Ecosystem Restoration of Mine Lands

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The problem

• ~0.4 × 10^6 km^2 area of land, globally, is estimated to be disturbed by mining activities

• Problems in restoration:
  – Loss of topsoil
  – Low levels of organic matter
  – High particle size and bulk density

• High metal(loids) concentrations in mine spoil can adversely impact microbial activity and subsequent revegetation succession
(A) The distribution of particle size in Cu-Au-Mo mine tailings (Ernest Henry Mine) bulk-sampled from the top layer (0–0.6 m)

(B) Bulk density of tailings at different depths from the surface (0–0.6 m) below the surface. The data were pooled from five pits accessible in the area across the tailings

Huang et al. (2011)
Concerns

• Human health risk

• Ecological risk - the chance of injury, damage, or loss associated with the relationship between living organisms and the environment

• Focused on organisms other than humans. However, the efforts to address ecological risk may reduce human exposure to the contaminants of concern
Primary ecological issues

- The lack of vegetation
- Stockpiles, shortfalls
- The metal(loids) in surface waters and stream sediments that exceed aquatic life criteria
- Acid mine drainage- oxidation of sulfidic materials (pH 2.5 to 4)

Issues are interrelated: lack of vegetation promotes the movement of runoff and sediments from mining-impacted areas to the surface water resources
Potential solution

• Large quantities of biowaste, such as manure compost, biosolids, and municipal solid waste (MSW) that are low in contaminants [including metal(loid)s] can be used to rehabilitate mine lands
  – Source of nutrients and improve fertility levels
  – Act as a sink for metal(loid)s in mine waste, reducing their bioavailability (adsorption, complexation, reduction, and volatilization)
Various approaches to the use of different biowaste for mine land restoration

- **Sources**
  - Municipalities
  - Miscellaneous products
  - Food waste

- **Treatments**
  - Composting and aerobic digestion
  - Alkaline stabilization
  - Anaerobic and aerobic digestion

- **Products**
  - Municipal solid waste
  - Biosolids
  - Poultry and animal manures
  - Papermill sludge
  - Yard and wood waste

- **Components**
  - OM, macro nutrients; micro nutrients; pollutants (heavy metals, pathogens, pharmaceuticals)

- **Applications**
  - Surface application
  - Deep placement through ripping

- **Soil improvements**
  - Physical
    - Texture
    - Structure
    - WHC
  - Chemical
    - pH
    - CEC
    - OM
    - Nutrient
  - Biological
    - MA
    - MCD

CEC, Cation exchange capacity; MA, microbial activity; MCD, microbial community diversity, OM, organic matter; WHC, water holding capacity

Source: Wijesekara et al., 2016
Example 1: Jasper county, MO

(A) Tailing amended with biosolids and lime 12-14 years prior
(B) Treated tailing amended with biosolids and lime, the area was not seeded post-amendment addition

Brown et al., 2009
Example 2: Galena, KS

Alkaline phosphatase activity at (A) Site A and (B) Site B

C, Unamended control
LC, low compost, 45 tons/ha
HC, high compost, 269 tons/ha

Baker et al., 2011, Wijsekara et al., 2016
(C-E) Deposits of alluvial tailing along the Arkansas River in Leadville, CO. Pre- and 10-years after postamendment addition. Areas closer to the river were amended with biosolids compost and lime. Areas more than 3-m from the river were amended with biosolids and lime.

Brown et al., 2005, 2007
Example 4: Palmerton, PA

Foreground - Biosolids+ Limestone+ FlyAsh
Background - untreated Control

Source: Rufus Chaney, Personal communication
References