SRP-Funded Research in Metal/Metalloid Remediation Technologies

Heather Henry, PhD

Program Administrator, Superfund Research Program

National Institute of Environmental Health Sciences

SRP is Part of the National Institutes of Health

Fundamental Knowledge → NIH Research Mission → Health Outcomes

…of living systems

…with environmental exposures

…including health effects, assessing risks, detection and remediation

National Institutes of Health

National Institute of Environmental Health Sciences

Superfund Research Program (SRP)
SARA Legislation

…reduced illness & disability

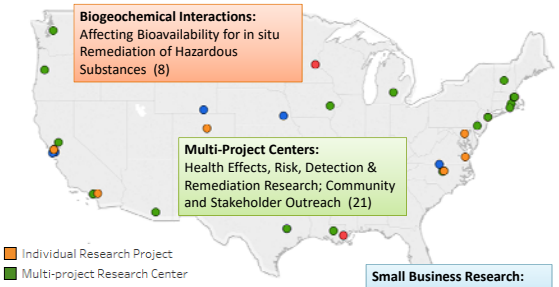
…caused by hazardous substances

…relevant to Superfund stakeholders

NIEHS Superfund Research Program (SRP)

- **Mission**: Provide practical science to solutions to protect human health
- NIH peer-reviewed, competitively awarded grants to Universities and small businesses
- **Unique team-science approach**
  - Brings together diverse disciplines: health researchers, engineers, biologists, ecologists, earth scientists, and social scientists
  - Aims to understand and reduce exposure to potentially harmful contaminants and improve health
- Works closely with industry, government, tribal, and business partners to deliver practical solutions

SRP – Funded Research Across the U.S.A.



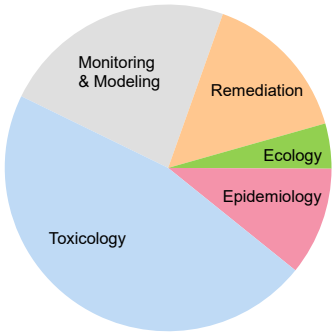
Biogeochemical Interactions: Affecting Bioavailability for in situ Remediation of Hazardous Substances (8)

Multi-Project Centers: Health Effects, Risk, Detection & Remediation Research; Community and Stakeholder Outreach (21)

- Individual Research Project
- Multi-project Research Center
- Research Education Programs in Emerging Technologies
- Small Business Innovation Research Grants

Small Business Research: Remediation and Detection technologies (6)

SRP Research Portfolio (2017)



Remediation Portfolio

Physical/Chemical (7)
- Barrier: 2
- Chemical: 3
- Electro/Thermal: 2

Biological (8)
- Extraction: 3
- Degradation: 5

Highlights:
SRP Metals Remediation and Related Research & Activities

Sustainable Solutions – Phytostabilization of Mine Tailings

PI: Raina Maier
University of Arizona

Phytostabilization Technology for Mining Wastes in Arid and Semiarid Environments: Plant-Microbe-Metal Indicators to Predict Sustainability

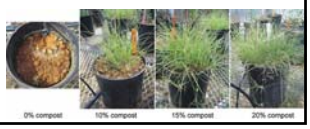
Researchers started a field trial at the Iron King Mine and Humboldt Smelter Superfund site in Arizona in 2010.

Sustainable Solutions – Phytostabilization of Mine Tailings

PI: Raina Maier, University of Arizona

Phytostabilization Technology for Mining Wastes in Arid & Semiarid Environments

- Targeted Metals: Arsenic, lead
- Innovation: Revegetation strategy "compost-assisted phytostabilization." Plants accumulate metals in root zone → prevent from entering food chain. Collected data will help assess phytostabilization as a remediation technology in semi-arid environments.
- Status: Field study at Iron King Superfund site in Dewey-Humboldt, AZ. Currently being translated to major mining companies to improve mine-tailing remediation practices.
- Relevant Publications:
  - Santos et al., PeerJ, 2017
  - Gil-Loaiza et al., Sci Total Environ, 2016



Sustainable Solutions – Stabilization of Metals in Soil

PI: Malcolm Burbank
BioCement Technologies, Inc

Microbial Induced Calcite Precipitation by Indigenous Soil Bacteria to Reduce Mobility of Lead and other Metals in Soil*

BioCement stabilizes metals in soil

*Previously Funded

Sustainable Solutions – Stabilization of Metals in Soil

PI: Malcolm Burbank, BioCement Technologies, Inc

Microbial Induced Calcite Precipitation by Indigenous Soil Bacteria

- Targeted Metals: Lead, other metals (e.g., barium, cadmium, cobalt, manganese, strontium and zinc). Also stabilizes uranium.
- Innovation: Simultaneously alter engineering characteristics of soil/sand while reducing the mobility of metals. Stable over geologic time. Process is carbon neutral to carbon negative.
- Status: BioCement is commercially available. Currently testing the use of BioCement to treat munitions-impacted soil.

Phone: 509-607-2406
Email: burbankm@cdmsmith.com

Assessing Effectiveness of Mercury Methylation

PI: Heileen Hsu-Kim
Duke University

Biogeochemical Framework to Evaluate Mercury Methylation Potential During in-situ Remediation of Contaminated Sediments

Assessing Effectiveness of Mercury Methylation

PI: Heileen Hsu-Kim, Duke University

Biogeochemical Framework to Evaluate Mercury Methylation Potential

- Targeted Metals: Mercury
- Innovation: Establishing biogeochemical indicators for methylmercury production to improve the effectiveness of in situ remediation.
- Status: Conducting lab sediment microcosm experiments simulating a range of conditions relevant to mercury-contaminated Superfund sites.
- Relevant Publications:
  - Wyatt et al., Environ Sci Technol, 2016
  - Kucharzyk et al., Environ Sci Process Impacts, 2015
  - Ticknor, et al., Environ Eng Sci, 2015
  - Pham et al., Environ Sci Technol, 2015 (DGT sampling)

Biogeochemistry: Bioavailability Assays at Clear Creek, CO

PI: Jim Ranville
Colorado School of Mines

Investigating Biogeochemical Controls on Metal Mixture Toxicity Using Stable Isotopes and Gene Expressions

Biogeochemistry: Bioavailability Assays at Clear Creek, CO

PI: Jim Ranville, Colorado School of Mines

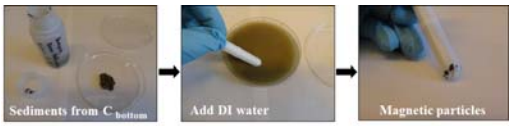
Biogeochemical Controls on Metal Mixture Toxicity

- Targeted Metals: Metal mixtures (lead, copper, zinc, nickel, iron)
- Innovation: Organism & community-level studies, genomic bioassays, & bioavailability studies. Applying concepts to study remediation effectiveness; simulated recovery experiments.
- Status: Field testing in metals-contaminated stream at North Fork Clear Creek Superfund site in CO.
- Relevant Publications:
  - Traudt et al., Environ Toxicol Chem, 2017
  - Cadmus et al., Environ Sci Technol, 2016
  - Traudt et al., Environ Toxicol Chem, 2016

Enhanced Remediation at Contaminated Sites in the U.S.

PI: Benjamin Bostick, Steven Chillrud, Columbia University

Enhanced Remediation at Contaminated Sites in the U.S. – Focusing on Arsenic for SRP, but also working with Mn



Enhanced Remediation at Contaminated Sites in the U.S.

PI: Benjamin Bostick, Steven Chillrud, Columbia University

Enhanced Remediation of Arsenic at Contaminated Sites in the U.S.

- Targeted Metals: Arsenic, Manganese.
- Innovation: Developing enhanced remediation technology that produces magnetite in situ → forms reactive barrier that sustains low As both in laboratory and in field trials.
- Status: Lab and field-based studies; pilot at US Geological Survey site on Cape Cod, Lot 86 Superfund site at North Carolina State University. First field-scale test of nitrate-Fe(III) injections for As remediation.
- Relevant Publications:
  - Sun et al., Environ Sci Technol, 2016
  - Sun et al., J Hazard Mater, 2016

Protecting Water from Mine Waste

PI: Jose Manuel Cerrato
University of New Mexico

Immobilization of Uranium, Arsenic, and Co-occurring Metals in Mine Wastes

Developing cost-effective remediation strategies that immobilize metals and prevent degradation of community water sources.

Protecting Water from Mine Waste

PI: Jose Manuel Cerrato, University of New Mexico

Immobilization of Uranium, Arsenic, and Co-occurring Metals in Mine Wastes

- Targeted Metals: Uranium, arsenic, metal mixtures (Mo, Se, V)
- Innovation: Studying reaction mechanisms involving metal mixtures of ubiquitous secondary mineral phases and the adsorption of locally abundant iron oxides that may help reduce exposure risks to human health. Engineering phytoremediation strategies using biogeochemistry and reactive transport modeling. Manipulating rhizosphere environment to alter microbiome-plant interactions controlling uptake of metals in surface water systems downstream of mine waste sites.
- Status: Recently funded, in-vitro and greenhouse experiments; working at Jackpile-Paguate Uranium Mine - Laguna Pueblo, New Mexico.

Outreach Activities: Informing Policy

- International Conference on Mercury as Global Pollutant (ICMGP): Science Informs Policy Questions
  (Celia Chen, Dartmouth SRP Center)