.
- Patent application and article publication are pending