National Institute of Environmental Health Sciences
*Your Environment. Your Health.*

# Developing a Pan American Hub for Environmentally and Socially Compatible Mining: New Technologies

# Desarrollo de un Consorcio Panamericano para la Minería Social y Ambientalmente Compatible: Nuevas Tecnologías


**Heather Henry**
**Superfund Research Program, NIEHS**
http://www.niehs.nih.gov/srp/

Instituto Nacional de Salud Ambiental (NIEHS)
ESTADOS UNIDOS

National Institute of Environmental Health Sciences (NIEHS)
USA

# Pan American Hub:
# A Collaboration of Diverse Stakeholders

Environment and Health Policy…

…and Research Funding

New Science & Training Scientists

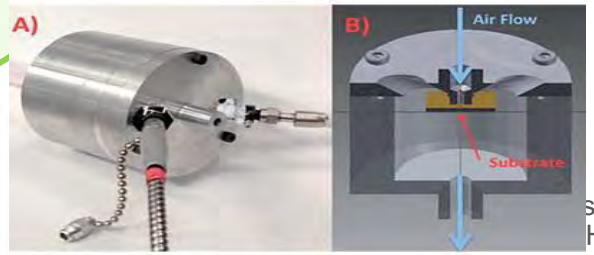
Impacts to Health and Wellbeing

Mining Operations & Job Opportunities

# Pan American Hub:
# A Role For NIEHS Superfund Research Program

**Universities: Health and Site Remediation & Detection**

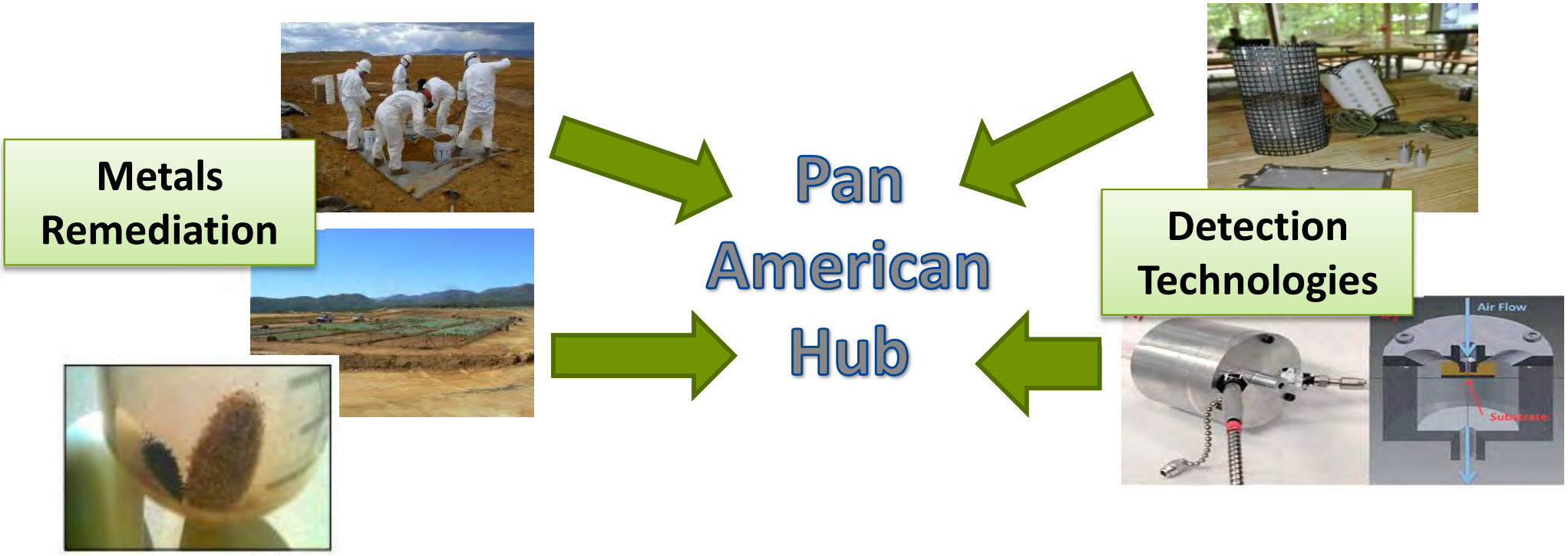
**Capacity Building Activities**




**New Detection and Remediation Technololgies**

# Pan American Hub:
# A Role For NIEHS Superfund Research Program –

***Provide a link to grantee research, products, and expertise to advance the goals of compatible mining.***



# Metals Remediation

## Biological-based

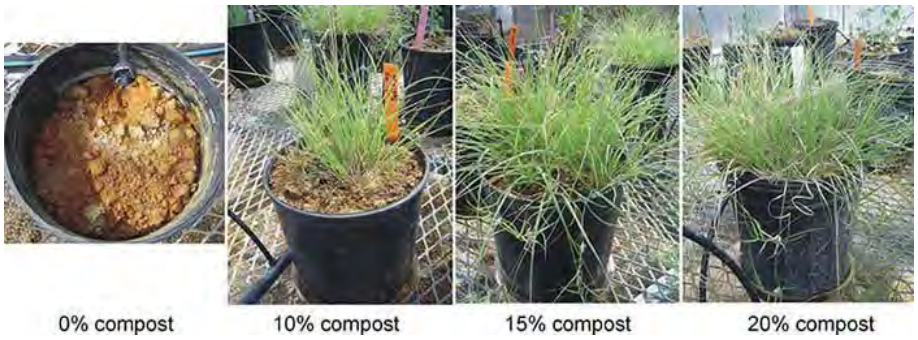
## In situ Approaches

## Other Technologies

# Sustainable Solutions – Phytostabilization of Mine Tailings

## U Arizona, Raina Maier

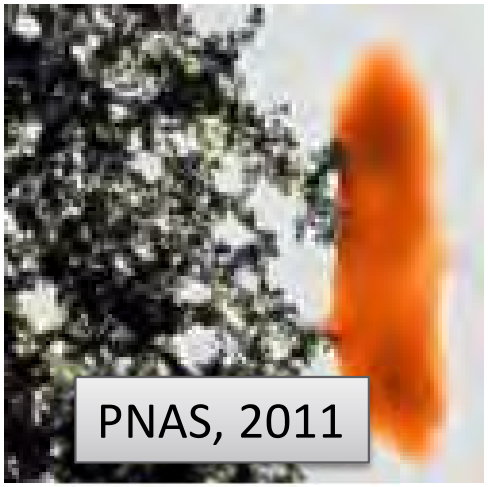
- Plants selected to accumulate metals in the root zone, rather than to extract them into above-ground biomass, preventing metals from entering the food chain.
- Semi-Arid location: Iron King Mine Superfund site.
- Revegetation process with native plants.
- Best practices for using phytostabilization as a remediation technology on tailings.

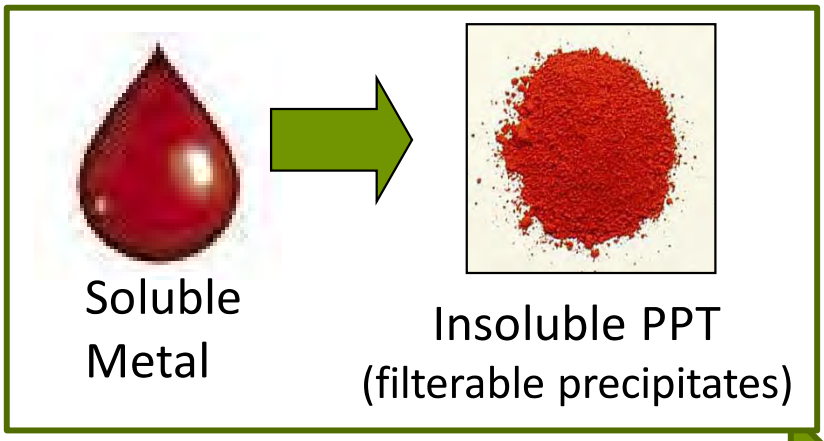



# Bioremediation or Uranium

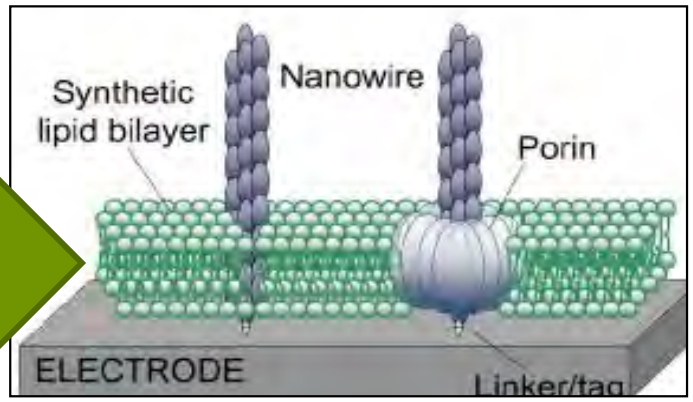
## Purdue University, Gemma Reguerra

- Gemma Reguera (MSU) developed device based on metal reduction by *Geobacter* spp
- The Solution: removes uranium from water – and tested at Oak Ridge National Laboratory




**4 Patents – a device duplicating bacterial clean up**



# Other Sustainable Remediation Technologies

- Plant-based Remediation:
  - Endophyte assisted phytoremediation of arsenic (Edenspace, Michael Blaylock)
  - Phytostabilization of mercury (Edenspace, Mark Elless)
  - Phytoextraction of cadmium from plant trichomes (Phyllotech, Ryan Shepherd)
- Other Bioremediation:
  - Immobilizing lead in soils (Biocement Technologies, Malcom Burbank; Carnow Conibear and Associates, Rod Musselman)

**Biocement stabilizes lead in soils.**

# Remediation Technologies – In Situ

- In situ Remediation – sustainable approaches for treatment "in place"
  - In situ remediation of arsenic in groundwater (Columbia University, Steve Chilrud)
  - Sub-micrometer zero valent metal for in-situ remediation of contaminated aquifers (Onmaterials, John Freim)
  - In situ stabilization of mercury in sediments using carbon and biochar admendments (UM Baltimore Co., Upal Ghosh; Duke University, Heileen Hsu-Kim)

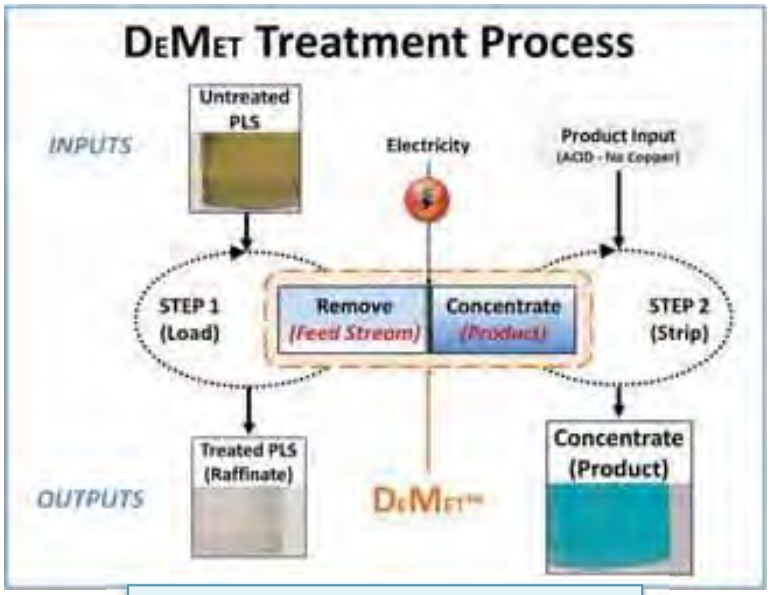
**Arsenic stabilization, Chilrud and Bostick**

## Ore Recovery and Removal

- "DeMet" ore recovery and reuse for acid mines (Blue Planet Strategies, Pat James)
- Electro winnowing (Brown University, Joseph Calo)

## Materials Reuse

- On-site mercury remediation via activated fly ash (Pollution Control Technologies, Kaspars Krutkramelis)




Blue Planet Strategies

Pollution Control Technologies

# Other Remediation Technologies

- Membrane Technologies:
  - Sorbent for the removal of arsenic and other heavy metals from drinking water (ADA Technologies Inc, John Lovell)
  - Arsenic selective ligand-anchored fiber for purification of drinking water (Chemica Technologies Inc., Takuji Tsukamoto)
- Barrier Technologies:
  - Sequestration and immobilization of arsenic and other metals in sediments through multilayered mat (UC Merced, Peggy O'Day)
  - A reactive mat to remediate contaminated sediments and reduce health risks (Northeastern University, Thomas Sheahan)

# Detection Technologies

**Nanotechnology**

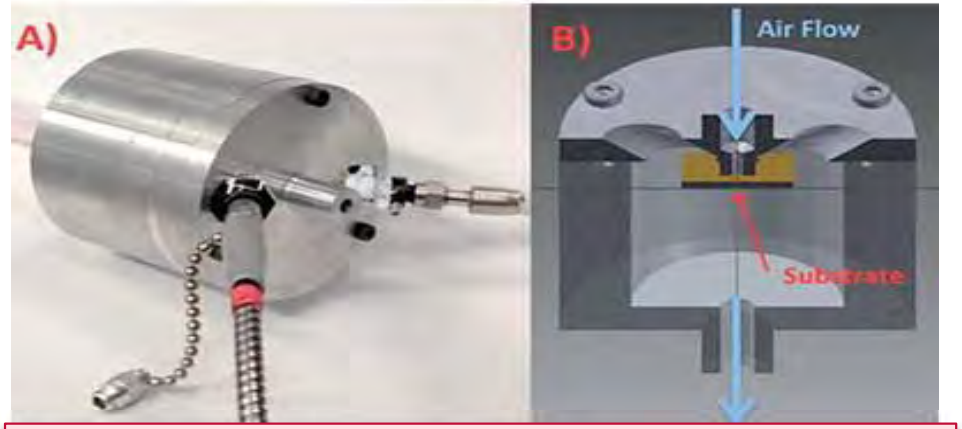
**Passive Sampling**

**Community-based**

# Mercury Detection Device – Gold Nanotechnology

## Picoyune, Jay James, (R43ES023729)

- Picoyune has a patented technology to detect mercury contamination in the environment.
- Inexpensive, simple, and highly sensitive gold nanoparticle-based sensor to measure mercury in air or water.
- Adapting the technology from air to soil and sediment detection.




The air enters the chamber and mercury readily adsorbs onto gold surfaces, creating a change in the nanoparticle film that is optically detectable by spectrometry.

http://picoyune.com/

PICOYUNE

# Universal Passive Sampling Device uPSD

Damian Shea, NC State (UNC Center)

- Developing a universal passive sampling device (uPSD): one device measures a wide-range of chemicals including measures bioavailable fractions
- Leave device in environment to achieve equilibrium
- Mixed-polymer sorptive phase contained within a non-selective and highly porous membrane will allow linear uptake of this very broad range of chemicals

Dan River Ash Spill, NC

50,000 to 80,000 tons of coal ash (EPA estimate); waste along the riverbed for 70 miles.

# Rapid Detection Technologies

- Field-deployable, rapid detection of arsenic in water
  - Cambrian Innovation, Justin Buck
  - Lynntech Inc, Bikas Vaidya
  - OndaVia Inc, Merwan Bernabib
- X-ray fluorescence (XRF) analyzer for measurement of toxic elements, including arsenic, in electronics and other related consumer products (X-Ray Optical Systems Inc, Danhong Li)
- Field-deployable monitor to assess personal exposure to multiple heavy metals (Giner Inc, Badawi Dweik)
- Field portable fluorescent sensing methods for detecting metals and other toxicants (UC San Diego, William Trogler)

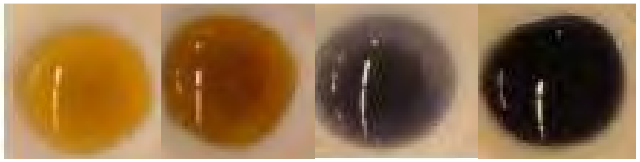
# Rapid Detection Technologies (cont'd)

- Chemifluorescent detection of lead in dust (Strategic Government Group, Joan Stader)
- Electrochemical paper-based analytical devices for metal determination in air (Access Sensor Technologies LLC, Daniel Miller-Lionberg)
- Disposable paper-based electrochemical metal ion sensors for water safety testing (Zansors LLC, Rebecca Y. Lai)
- Test strips for lead detection in soil and sediment (Morphix technologies, Edward Locke)

# Community-based sampling: Mapping Tailings in Peru

## (Columbia University, Lex Van Geen)

Community engaged in sampling of soil using field-kit test – used for mapping lead concentrations



**Rhodizonate score**


# Summary

- Superfund Research Program – Link Between Pan American Hub and Grantees in Health, Environment, New Technologies
- Sustainable Remediation Technologies
  - Biological-based – phytotechnology, bioremediation
  - “in situ” - treatment in place
  - Reuse, membrane technology, barrier technologies
- Detection Technologies
  - Nanotechnology
  - Passive Sampling Devices - bioavailability
  - Rapid, easy to use, cheap
- Technologies still under development…not ready for “Prime Time”

# Thank You! Gracias!


National Institute of Environmental Health Sciences

CESM
Center for Environmentally Sustainable Mining

Superfund Research Program
The University of Arizona

The University of Arizona, Tucson
IMR
Lowell Institute for Mineral Resources

PUCP

FCM Federation of Canadian Municipalities / Fédération canadienne des municipalités
Sustainable and Inclusive Communities in Latin America

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Special Thanks: Sara Mishamandani, MDB, Inc.

http://www.niehs.nih.gov/srp/

SRP WATER INNOVATION
An Integrated Approach to Sustainable Solutions

# Upcoming Webinar – Innovative Technologies for Water

www.cluin.org

**Sustainable Approaches to Remediation: March 21, 1-3 pm EST**

- Enhanced Non-fouling Membranes for Water Purification and Recycling
  David Battaglia, Ph.D., Lynntech Inc.
- Remediating Contaminated Groundwater with Slow-Release Oxidants
  Steve Comfort, Ph.D., Airlift Environmental LLC
- Rapid and Inexpensive Alternative for Ion Analysis: Online Microchip Electrophoresis
  Philippe Dekleva and Scott Noblitt, Ph.D., MicroChemica LLC
- High Performance Bioprocess for Eliminating 1,4-Dioxane in Water
  Fatemeh Shirazi, Ph.D., Microvi Biotechnologies

**Innovative Detection Technologies: March 23, 2016, 1-3 pm EST**

- Quantitative Analysis of Water Contaminants using Surface-Enhanced Raman Spectroscopy
  Mark Peterman, Ph.D., OndaVia Inc.
- Rapid Detection of Arsenic in Water
  Bikas Vaidya, Ph.D., Lynntech Inc.
- Portable SERS Detector for Simultaneous Detection of Trace-level Polycyclic Aromatic Hydrocarbons at Superfund Sites
  Wayne Weimer, Ph.D., and Lili He, Ph.D., Agiltron Inc.

# Extra Slides

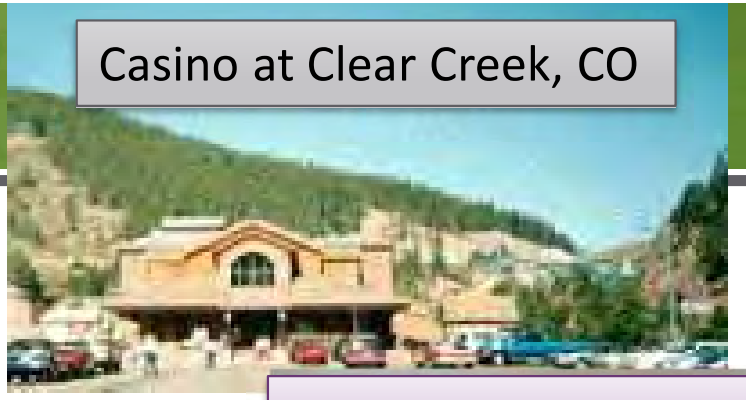
# Biogeochemical Research

## Predicting Metal Fate and Transport

# Biogeochemistry: Bioavailability Assays at Clear Creek, Colorado

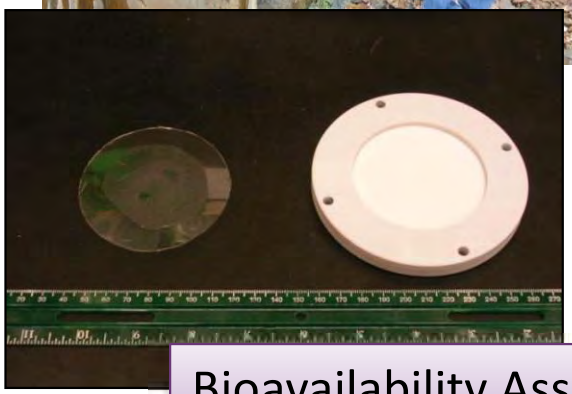
**Colorado School of Mines, Jim Ranville**
**Harvard School of Public Health, Jim Shine**

- Clear Creek is a Historical Mine Region – situated near Denver, Colorado.
- They are looking at effects of metal removal efforts on stream recovery.
- Their ongoing efforts will tell us about overall effectiveness of cleanup efforts – to remove toxic metals (zinc, lead, copper) but not impact essential metals (iron).


Casino at Clear Creek, CO

Ecological Indicators




Bioavailability Assay

# Other Biogeochemical Research

- Methylmercury production and fate in aquatic systems (Dartmouth College, Celia Chen)
- Mobility, bioaccumulation, and ecological toxicity of arsenic in urban lakes (University of Washington, Rebecca Neumann)
- Arsenic biogeochemical interactions (University of Arizona, Jim Field & Jon Chorover)

Callahan Mine open pit (above) and (below) Charles Wray, left, and Celia Chen investigate seepage of dissolved copper at the Callahan Mine EPA Superfund site in Maine.

# Biogeochemical Research

- Impact of sediment mineralogy and related transformations on arsenic groundwater concentrations (Columbia University, Benjamin Bostick)
- Attenuation and remediation of groundwater contamination from hardrock acid-mine drainage (University of Arizona, Mark Brusseau)
- Arsenic and manganese mobility and geochemical processes affecting temporal variability in soil (Harvard University, Charles Harvey and James Shine)