A Pathway to Walk-Away?
30 Year Old Technology to Suppress Acid Rock Drainage Revisited

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Solutions for the World of Water
Acid Rock Drainage

IN PERPETUITY

Unless we can find practical source control remedies
OUTLINE

- ARD Suppression Background
  - ARD Tetrahedron
  - History
  - How Bactericides Work

- A Pathway to Walk-Away?
  - Employ New Technologies
    - Decimate, Out-Compete; Sustain [DOS]
Acid Rock Drainage Tetrahedron

Fuel
Air
Heat
FIRE

Water

Oxidizer
(Air, Fe$^{+3}$)

Pyrite

ARD

Bacteria
Acid Rock Drainage Tetrahedron

DO NOTHING = PERPETUAL TREATMENT

DO SOMETHING (anything) = PATHWAY TO WALK-AWAY
Acid Rock Drainage Tetrahedron

“PROBIOTIC” PATHWAY TO WALK-AWAY

Water

Oxidizer (Air, Fe$^{+3}$)

Pyrite

Good Bacteria
History

- Bacteria are important (1950)
- Common surfactants are effective bactericides (1980s-1990s)
- Kleinmann & Erickson USBM RI 8847 (1983)
Thiobacillus ferrooxidans dramatically increases rate of pyrite oxidation.

Developed a laboratory procedure to determine application rates.

Case studies: two sites
- 60% to 95% decrease in acid production
- 90% to 95% decrease in iron

Temporary effect: must re-apply three times per year – improvement required.
History

- Bacteria are important (1950)
- Common surfactants are effective bactericides (1980s-1990s)
- Kleinmann & Erickson USBM RI 8847 (1983)
- Probiotic Bacteria Substitution w/Organics (1990 to 2008)
- Revegetation is a key requirement for sustainability

Zaburunov, 1987
Known Bactericidies

- Sodium lauryl sulfate (SLS)
- Sodium laureth sulfate (SLES)
- Slow release commercial products – ProMac™ (no longer available)
- Alkyl-benzene sulfonate (laundry detergent is cheaper than SLS)
- Sodium Thio-cyanate (NaSCN)
- Bi-Polar Lipids (patented)

Some of these concepts are 35 years old.
How Bactericides Work
(Anionic Surfactants)

After Baker-Austin & Dopson (2007)
Organic Amendments

- Organic acids (Tuttle, et al., 1977)
- Composted sewage sludge (Pichtel & Dick, 1990)
- Composted paper mill sludge (ditto)
- Pyruvic acid (ditto)
- Water-soluble extract from composted sewage sludge (ditto)
- Spent brewery grain (Lindsay et al., 2010)
- Waste milk & dairy products (Jin et al., 2008)
How Bactericides Work
(Organic Acids)

Tuttle, et al. 1977

Outer membrane disruption

Cell contents “leaking”
Bactericide Case Histories

1. Coarse Coal Refuse; Route 43, Jefferson County, OH (1984)
2. Branchton Coal Refuse, Butler County, PA (1990)
4. Dawmont Coal Refuse, Harrison County, WV (1986)

Ref: Gusek, 2016
**DECIMATE; OUT-COMPETE; SUSTAIN [DOS]**

1. Primary application of SLS to **decimate** acid-loving bug populations

2. Application of waste milk or other organic (with inoculant) to make heterotrophic **good bugs** happy & **out-compete** acid-loving bugs

3. Establishing a vibrant and **sustainable** vegetative cover to keep **good bugs** happy for **decades or longer**
Acid Rock Drainage Tetrahedron

Water
Oxidizer (Air, Fe$^{3+}$)
Pyrite
Bad Bacteria

DO SOMETHING (anything) = PATHWAY TO WALK-AWAY
Thank You

“Chance favors the prepared mind”

Nihil simul inventum est et perfectum

- Latin Proverb

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“Chance favors the prepared mind”

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Nothing is invented and perfected at the same time.

- Latin Proverb

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