Copper and Zinc Phytoremediation by Native Herbaceous and Grass Species Colonized on Remediated Soils at the Bullion Mine, Montana

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Phytoremediation

Definition: The use of vascular plants to improve environmental quality.

Alan Baker, Botanist (1980)

University of Sheffield, UK (2000) and University of Melborne, Australia (Current)

His studies include:

-Ecological restoration of mineral wastes

-Phytomining, phytostabalization

-Heavy metal toxicity/tolerance in plants

Plant-Soil Relationships

<u>Accumulators</u> – Species shown to accumulate greater metal concentrations in the aerial portions of the plant with shoot/root ratio >1 (Baker 1981)

<u>Hyperaccumulators</u> – Accumulate higher concentrations of metals in aerial parts than found naturally in the soil Cu >1000 ppm dry weight Zn >10,000 ppm dry weight

<u>Excluders</u> – Avoidance of metal uptake, metal restriction to the roots shoot/root ratio <1 (Baker 1981)</p>



Bullion Mine, Jefferson County, MT

- Gold and silver deposits
- Underlying igneous geology
- Ores and mine tailings pervasive
- Bullion Mine closed by 1933



Bullion Mine

- Jack Creek contamination and metal loading along the Bullion Mine Tributary (BMT)
- Listed as EPA Superfund site in 1999
 Metals of concern: As, Cd, Cu, Fe, Zn
- Soil cores under mine tailings contained:
 16 9000 μg/g Cu
 300 18,000 μg/g Zn (Fey et al. 2000)

Remediation Efforts

- USFS and EPA removed mine tailings and contaminated sediment from Jack Creek from 2001-2005
- Acid mine drainage(AMD) was still present in 2005 post remediation (Unruh *et al.* 2005)
- Site was re-graded in 2008
 - No re-seeding, allowed natural re-establishment

Site Characteristics



Bullion Mine Tributary (BMT)





Transect view north from 60 m

Note patchy plant distribution

60 m

0 m



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Phleum alpinum (mountain Timothy) Oryzopsis hymenoides (Indian ricegrass)

Select native grasses that dominate along the transect.



Select native herbaceous species that dominate along the transect.





cyanobacteria and moss mat

Equisetum arvense (common horsetail)

Other select species found along the transect.



Scaled horizontal profile with dominate species shown along the transect.

Thermopsis sp. (goldenbanner) metal accumulation



Cu accumulation in flowers 2-14 mg/Kg dry wt.

Zn 30-290 mg/Kg dry wt.



D. cespitosa (tufted hair-grass) metal accumulation



Cu accumulation in seeds 1-30 mg/Kg dry wt. Zn accumulation in roots 10-560 mg/Kg dry wt.

Average shoot/root metal ratio	
Cu	Zn
1.7	0.3

E. arvense (common horsetail) metal exclusion



Accumulators & Excluders at Bullion Mine

Accumulators can remove copper from contaminated soils

Effective phytoremediation relies on hyperaccumulators

Excluders show greater tolerance

Excluders used to contain windblown contamination (phytostabilization) (Alkorta *et al.* 2010)



Hydraulic control

Natural succession on metal contaminated soils

Past remediation attempts were incomplete

Despite soil contamination, natural succession is occurring

Possible because of the different tolerance mechanisms present

Plant distribution controlled by soil moisture



Summary

- In future, examine other contaminants identified by EPA/USFS including As, Cd, and Fe
- AMD is an ongoing problem
- Not an isolated problem in this area
- Examining other related sites may lead to successful phytoremediation or better understanding of natural succession on these soils