Green Remediation

Restoration Alternatives

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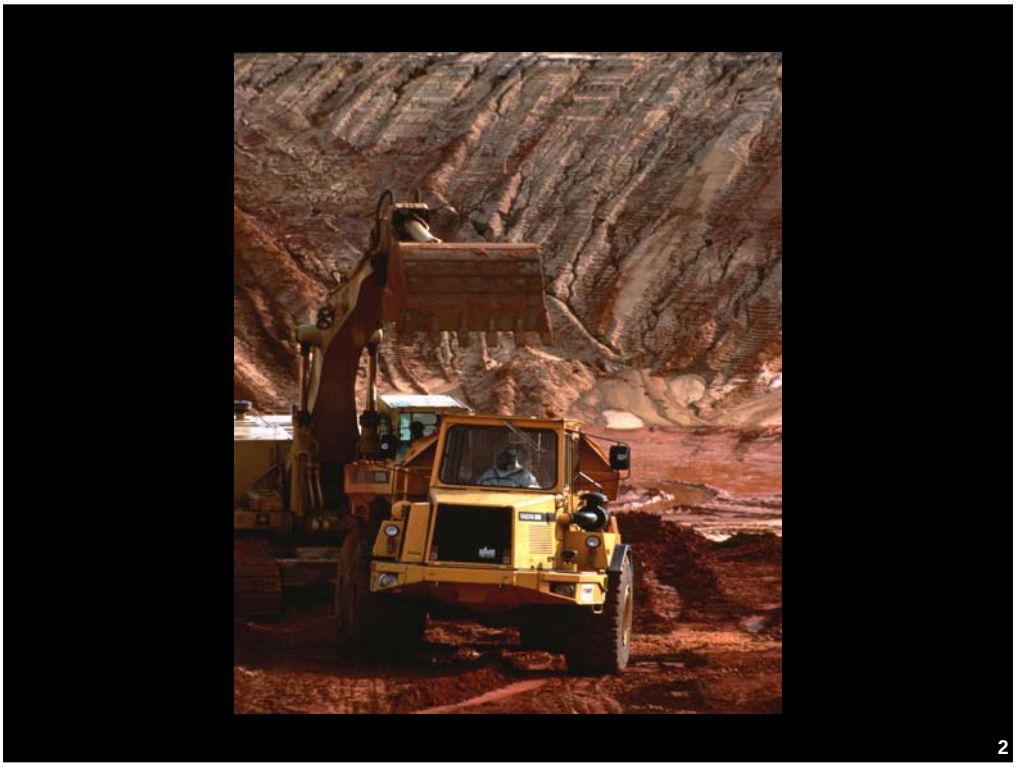

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EPA's OSWER Priorities

- Revitalization
- Recycling
- One Clean-up Program

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Bunker Hill

Rottne & AeroSpread

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LINCOLN'S WORLD FAMOUS
10,000 SILVER $
GIFT SHOP & RESTAURANT - 42 MILES
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Mine Sites

- Lack of vegetation is a result of:
  - Low fertility
  - Poor soil physical properties
  - Acidity
  - Metal toxicities
  - Salts

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Goals of Remediation

- Reduce bioavailability of contaminant in place
  - In-situ treatment in EPA lingo
- Rebuild soil or build new soil
- Restore soil function
  - Sustain plant growth
  - Sustain soil fertility
- Establish native plant ecosystem

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Residuals as Soil Amendments Why use wastes?

- Alternative to conventional remedial technologies
  - lower costs
  - recycling wastes for a better use
  - Can be economical large scale solutions
  - Use application expertise from generators

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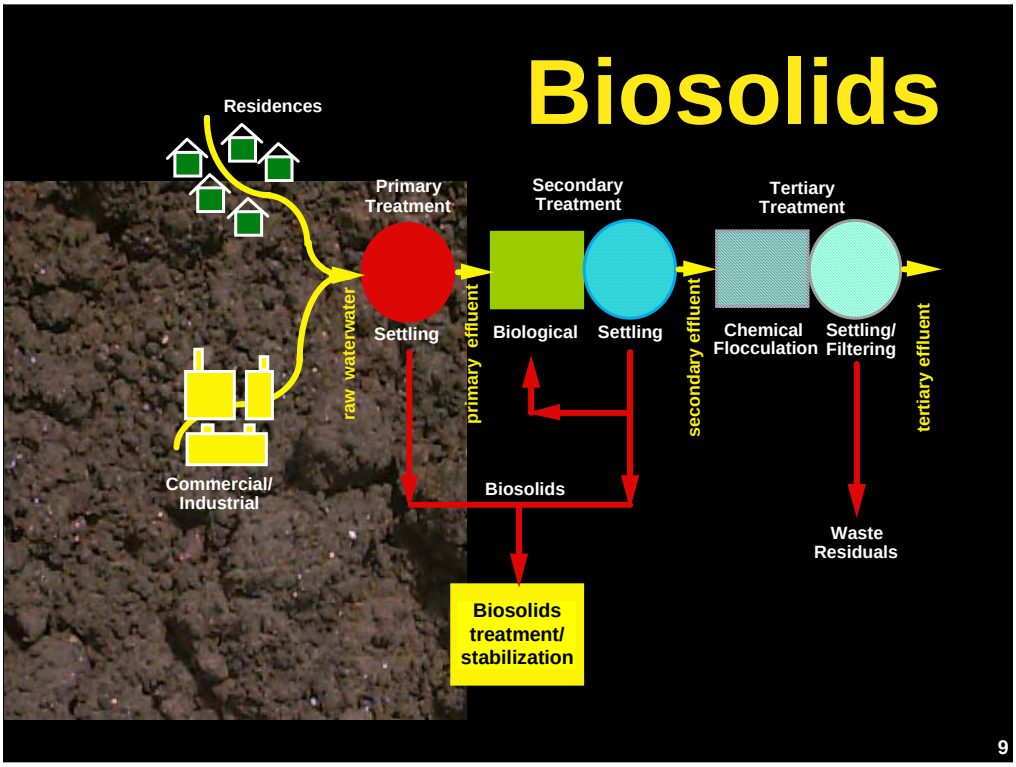
Biosolids
Residences
Primary Treatment
Secondary Treatment
Tertiary Treatment
raw wastewater
Settling
primary effluent
Biological
Settling
secondary effluent
Chemical Flocculation
Settling/ Filtering
tertiary effluent
Commercial/ Industrial
Biosolids
Waste Residuals
Biosolids treatment/ stabilization
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Biosolids

- Produced by all municipalities
- Use regulated under 40 CFR 503
- 70% of biosolids are now land applied
- Cost - "subsidized" by municipality

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Primary and secondary pulp & paper sludge

- Primary settled solids
  - High C:N ratio
- Secondary settled solids
  - Lower C:N ratio
- Adhesive properties
- Readily available in some parts of the country

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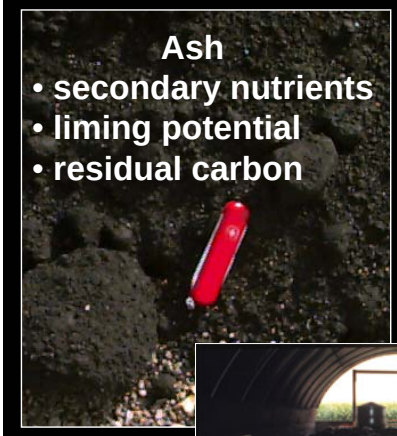
Other waste products



lumber industry, land clearing debris

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Compost

Stable soil like material
Pathogen and odor free

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Steps in design

- Site history
- Soil sampling and analysis
- Identify site problems
  - Contaminants
  - Soil physical conditions
  - Climate
- Inventory of available materials
- Identify appropriate mixtures

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Three examples of restoration of metal contaminated sites

- Bunker Hill, Idaho
  - Contaminated wetland
- Leadville, Colorado
  - River-deposited tailings
- Tar Creek, Oklahoma
  - Yard soils
  - Mine tailings

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Bunker Hill - wetland restoration

- Lead 30,000 mg kg^{-1}
- Zinc 15,000 mg kg^{-1}
- Cadmium 100 mg kg^{-1}

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Goal: Wildlife Protection from Acute Pb Poisoning
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Waterfowl:

- Use Lateral Lakes wetlands as feeding, nesting area
- Dive for roots and tubers
- 20% of diet is sediment
- Acute Pb poisoning
- 100 sq mile area is Pb ‘enriched’

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Compost
Wood ash
Cap

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Scientific basis of treatments

- Barrier to contaminated sediments
  - Preferred rooting
  - Limit - access to tailings
- Create a functional wetland
  - Reducing conditions
  - Reduction of sulfur
  - Formation of galena
- Galena
  - Reduces Pb availability
  - Further reduces ecosystem threat

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Scientific basis of treatments

- Biosolids - compost add:
  - nutrients
  - organic matter = wetland muck
  - Microbial food source
- Wood ash/waste lime add:
  - pH adjustment
  - Mineral soil
- Wood waste/other C-rich residuals:
  - limits N availability
  - Road building

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15 cm deep treatment of a mixture of:

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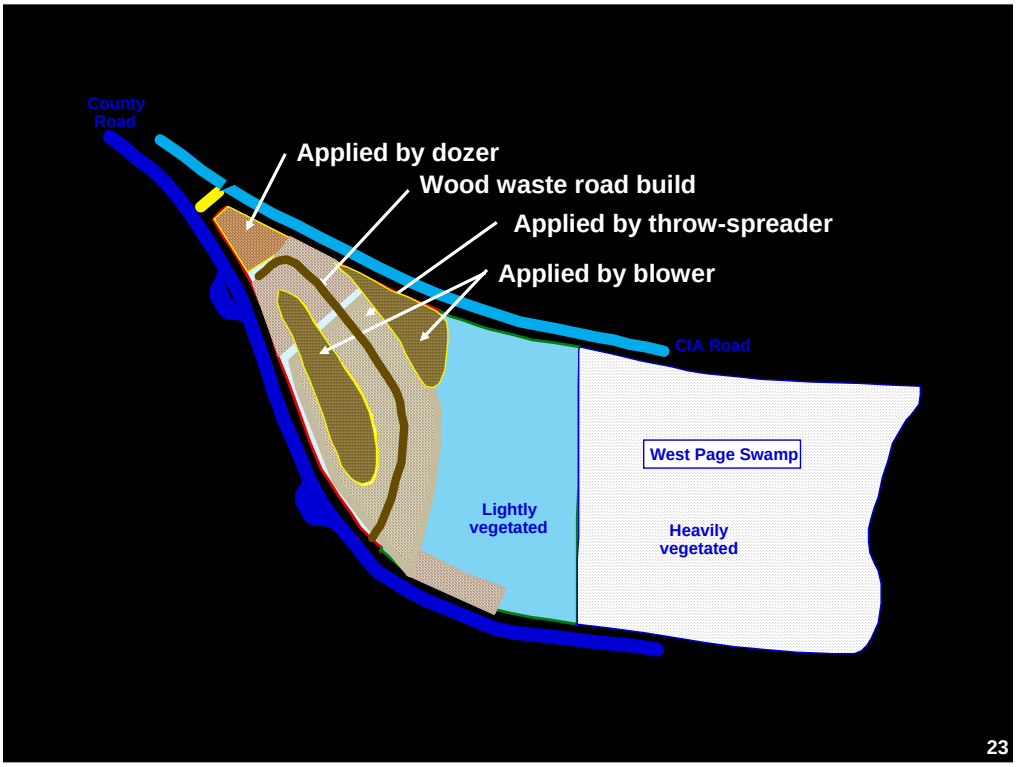
County Road
Applied by dozer
Wood waste road build
Applied by throw-spreader
Applied by blower
CIA Road
West Page Swamp
Lightly vegetated
Heavily vegetated
23

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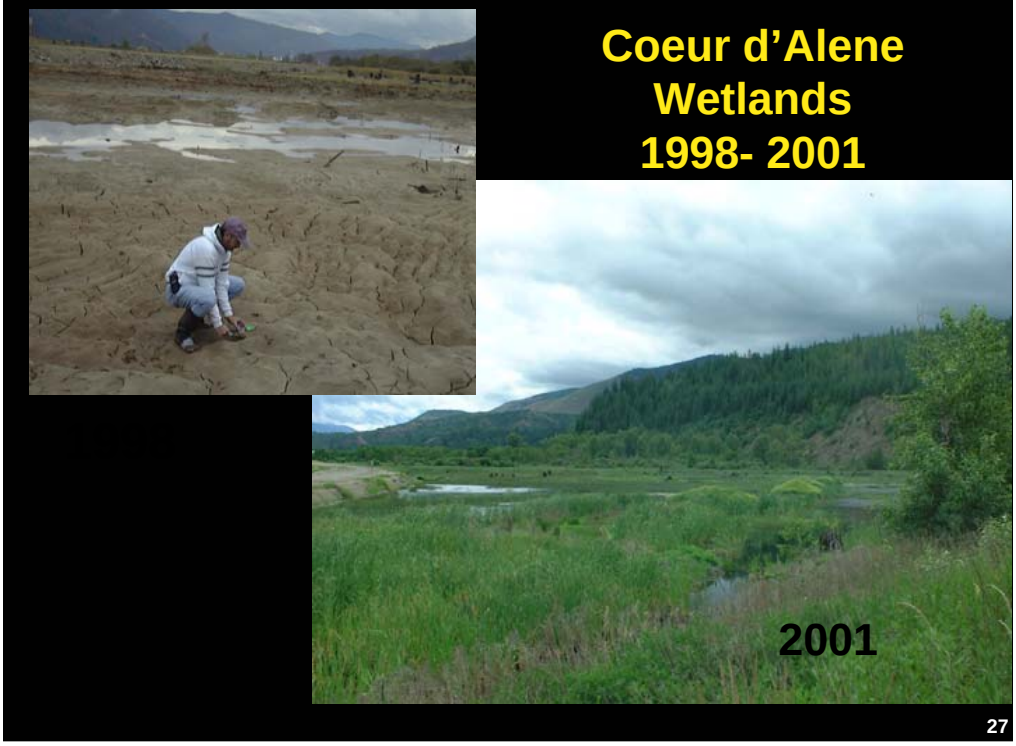
Coeur d'Alene
Wetlands
1998- 2001
2001
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1999
Coeur d'Alene
Wetlands
1998- 2000
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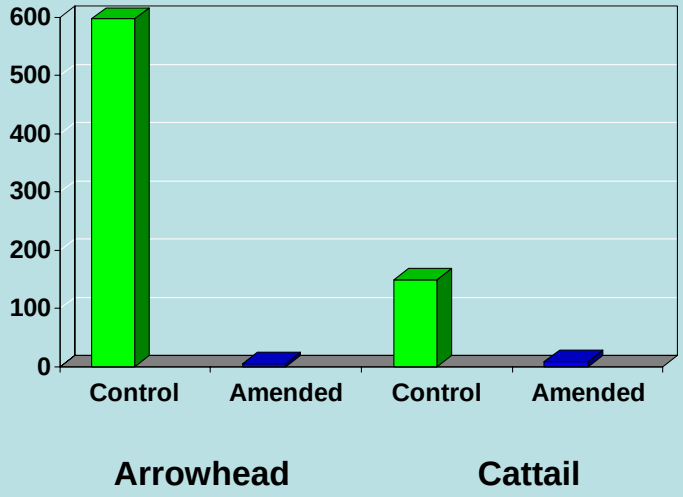
Ecosystem Implications- Wetland - Plant lead ($mg\ kg^{-1}$)



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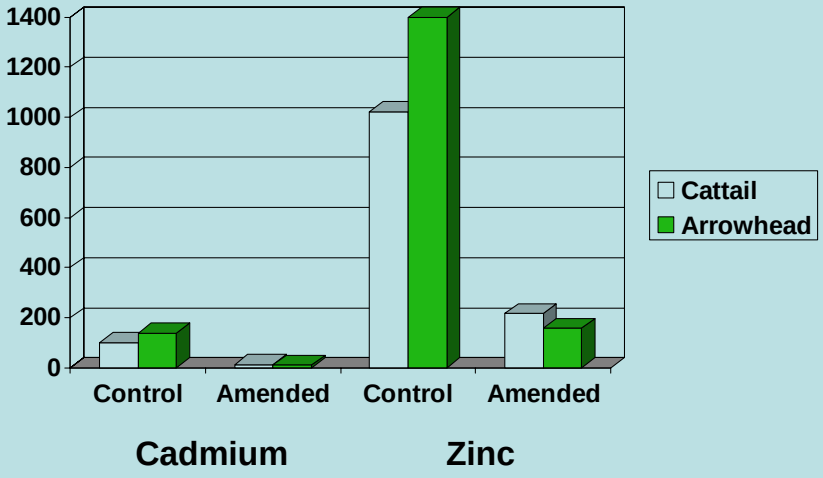
Ecosystem Implications
Other metals



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2005-
Collecting cores for metal speciation/ bioavailability analysis

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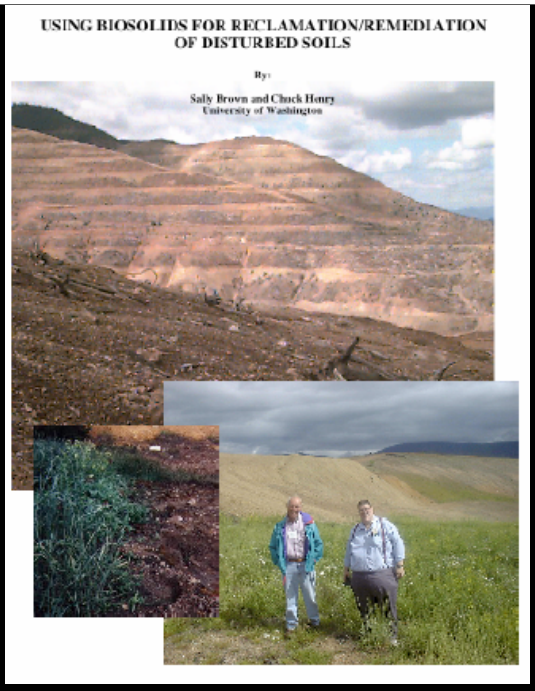

- http://faculty.washington.edu/clh/whitepapers.html

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Upper Arkansas
River Alluvium
Remediation
Leadville, CO
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Historic mine tailings washed down and accumulated in deposits up to and exceeding 2’

Deposits are toxic to riparian vegetation

Contaminated soils, barren of vegetation, are highly susceptible to continued erosion by the river

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Risks

- Re entrainment of tailings
  - Risk to river ecosystem
- Stabilized tailings
  - Potential risk to upland ecosystem

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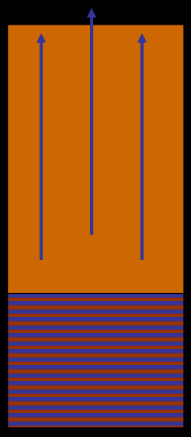
Soil System

- Pyretic tailings
  - Highly acidic
- Fluctuating water table
- Often insufficient rainfall
  - Reduced metals oxidize
  - Are wicked to soil surface
  - Salt crust



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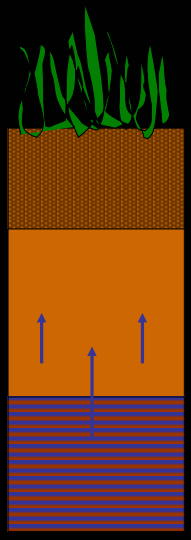
Biosolids/Lime amendment

- Increase subsoil and surface pH
- Increased organic matter at surface reduce wicking effect
- Precipitate metals currently in solution on oxides in biosolids
- Increased microbial activity- increase potential for reduction and sulfide precipitation
- Two mechanisms to reduce metal availability



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Filling vehicle

Application

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Leadville, CO
1997 - 2000

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Leadville, CO
1997-2000
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Ecological Assessment
Mark Sprenger, US EPA ERT

- Leadville, CO
- Similar results from Jasper County
- Similar results from Palmerton, PA

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Microbial Function

	CO_2-C Respiration	Ratio NO_3/NH_4
Tailings	4.7 ±0.6	0.01
Upstream Control	16.9 ± 9	1.1
Biosolids amended tailings	28.2 ± 7.2	12. 7

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Earthworm Survival

	Tailings	Biosolids amended tailings	Upstream control
Survival	0%	89± 3	96
Biomass	---------	12 mg	6.8

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Rye Grass

	Tailings	Treated	Control
Survival (%)	0	95	98

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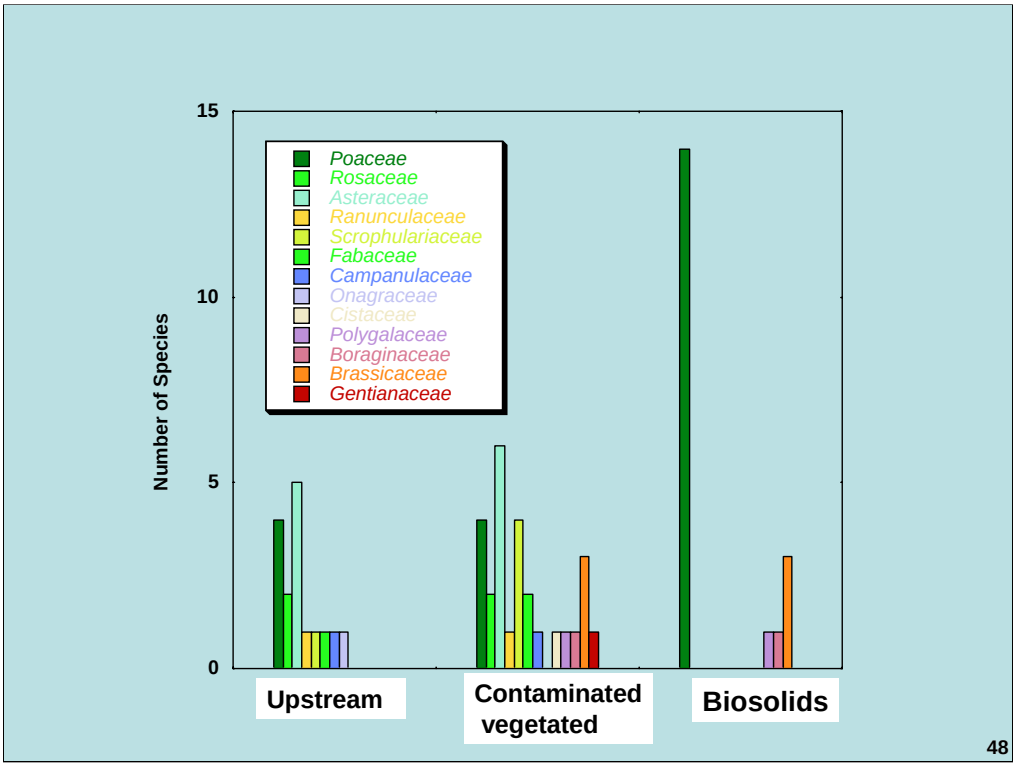
15
10
5
0
Number of Species
Poaceae
Rosaceae
Asteraceae
Ranunculaceae
Scrophulariaceae
Fabaceae
Campanulaceae
Onagraceae
Cistaceae
Polygalaceae
Boraginaceae
Brassicaceae
Gentianaceae
Upstream
Contaminated vegetated
Biosolids
48

Small Mammals

- Trapping
  - Analysis of body burden
  - Concentrations in specific organs
- Modeling to assess potential for food chain transfer
  - Primary risk - direct soil ingestion assuming 100% bioavailability of soil metals

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Herbivore Pathway-safe

Soil

Carnivore Pathway-safe

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Re entrainment

- **Safe on land, if amended soils are re suspended in Arkansas River**

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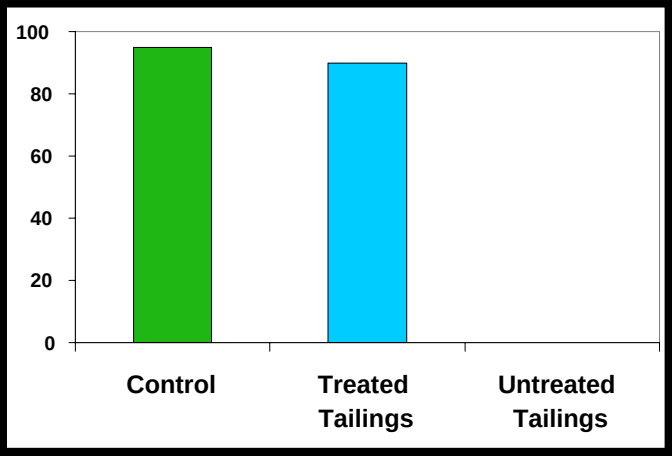
Re-entrainment Study
Fathead Minnow % Survival



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Leadville in August

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Plant Diversity

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Plant Diversity
Small Plots

- Plant Zinc
  - Range from 80-500 ppm
- Species Per plot
  - Shepard's purse
  - Poa paulustris
  - Yarrow
  - Pineapple weed
  - Potentilla
  - Sedge
  - Timothy
  - Alkali grass
  - Tufted hairgrass

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Sure Sign of Success

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Concerns using residuals

- Not a commodity
  - No fixed price or infrastructure
  - Generators not used to process
- Perception that they contain toxic levels of contaminants

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However -
3 reasons to rest assured

1) History of success
2) Complimented by a body of research
   - Basic and Applied
   - Shows potential to absorb metals
3) Metals are low

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Hettiarachchi et al. (EPA Cincinnati Lab)

- Objectives
  - Evaluate adsorption capacity of biosolids amended soil
- Results
  - Observed excess adsorption factor of Fe/Mn oxides and organic matter

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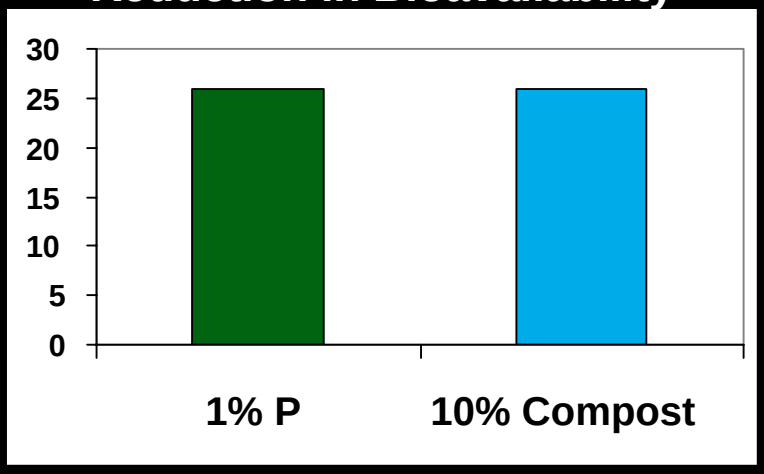
Joplin, MO
In Vivo Feeding

Reduction in Bioavailability



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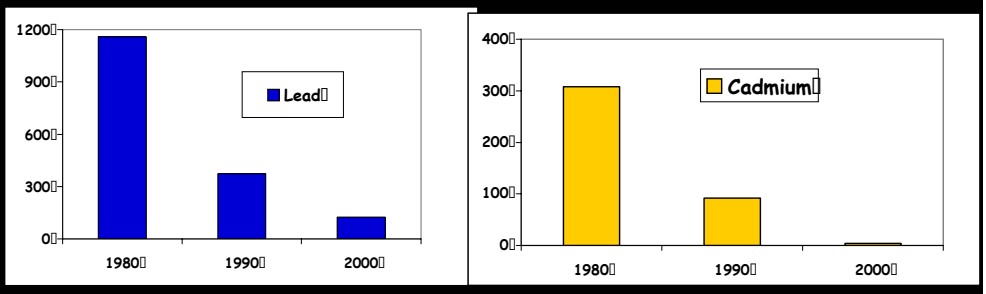
1) Aren't many metals left to worry about



Data from Chicago Water Reclamation District
(generates 200,000 dry tons of biosolids per year)

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Because they work at highly contaminated sites

- Will be effective at a wide range of sites
- Where ecosystem restoration is a goal
- Residuals offer an inexpensive and rapid way to lay a foundation for restoration

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Links to Additional Resources

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