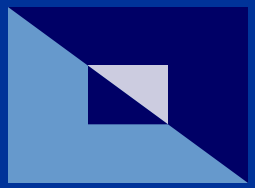
Short Course: Mine Water Treatment – Technologies, Case Studies and Costs

Emerging Treatment Technologies

May 3, 2015



New Processes For:

- Metals and sulfate: Biochemical reactor
- Sulfate and TDS: TSAES
- Nitrate
  - ARoNite
  - MBBR
  - FTWs
- Arsenic
  - ECAR
  - Regenerating adsorptive media
  - Nanomaterials
  - SAR

Biochemical Reactors (BCRs)

- "Passive bioreactor"
- Design life of 20-30 years with minimal O&M
- Mixture of long-term and short-term carbon courses (+ limestone?)
- Can remove sulfate and metals, increase pH
- Evaluated over past 20+ years

BCRs cont.

- Mixed consortium of bacteria
- Organic degradation, fermentation, denitrification, sulfate reduction, etc.
- Sulfate reduction reaction:

SO_4^{2-} (sulfate) + CH_2O (organics) + H^+

→

$C_5H_7O_2N$ (biomass) + S^{2-} (sulfide ion) + CO_2 + H_2O

Installed BCRs

Site Name	Location	Design Flow (gpm)
West Fork	Missouri	1,200
Golinsky Mine	California	10
Iron King Mine	Arizona	7
Yellow Creek 2B	Pennsylvania	10
Ore Hill Mine	New Hampshire	6
Golden Cross Mine	New Zealand	300
Kendall Mine	Montana	5
Haile Mine	South Carolina	6
Quinsam Mine	British Columbia	250
Delamar Mine	Idaho	20
Luttrell Repository	Montana	5

BCRs cont.

- Designing several systems now for Jerritt Canyon Mine in Nevada
  - Flows of 5-30 gpm
  - [SO_4] of 2,500-8,000 mg/L

  - Much more information in ITRC report: Biochemical Reactors for Mining-Influenced Water (November 2013)

Transpired Solar Air Eductor System (TSAES)

- Accelerated evaporator for difficult-to-treat waters (TDS, sulfate, etc.)
- Solar Multiple company
- Increase passive evaporation by 50-80%
- Piloting stage

TSAES Costs

Pond Size (acres)	Flow (gpm)	Capital Cost	Annual O&M
1	2.7	$492,000	$55,000
4	10.6	$1,240,000	$195,000
10	26.6	$2,800,000	$450,000
40	107	$9,500,000	$1,700,000

TSAES cont.

- Advantages:
  - Higher efficacy than standard evaporation pond
  - Less expensive than conventional evaporators and crystallizers
  - Solids remain in pond
- Disadvantages:
  - Need favorable climate
  - Water is not recovered

NITRATE REMOVAL

ARoNite Process

- Autotrophic Reduction of Nitrate (fixed-film biological process)
- Can also remove selenate, perchlorate, etc.
- Uses hydrogen and carbon dioxide
- Purchase hydrogen or generate on-site
- System in Rancho Cucamonga, CA (2012)
- Drinking water with < 1 mg/L NO_3-N

Moving Bed Biological Reactor (MBBR)

- Plastic media for biofilm attachment
- AnoxKaldnes/Veolia: Stillwater East Boulder, Kensington Mine design
- Headworks BIO: Gold mine in northern Saskatchewan
- Lentikats: Full-scale and pilot tests; uses porous biocatalyst pellets

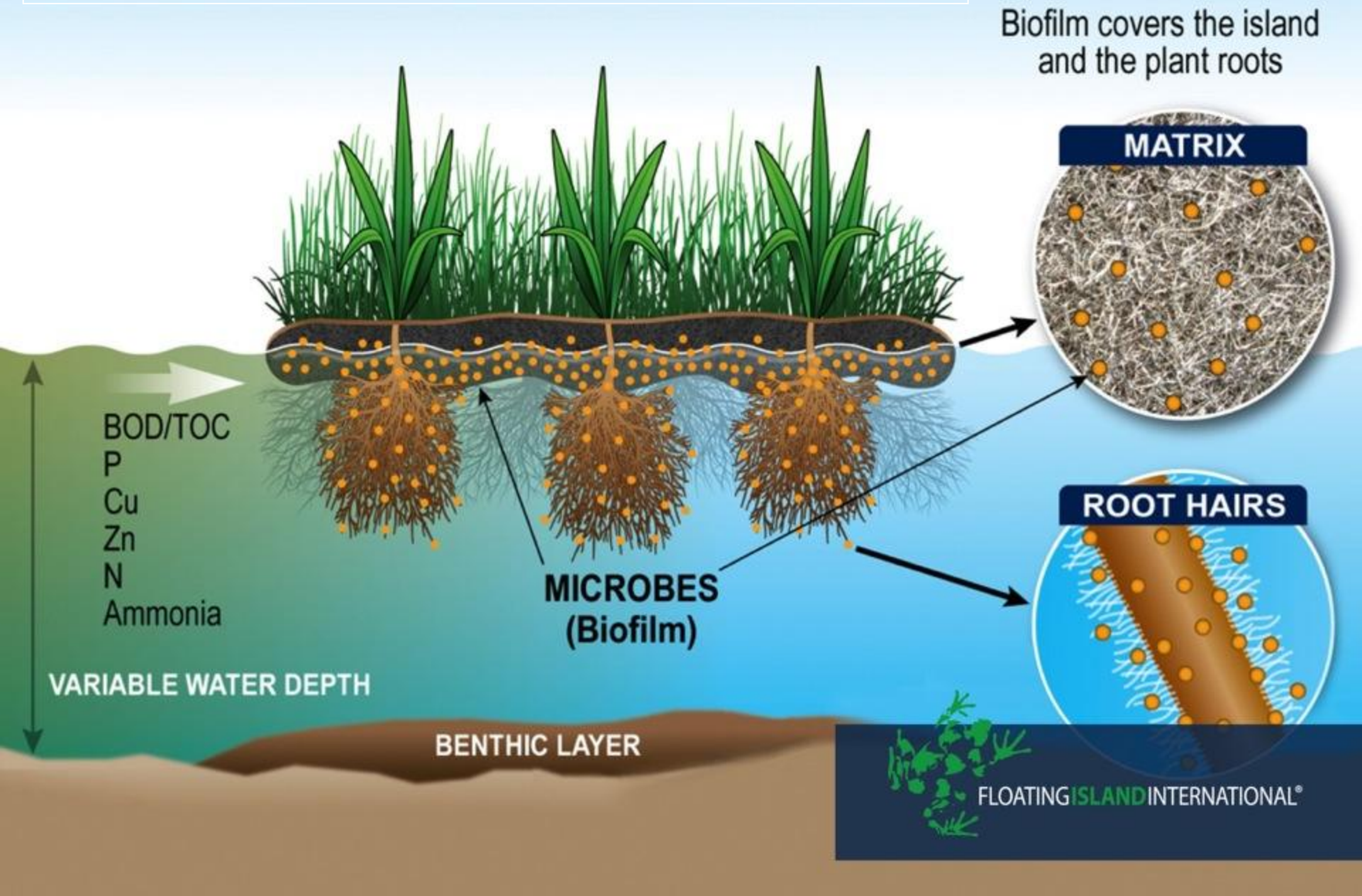
Floating Treatment Wetlands (FTWs) or floating islands

- Developed in 2005
- Over 5,000 installations worldwide
- Used for water treatment, habitat, beautification, shoreline protection
- Bacterial + plant activity
- Passive (no flow) or active

FTWs

- NO_3-N removal rates as high as 0.9 lb/yr/ft^3 of island (Rehberg Ranch, MT)
- Total N removal rates as high as 1.7 lb/yr/ft^3 (Pasco County, FL)
- Effective for high (30-40 mg/L) or low (< 10 mg/L) influent concentrations
- Need organic carbon source
- Capital cost = \$20-30/ft^2; almost no O&M

Add plants and surface area is increased
and synergies between chemistry and biology are enhanced



Most Applicable to Mine Water

1. MBBR
2. FTWs
3. AroNite

ARSENIC REMOVAL

ElectroChemical Arsenic Remediation (ECAR)

- Low electrical current creates rust from iron plates
- Arsenic binds to rust; remove solids through settling and/or filtration
- SimpleWater: piloting
- Simpler than conventional coagulation/filtration

Regenerating Adsorptive Media

- Can regenerate iron-based media with caustic soda solution (pH 13)
- NA for titanium or alumina-based media
- Evaluated at Twentynine Palms, CA for 5 years
- Each regeneration removes 90% of As
- Reduces O&M cost by 60%

Nanomaterials

- Nanoporous substances is densely packed with material for selective As adsorption
- Nanomaterial color changes with adsorption
- Lightweight with rapid kinetics
- Exploring full-scale and point-of-use systems

Subterranean Arsenic Removal (SAR)

- Controlled oxidation + filtration
- Water is pumped and oxidized w/air above-ground, then injected back into the aquifer, where ferric arsenate is naturally filtered
- No chemicals
- Sludge is immobilized underground
- Evaluated in India and Washington State

Most Applicable to Mine Water

1. SAR
2. ECAR
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